

## 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 10° or less. Where slopes exceed 10°, 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 10°, 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 10° or less, will not exceed 18°. 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-OPE, 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 Project Site 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 Project Site (**Table 4.3**).

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

| Rural Land Capability | Pre-mining   |            | Post-mining  |            | Change |     |
|-----------------------|--------------|------------|--------------|------------|--------|-----|
| Class                 | ha           | %          | ha           | %          | ha     | %   |
| II                    | Nil          | Nil        | 0            | 0          | 0      | 0   |
| III                   | 782          | 17         | 1,105        | 24         | 323    | 7   |
| IV                    | 2,380        | 50         | 1,743        | 37         | -637   | -13 |
| V                     | 435          | 9          | 156          | 3          | -279   | -6  |
| VI                    | 790          | 17         | 1,406        | 30         | 616    | 7   |
| VII                   | 313          | 7          | 5            | 0          | -308   | -7  |
| VIII                  | Nil          | Nil        | 285          | 6          | 285    | 12  |
| <b>Total</b>          | <b>4,700</b> | <b>100</b> | <b>4,700</b> | <b>100</b> |        |     |

**Table 4.3: Post-mining Rural Land Capability – Project Site**

| Rural Land Capability | Pre-mining |    | Post-mining |    | Change |     |
|-----------------------|------------|----|-------------|----|--------|-----|
| Class                 | ha         | %  | ha          | %  | ha     | %   |
| II                    | 568        | 2  | 568         | 2  | Nil    | Nil |
| III                   | 5,985      | 22 | 6,308       | 23 | 323    | 1   |
| IV                    | 9,880      | 36 | 9,243       | 34 | -637   | -2  |
| V                     | 4,797      | 18 | 4,518       | 17 | -279   | -1  |
| VI                    | 4,664      | 17 | 5,280       | 19 | 616    | 2   |

| Rural Land Capability | Pre-mining    |            | Post-mining   |            | Change |    |
|-----------------------|---------------|------------|---------------|------------|--------|----|
| VII                   | 1,492         | 5          | 1,184         | 4          | -308   | -1 |
| VIII                  | Nil           | Nil        | 285           | 1          | 285    | 1  |
| <b>Total</b>          | <b>27,386</b> | <b>100</b> | <b>27,386</b> | <b>100</b> |        |    |

## 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 Project Site (**Table 4.5**).

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

| Agricultural Suitability | Pre-mining   |            | Post-mining  |            | Change |     |
|--------------------------|--------------|------------|--------------|------------|--------|-----|
| Class                    | ha           | %          | ha           | %          | ha     | %   |
| 1                        | Nil          | Nil        | Nil          | Nil        | Nil    | Nil |
| 2                        | 782          | 17         | 1,105        | 24         | 323    | 7   |
| 3                        | 2,815        | 59         | 1,899        | 40         | -916   | -19 |
| 4                        | 790          | 17         | 1,406        | 30         | 616    | 13  |
| 5                        | 313          | 7          | 290          | 6          | -23    | -1  |
| <b>Total</b>             | <b>4,700</b> | <b>100</b> | <b>4,700</b> | <b>100</b> |        |     |

**Table 4.5: Post-mining Agricultural Suitability – Project Site**

| Agricultural Suitability | Pre-mining    |            | Post-mining   |            | Change |     |
|--------------------------|---------------|------------|---------------|------------|--------|-----|
| Class                    | ha            | %          | ha            | %          | ha     | %   |
| 1                        | 568           | 2          | 568           | 2          | Nil    | Nil |
| 2                        | 5,985         | 22         | 6,308         | 23         | 323    | 1   |
| 3                        | 14,677        | 54         | 13,761        | 51         | -916   | -3  |
| 4                        | 4,664         | 17         | 5,280         | 19         | 616    | 2   |
| 5                        | 1,492         | 5          | 1,469         | 5          | -23    | <1  |
| <b>Total</b>             | <b>27,386</b> | <b>100</b> | <b>27,386</b> | <b>100</b> |        |     |

## 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 western side of the Northern Mining Operations area and 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 a net increase in Rural Land Capability Class III cropping land over the area directly impacted by the Project (**Table 4.2**). This increases the overall coverage of Rural Land Capability Class III land in the Mining Operations Domain from approximately

660 ha to 1,000 ha, representing an increase of 340 ha. 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 a net increase in the quantity of woodland in the Mining Operations Domain to that directly impacted by the Project. This increases woodland coverage from 1,900 ha to 2,200 ha. 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 56% woodland (Class IV, V and VI), 25% cropping (Class III) and 15% pastoral land (Classes IV). The remaining 4% 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   | 1,000        | 25         |
| Pastoral     | IV                                     | Flat to gently sloping land   | 585          | 15         |
| Woodland     | IV, V and VI                           | Flat to steeply inclined land | 2,200        | 56         |
| Subtotal     |                                        |                               | 3,785        | 96         |
| Void         | VIII                                   | Void                          | 165          | 4          |
| <b>Total</b> |                                        |                               | <b>3,950</b> | <b>100</b> |

## **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.



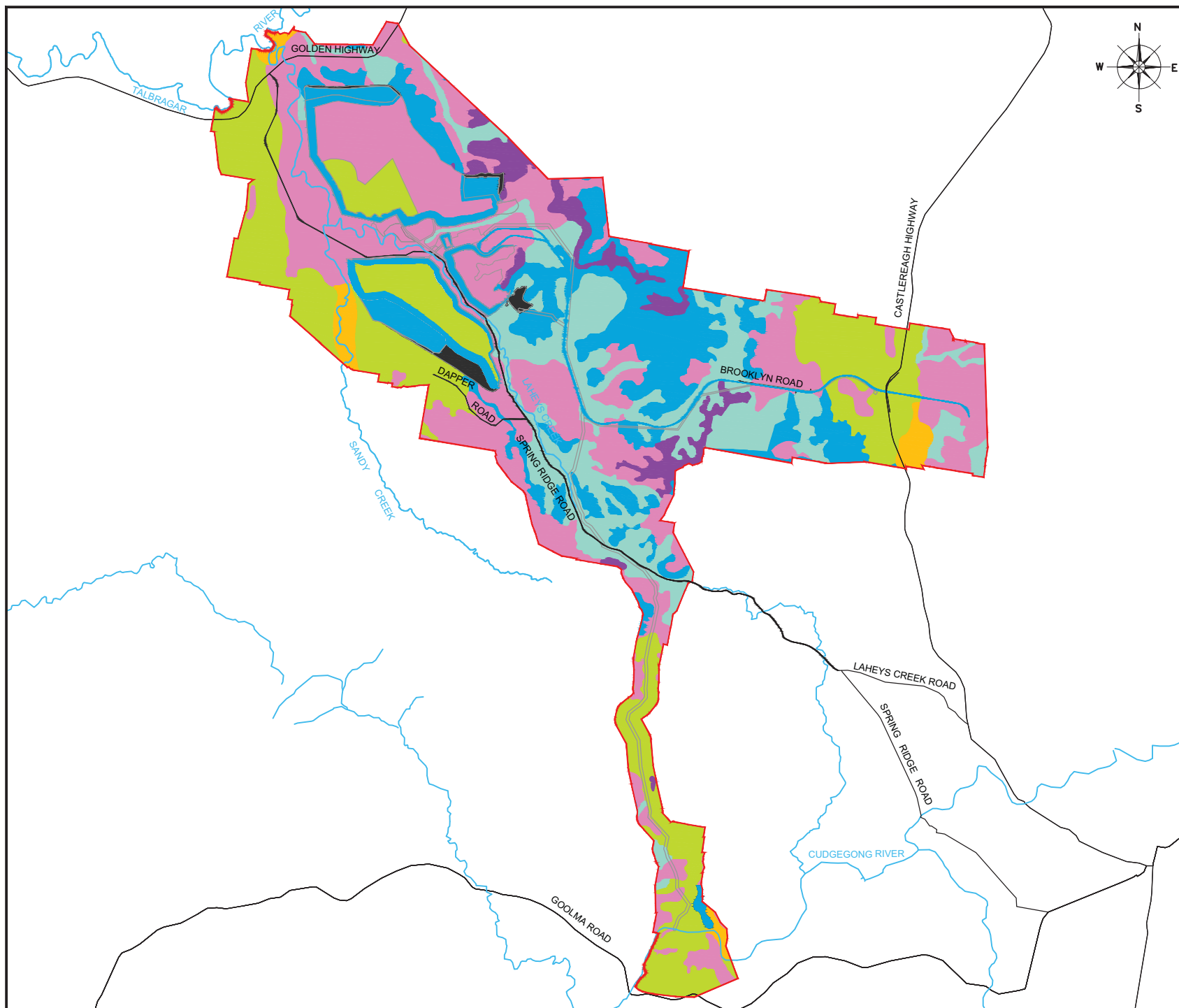
To be printed A4



Mine Rehabilitation Strategy: Cobbora Coal Project  
 Domain 1: Rehabilitated Landform (Closure)

**FIGURE 4.1**





## LEGEND

- Project Application Area
- Disturbance Footprint
- Waterways
- Roads

## LAND CAPABILITY

- Class II
- Class III
- Class IV
- Class V
- Class VI
- Class VII
- Class VIII

0 3.0km 6.0km  
Scale 1: 190 000

## FIGURE 4.2

### Post-mining Rural Land Capability

Project: Mine Rehabilitation Strategy:  
Cobbora Coal Project

Client: EMGA Mitchell McLennan  
Pty Limited

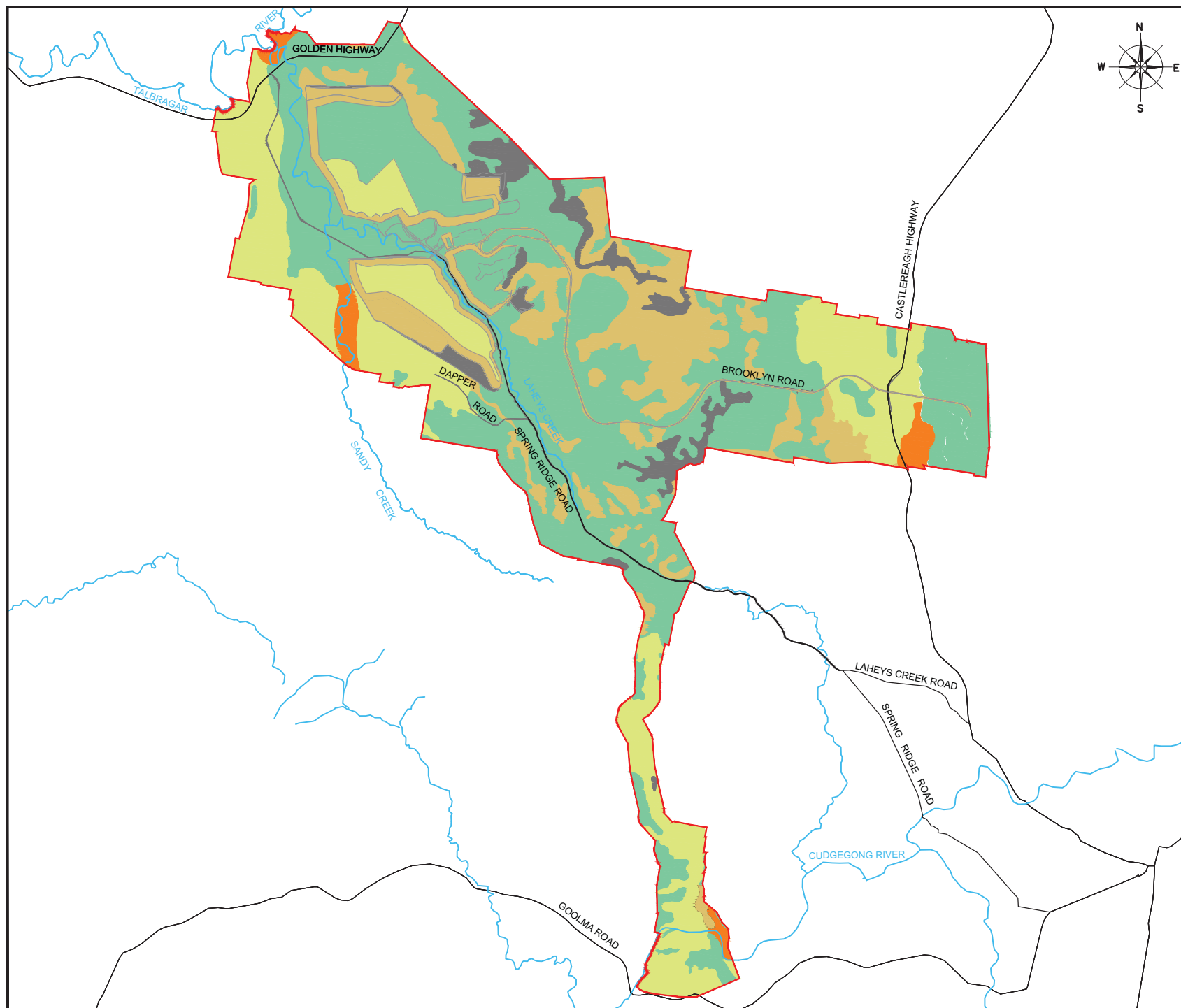
File:  
Fg4.2\_EMG00-005\_PostMineLandCap\_120904

Projection:  
MGA94 Zone 55

| Version: | Date:    | Author: | Checked: | Approved: |
|----------|----------|---------|----------|-----------|
| 1        | 30/03/12 | KC      | AC       | AC        |
| 2        | 25/05/12 | ZJ      | AC       | AC        |
| 3        | 04/09/12 | KC      | AC       | AC        |



**GSS ENVIRONMENTAL**  
Environmental, Land and Project  
Management Consultants



## LEGEND

- Project Application Area
- Disturbance Footprint
- Roads
- Waterways

## AGRICULTURAL SUITABILITY

- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

0 3.0km 6.0km  
Scale 1: 190 000

## FIGURE 4.3

### Post-mining Agricultural Suitability

Project: Mine Rehabilitation Strategy:  
Cobbora Coal Project

Client: EMGA Mitchell McLennan  
Pty Limited

File:  
Fg4.3\_EMG00-005\_PostMineAgSuit\_120904

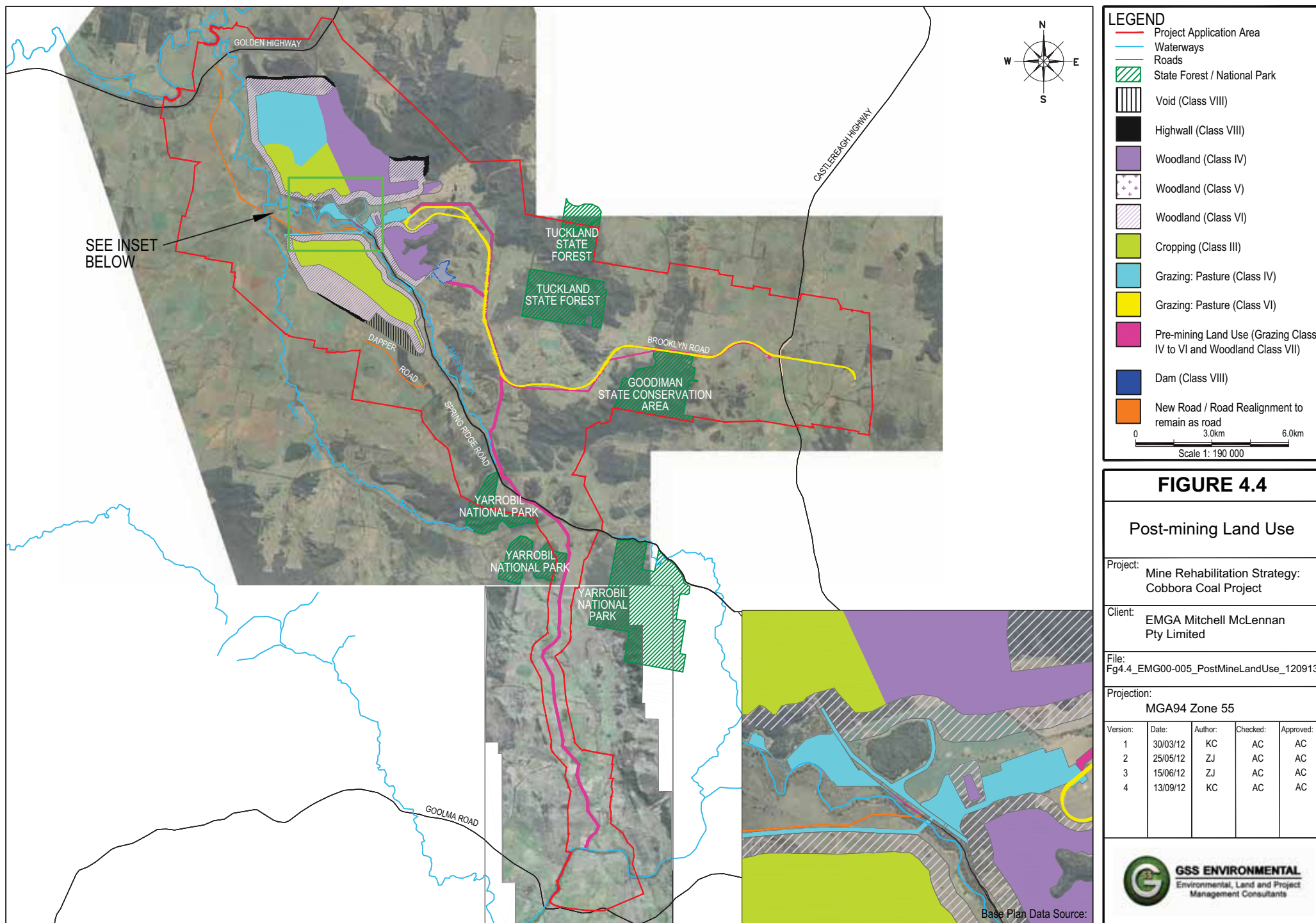
Projection:  
MGA94 Zone 55

| Version: | Date:    | Author: | Checked: | Approved: |
|----------|----------|---------|----------|-----------|
| 1        | 30/03/12 | KC      | AC       | AC        |
| 2        | 25/05/12 | ZJ      | AC       | AC        |
| 3        | 19/06/12 | ZJ/LF   | AC       | AC        |
| 4        | 04/09/12 | KC      | AC       | AC        |



**GSS ENVIRONMENTAL**  
Environmental, Land and Project  
Management Consultants





## 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                      | Woodland | IV                    | 240          | 6          |
|                          | Woodland | VI                    | 170          | 5          |
| Subtotal                 |          |                       | 410          | 11         |
| 4–8                      | Woodland | IV & VI               | 115          | 3          |
|                          | Pastoral | IV                    | Nil          | Nil        |
|                          | Cropping | III                   | 100          | 3          |
| Subtotal                 |          |                       | 215          | 6          |
| 8–16                     | Woodland | IV & VI               | 250          | 7          |
|                          | Pastoral | IV                    | 300          | 8          |
|                          | Cropping | III                   | 380          | 10         |
| Subtotal                 |          |                       | 930          | 25         |
| 16–21 (end of mine life) | Woodland | IV & VI               | 1,425        | 38         |
|                          | Pastoral | IV                    | 285          | 7          |
|                          | Cropping | III                   | 520          | 13         |
| Subtotal                 |          |                       | 2,230        | 58         |
| <b>Total</b>             |          |                       | <b>3,785</b> | <b>100</b> |

In total, 3,785 ha will be rehabilitated and 165 ha will be left as void areas in the Mining Operations Domain at closure. The following is a brief description of the annual rehabilitation sequencing:

|             |                                                                                                                                                                                                  |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Year 1      | No rehabilitation.                                                                                                                                                                               |
| Years 2–4   | Rehabilitation of 410 ha of land, which includes all of the Eastern Mining Operations area and some land in the east of the Southern Mining Operations area.                                     |
| Years 4–8   | Rehabilitation of 215 ha of land, which includes land in the east of the Southern Mining Operations area and in the south of the Northern Mining Operations area.                                |
| Years 8–16  | Rehabilitation of 930 ha of land, which includes land in the north and east of the Southern Mining Operations area, and land in the south and south-west of the Northern Mining Operations area. |
| Years 16–21 | Rehabilitation of 2,230 ha of land, which includes all remaining land in the Mining Operations Domain.                                                                                           |

## 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 is 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, which include soil texture, soil structure, pH and salinity, are listed in **Table 5.2**.

**Table 5.2: Soil Resources – Soil 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                    |

The assessment has shown that the suitability of the soil in areas subject to disturbance has a recommended stripping depth range of 0–0.55 m. Most 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 and/or chemical limitations (e.g. sodicity). **Table 5.3** details the maximum recommended stripping depths for each soil type and their major limitations. **Figure 5.2** provides the spatial distribution of the recommended stripping depths.

**Table 5.3: Soil Resources – Stripping Depth**

| Soil Type |                  | Stripping Depth (m) |         | Limitations                                                                                                               |
|-----------|------------------|---------------------|---------|---------------------------------------------------------------------------------------------------------------------------|
| #         | Name             | Topsoil             | Subsoil |                                                                                                                           |
| 1         | Red-Brown Duplex | 0.40                | Nil     | Topsoil has a weak structure and amelioration is required <sup>1</sup> ; subsoil has a high clay content and can be sodic |
| 2         | Yellow Duplex    | 0.35                | Nil     | Topsoil has a weak structure and amelioration is required <sup>1</sup> ; subsoil has a high clay content and can be sodic |
| 3         | Grey Skeletal    | Nil                 | Nil     | Soil has a very weak structure and high stone content                                                                     |
| 4         | Friable          | 0.55                | Nil     | Topsoil has a moderately fine texture and amelioration is required <sup>2</sup> ; subsoil has a high clay content         |
| 5         | Alluvial         | 0.40                | Nil     | Topsoil contains nil limitations; subsoil is limited by a coarse texture                                                  |

1 Ameliorate with organic amendments to improve weakly structured soils.

2 Ameliorate with gypsum reduce 'cloddiness' of soil.

### 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 Project is 14.4 million cubic metres (MCM). When a handling loss of 5% is allowed, this volume is reduced to approximately 13.7 MCM (**Table 5.4**). As discussed in **Section 5.3.1**, Soil Types 1 and 2 require amelioration with organic amendments prior to use. 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 5.4: Soil Resources – Available Volume**

| Domain                              | Soil Type |                  | Stripping Area | Stripping Depth | Quantity of Soil |
|-------------------------------------|-----------|------------------|----------------|-----------------|------------------|
|                                     | #         | Name             | ha             | m               | MCM              |
| 1                                   | 1         | Yellow Duplex    | 1,535          | 0.35            | 5.4              |
|                                     | 2         | Red-Brown Duplex | 2,080          | 0.40            | 8.3              |
|                                     | 3         | Grey Skeletal    | Nil            | n.a.            | Nil              |
|                                     | 4         | Alluvial         | Nil            | n.a.            | Nil              |
|                                     | 5         | Friable          | Nil            | n.a.            | Nil              |
| Subtotal                            |           |                  |                |                 | 13.7             |
| 2,5                                 | 1         | Yellow Duplex    | 177            | 0.35            | 0.6              |
|                                     | 2         | Red-Brown Duplex | 13             | 0.40            | 0.1              |
|                                     | 3         | Grey Skeletal    | Nil            | n.a.            | Nil              |
|                                     | 4         | Alluvial         | <1             | 0.4             | <0.01            |
|                                     | 5         | Friable          | Nil            | n.a.            | Nil              |
| Subtotal                            |           |                  |                |                 | 0.7              |
| <b>Total</b>                        |           |                  |                |                 | <b>14.4</b>      |
| <b>Total minus 5% handling loss</b> |           |                  |                |                 | <b>13.7</b>      |

n.a. means that the soil type is not in the disturbance footprint

### 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 Project Site. 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 10°. 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 300 mm prior to spreading a final cover of topsoil. The depth of topsoil will be a minimum of 200 mm.

### *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 Mining Operations Domain, using the soil spreading depths specified above, will require 11.2 MCM of soil (**Table 5.5**). The rehabilitation of Domains 2–4 (maximum area of 630 ha) may require (depending on level of surface disturbance) a maximum amount of 2.0 MCM. Sufficient soil resources are available (refer **Table 5.4**).

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

| Land Use           | Associated Rural Land Capability | Nominal Soil Depth (mm) |         |       | Area <sup>1</sup> | Total Volume of Soil Required |
|--------------------|----------------------------------|-------------------------|---------|-------|-------------------|-------------------------------|
| Type               | Class                            | Topsoil                 | Subsoil | Total | ha                | MCM                           |
| <b>Domain 1</b>    |                                  |                         |         |       |                   |                               |
| Cropping           | III                              | 300                     | 200     | 500   | 1,000             | 5.0                           |
| Pastoral           | IV                               | 150                     | 150     | 300   | 585               | 1.8                           |
| Woodland           | IV and VI                        | 100                     | 100     | 200   | 2,200             | 4.4                           |
| Subtotal           |                                  |                         |         |       | 3,785             | 11.2                          |
| <b>Domains 2–4</b> |                                  |                         |         |       |                   |                               |
| Pastoral           | III                              | 300                     | 200     | 500   | 105               | 0.5                           |
| Pastoral           | IV                               | 150                     | 150     | 300   | 250               | 0.8                           |
| Pastoral           | V                                | 150                     | 150     | 300   | 145               | 0.4                           |
| Pastoral           | VI                               | 100                     | 100     | 200   | 125               | 0.3                           |
| Woodland           | VII                              | 100                     | 100     | 200   | 5                 | <0.1                          |
| Subtotal           |                                  |                         |         |       | 630               | 2.0                           |
| <b>Total</b>       |                                  |                         |         |       | <b>4,415</b>      | <b>13.2</b>                   |

<sup>1</sup> Total disturbance area is 4,700ha; however, not all land is being rehabilitated, e.g. raw water dam, final voids and roads.

### 5.4.3 Soil Respreding 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 Project Site'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) |
|---------------------------------|--------------|
| <b>Warm Season Grasses</b>      |              |
| Bombatsi Panic                  | 1–2          |
| Green Panic <sup>1</sup>        | 2–4          |
| Rhodes Grass <sup>1</sup>       | 1–2          |
| Purple Pigeon Grass             | 1–2          |
| <b>Annual Legumes</b>           |              |
| Subterranean Clover             | 4–5          |
| <b>Cool Season Legumes</b>      |              |
| Barrel (Sephi) Medic            | 2–4          |
| Snail (Sava) Medic <sup>1</sup> | 3–5          |
| Woolly Pod Vetch                | 4–6          |
| Serradella (Elgara)             | 1–2          |
| Lucerne                         | 0.5          |
| <b>Cool Season Grasses</b>      |              |
| Phalaris (Sirolan or Holdfast)  | 1–2          |
| Wallaby Grass                   | 0.3–1        |

<sup>1</sup> 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 through 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 ( <i>Eucalyptus blakeyi</i> ), Yellow Box ( <i>E. Mellidor</i> ), White Box ( <i>E. albens</i> ), Grey Box ( <i>E. microcarpa</i> ), Rough-barked Apple ( <i>Angophora floribunda</i> ) and Kurrajong ( <i>Brachychiton populneus</i> ) |
| Pastoral | VI                          | Moderately to steep slopes | Black Cypress Pine ( <i>Callitris endlicheri</i> ), Red Ironbark ( <i>E. sideroxylon</i> ), Broad-leaved Red Ironbark ( <i>E. fibrosa</i> ) and Red Stringybark ( <i>E. macrorrhyncha</i> )                                                               |

#### 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 it 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 Project Site 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 Project Site meets the relevant water quality limits;



- prevent water from being discharged from the Project Site 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 Project Site 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**

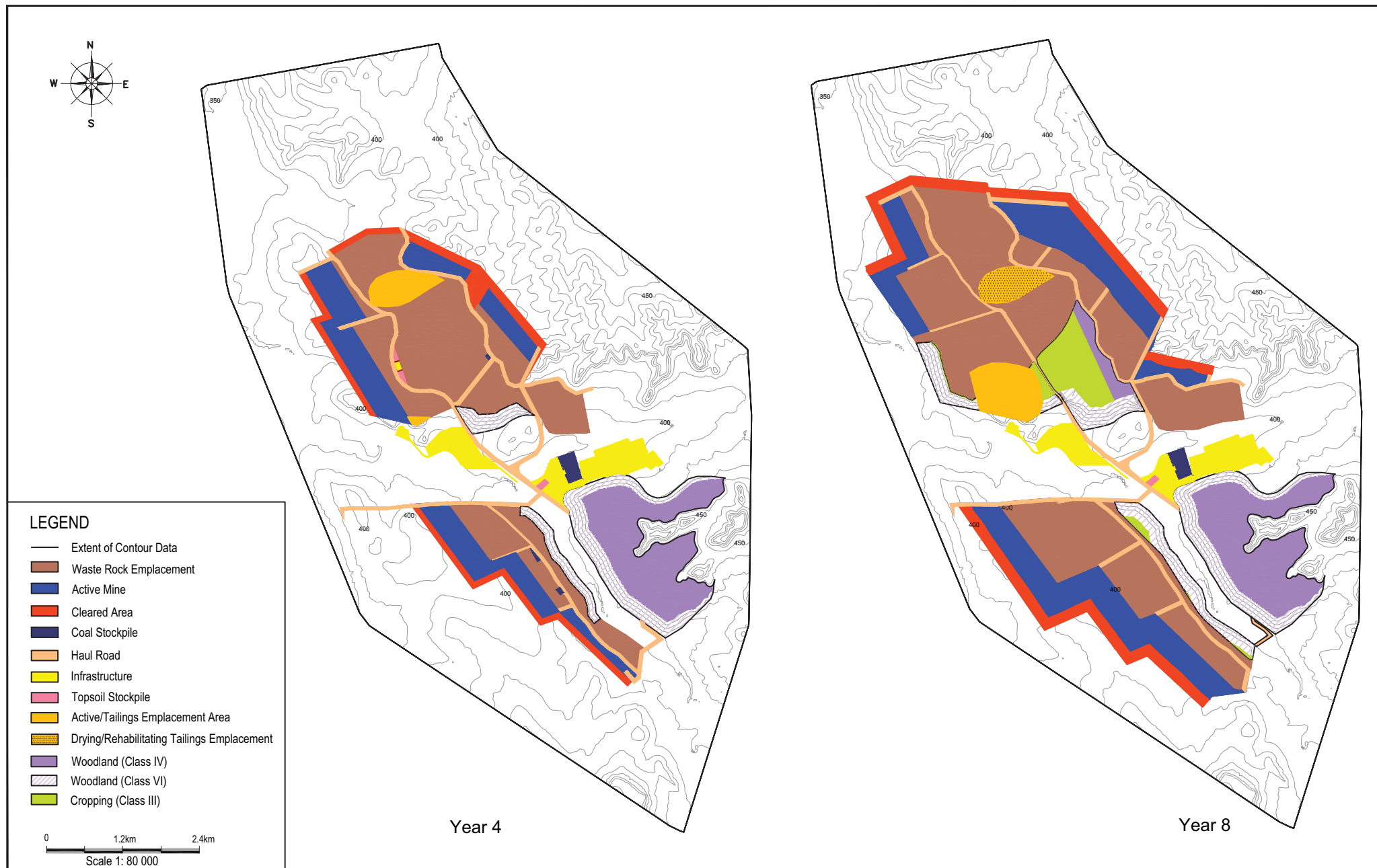
The primary design aspect of the Project is the prevention of clean water in ephemeral drainage channels entering the active disturbance footprint. This will be achieved through the use of diversionary structures such as drains, berms and banks, as well as the containment of contact water in sediment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

Effective erosion and sediment control for the Project Site 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.

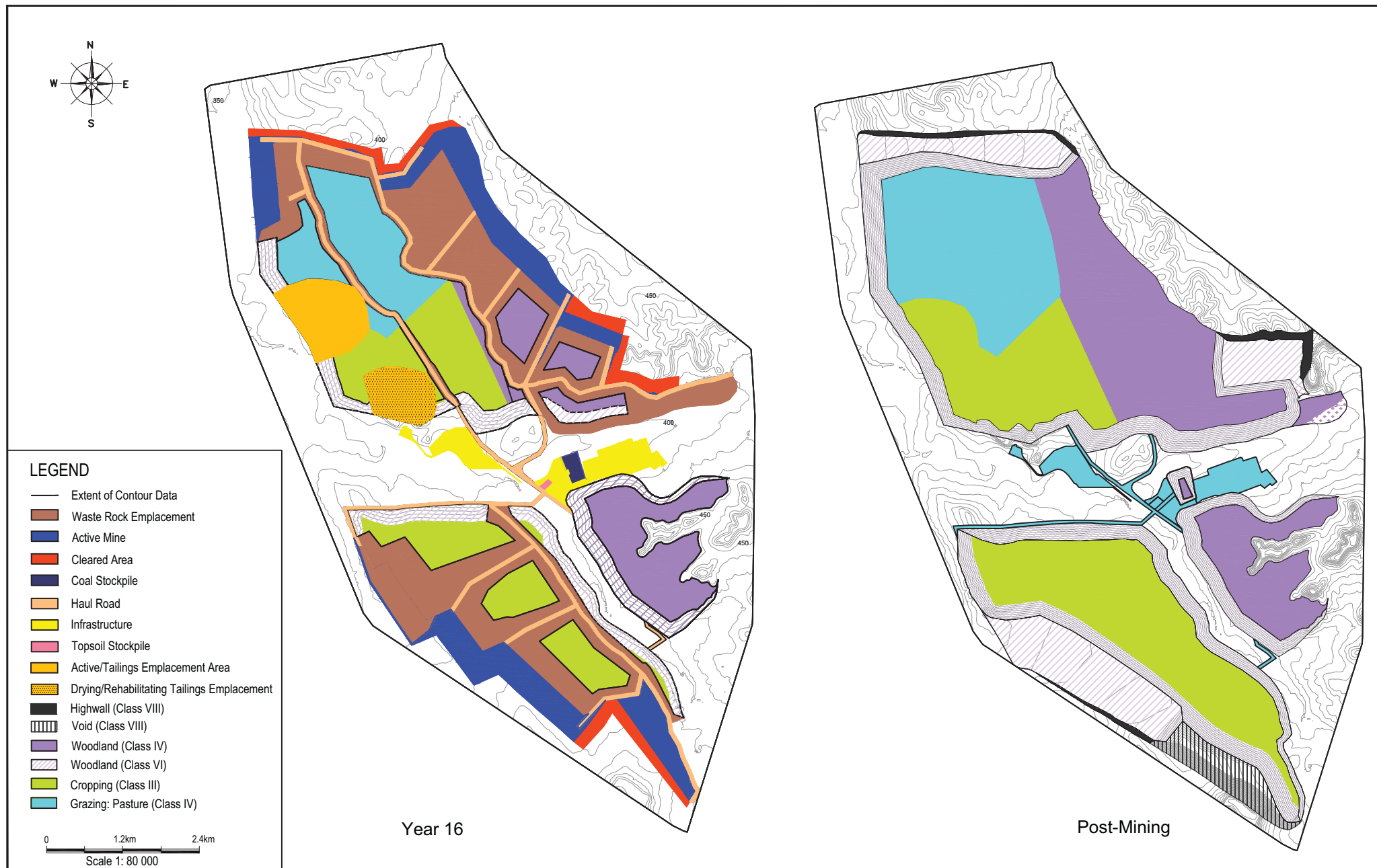


To be printed A4



Mine Rehabilitation Strategy: Cobbora Coal Project  
Staged Rehabilitation Year 4 & 8

**FIGURE 5.1a**



To be printed A4



Mine Rehabilitation Strategy: Cobbora Coal Project  
Staged Rehabilitation Year 16 & 21

**FIGURE 5.1b**

## 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 Project Site'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 $\leq 3H:1V$<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                                                                                                                                                                      |
|      |                             |                        | 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<br>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)<br>No bare surfaces >20 m <sup>2</sup> 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<br>Weeds do not dominate native species after disturbance or after rain<br>Pests do not occur in substantial numbers or visibly affect the development of native plant species |
| 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)<br>No bare surfaces >20 m <sup>2</sup> 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<br>Weeds do not dominate native species after disturbance or after rain<br>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<br>All drill holes, pits, open cuts and other openings are securely capped, filled or otherwise made safe<br>Access by members of the public and livestock is restricted as appropriate to site conditions<br>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<sup>2</sup>) 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        | <i>Woodland</i><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           | <i>Pastoral land</i><br>Measure live vegetation grass cover in 2 m x 2 m (4 m <sup>2</sup> ) 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         | <i>Cropping land</i><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><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. Additional 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 REHABILITATION 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 Project will disturb land primarily covered by Rural Land Capability Class IV (50%), Class VI (17%) and Class III land (17%). No Class II land will be impacted.
- Post-mining, and following rehabilitation, the Project will reinstate 7% more Rural Land Capability Class III land than was present pre-mining. In practice, about 1,000 ha of Rural Land Capability Class III land will be reinstated, compared with 780 ha of Class III land that will be disturbed.
- 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 Project Site; 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

- ANZMEC (2000) *Strategic Framework for Mine Closure*. Australian and New Zealand Energy Minerals Council and Minerals Council of Australia.
- Australian Bureau of Meteorology (BOM) (2012) *Dunedoo Post Office*, BOM Station No. 064009, 2012 <[http://www.bom.gov.au/climate/averages/tables/cw\\_064009.shtml](http://www.bom.gov.au/climate/averages/tables/cw_064009.shtml)> 9accessed February 2012)
- Australian Bureau of Meteorology (BOM) (2008) *Australian climate variability & change - Trend maps: Pan Evaporation* (Commonwealth of Australia).
- Colquhoun G.P., Meakin N.S., Morgan E.J., Raymond O.L., Scott M.M., Watkins J.J., Barron L.M., Cameron R.G., Henderson G.A.M., Jagodzinski E.A., Krynen J.P., Pogson D.J., Warren A.Y.E., Wyborn D. and Yoo E.K., (1999). *Dubbo 1:250 000 Geological Sheet SI/55-04*, 2nd edition, Geological Survey of New South Wales, Sydney.
- Cunningham G.M., Higginson F.R., Riddler A.M.H and Emery K.A. (1988) *Systems Used to Classify Rural Lands in New South Wales*, Soil Conservation Service of NSW. Sydney, NSW.
- DP&I (2011) draft *Strategic Regional Land Use Policy* (NSW). Information available at <<http://www.planning.nsw.gov.au/StrategicPlanning/StrategicRegionalLandUse/tabid/495/language/en-AU/Default.aspx>>, accessed 14 March 2012.
- Elliot and Reynolds (2007) *Soil and Extractive Industries IN: Soils – their properties and management: 3<sup>rd</sup> Edition* (Eds P Charman & Murphy) (Oxford University Press, Australia).
- EMM (EMGA Mitchell McLennan Pty Limited) 2012 *Cobbora Coal Project – Ecology Assessment*.
- GSS Environmental (2012) *Agricultural Impact Statement – Cobbora Coal Project*. GSS Environmental, Newcastle, NSW.
- Isbell R.F. (1996), *Australian Soil Classification* (CSIRO Publishing, Australia)
- Murphy B.W. and Lawrie, J.M. (1998) *Soil Landscapes of the Dubbo 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.
- NSW Agriculture & Fisheries (1990) *Agricultural Suitability Maps – Uses and Limitations*. Agfact AC.9 Second Edition, NSW Government, Orange.
- Parsons Brinkerhoff (2012). *Surface Water Assessment – Cobbora Coal Project*.

*"This page has been intentionally left blank"*

**SOIL SURVEY**  
**COBBORA COAL PROJECT**  
**GSS ENVIRONMENTAL**



**APPENDIX 1**





**Office locations:**

Newcastle: Phone: (02) 4920 3000  
Mackay: Phone: (07) 4998 5255  
Central Coast: Phone: (02) 4385 7899

Our Ref:- Lt\_EMG00-005\_Soil Survey\_v3\_20120627

17th June 2012

Phil Towler  
EMGA Mitchell McLennan  
1/20 Chandos Street  
ST LEONARDS NSW 2065

*Sent Via: Email Transmission*

Dear Phil,

**RE: SOIL SURVEY: COBBORA COAL PROJECT**

Proponent: Cobbora Holding Company Newcastle NSW

---

**INTRODUCTION**

GSS Environmental (GSSE) was commissioned in 2009 by Environmental Resources Management (ERM) on behalf of the proponent, Cobbora Holding Company Pty Limited (CHC), to prepare a Soil Survey 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).

On behalf of the proponent, the letter provides to EMGA Mitchell McLennan Pty Limited (EMM) a detailed overview of the surveyed soil resources as assessed during the 2009 survey.

**BACKGROUND**

The Project is a new open-cut coalmine that will be developed on approximately 274 square kilometres (km<sup>2</sup>) (or 27,386 hectares (ha)) of land near Cobbora in the central west of NSW. The Project will supply up to 9.5 million tonnes per annum (Mtpa) of coal for domestic power generation in NSW. In addition, up to 2.5 Mtpa will be produced for a combination of the export and spot domestic markets.

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, including 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 first half of 2015. The mine life will be 21 years.

## SOIL SURVEY METHODOLOGY

### Background Reference Information

An initial soil map was developed using the resources and techniques listed below.

- Aerial photos, satellite imagery and topographic maps were used to provide detailed analysis of the landscape and mapping of features expected to be related to the distribution of soils.
- Existing literature on the area which included the *Soil Landscapes of the Dubbo 1:250 000 Sheet* Murphy and Lawrie (1998).
- Following production of a base soils map, surface soil exposures throughout the survey area were visually assessed to verify soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations of the proposed Project Site.

### Survey Observations

A site inspection was undertaken in October 2009 by GSSE personnel to classify the soil types associated with Project. Field survey observations comprised of detailed soil profile observations (also referred to as soil pits) and mapping observations. Eleven soil profiles were exposed by backhoe excavation to a depth of 1–1.5 m and soil profiles were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* soil classification procedures (NCST, 2009). This assessment included parameters as detailed in **Table 1**.

**Table 1: 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                             |
| Soil structure                  | 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                                                     |

Mapping observations used existing surface exposures located on track cuttings, gullies and creek banks.

### Soil Laboratory Assessment

Soil samples from the 11 soil pits were sent to the NSW Land and Property Management Authority Soil Conservation Service Laboratory (Scone Laboratory) for analysis. All samples were laboratory tested for the parameters in **Table 2**, and their practical applications are listed. The accompanying certificates of analysis are provided in **Attachment 1**.

**Table 2: Laboratory Analysis Parameters**

| Parameter                                                  | Application                                                                                                                                                                                 |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Physical</b>                                            |                                                                                                                                                                                             |
| Colour                                                     | Soil colour based on Munsell Colour Chart                                                                                                                                                   |
| Particle-size analysis (PSA) (<2mm)                        | Nutrient retention; exchange properties; erodibility; workability; permeability; sealing; drainage; interpretation of most other physical and chemical properties and soil qualities        |
| Emerson Aggregate Test (EAT)                               | Stability of soil structural units when immersed in water; measure of soil dispersibility or soils structural stability                                                                     |
| <b>Chemical</b>                                            |                                                                                                                                                                                             |
| Soil reaction (pH) (1:5, soil: water suspension)           | Nutrient availability; nutrient fixation; toxicities (especially aluminium and manganese); liming; sodicity; correlation with other physical, chemical and biological properties            |
| Electrical conductivity (EC) (1:5, soil: water suspension) | Appraisal of salinity hazard in soil substrates or groundwater; total soluble salts                                                                                                         |
| Cation exchange capacity (CEC) and exchangeable cations    | Nutrient status; calculation of exchangeable sodium percentage (ESP); assessment of other physical and chemical properties, especially dispersivity, shrink-swell, water movement, aeration |

## SOIL SURVEY RESULTS

### Soil Types Overview

The Project Site contains five main soil types: (1) Red-Brown Duplex; (2) Yellow Duplex; (3) Grey Skeletal; (4) Friable; and (5) Alluvial. These soil types are listed in **Table 3** and described below. **Figure 3.2** in the Project's Mine Rehabilitation Strategy shows the spatial distribution of these soil types across the Project Site.

**Table 3: Soil Types Overview**

| Soil Type    |                  |                             | Project Site  |            | Disturbance Footprint |            |
|--------------|------------------|-----------------------------|---------------|------------|-----------------------|------------|
| #            | Common Name      | ASC Name                    | ha            | %          | ha                    | %          |
| 1            | Red-Brown Duplex | Red-Brown Chromosol/Sodosol | 11,253        | 41         | 2,209                 | 47         |
| 2            | Yellow Duplex    | Yellow Chromosol/Sodosol    | 12,944        | 47         | 2,115                 | 45         |
| 3            | Grey Skeletal    | Grey Tenosol/Rudosol        | 1,783         | 7          | 329                   | 7          |
| 4            | Friable          | Red-Brown Dermosol          | 656           | 2          | <5                    | <1         |
| 5            | Alluvial         | Rudosol/Tenosol             | 750           | 3          | 47                    | 1          |
| <b>Total</b> |                  |                             | <b>27,386</b> | <b>100</b> | <b>4,700</b>          | <b>100</b> |

The co-dominant soil types across the site are the Red-Brown Duplex and Yellow Duplex, which comprise 47% and 41% of the Project Site respectively. The Grey Skeletal soil type comprises a minor proportion (7%) and the Alluvial and Friable soil types comprise a very minor proportion of the Project Site (<3% coverage each). The disturbance footprint is covered mainly by the co-dominant soil types.

## Soil Type 1: Red-Brown Duplex

The Red-Brown Duplex soil type generally consists of weakly structured brown loams and sandy loams overlying strongly structured brown to strong-brown medium-heavy clay subsoil. These soils range from moderately acidic in the upper layers to moderately alkaline at depth, are non-saline and can have sodic subsoil.

**Table 4: Overview of Soil Type 1**

| Site Description                                                                   |             |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |                                                                                     |                 |                          |         |
|------------------------------------------------------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------|--------------------------|---------|
|  |             |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |  |                 |                          |         |
| Plate 1: Profile (Pit 8)                                                           |             |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  | Plate 2: Landscape (Pit 8)                                                          |                 |                          |         |
| Common Name                                                                        |             |                                                                                                                                                                                                                                                                                                                                                    | Red-Brown Duplex                                                                                                 |                                                                                     |                 |                          |         |
| Australian Soil Classification                                                     |             |                                                                                                                                                                                                                                                                                                                                                    | Brown Chromosol and/or Sodosol                                                                                   |                                                                                     |                 |                          |         |
| Representative Pit                                                                 |             |                                                                                                                                                                                                                                                                                                                                                    | 8                                                                                                                |                                                                                     |                 |                          |         |
| Sampled Pit(s)                                                                     |             |                                                                                                                                                                                                                                                                                                                                                    | Profile sites 8 and 18                                                                                           |                                                                                     |                 |                          |         |
| Soil-stripping Recommendation                                                      |             |                                                                                                                                                                                                                                                                                                                                                    | 0.4 m suitable for stripping and re-use in rehabilitation works; amelioration required to improve soil structure |                                                                                     |                 |                          |         |
| Physical Characteristics: Representative Pit <sup>1</sup>                          |             |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |                                                                                     |                 |                          |         |
| Horizon                                                                            | Depth (m)   | Description                                                                                                                                                                                                                                                                                                                                        |                                                                                                                  |                                                                                     |                 |                          |         |
| A1                                                                                 | 0.00 – 0.10 | Dark brown (7.5YR 3/3) weak consistence clay loam. A moderate pedality (blocky peds <20 mm) soil with strong acidity (pH 5.4). Negligible to slight dispersion (EAT Class 8/3(1)), very low salinity (0.05 dS/m), roots common to many, and stones <10% (<20 mm). Approx. sample depth 0.10 m. Boundary is clear and irregular to the next horizon |                                                                                                                  |                                                                                     |                 |                          |         |
| A2                                                                                 | 0.10 – 0.40 | Dark reddish-brown (5YR 3/4) moderate consistence sandy clay loam. A weak pedality (blocky peds <10 mm) soil with slight acidity (pH 6.2). Slight dispersion (EAT Class 3(1)), very low salinity (0.02 dS/m), roots many and fine, and stones 80% (1–200 mm). Approx. sample depth 0.25 m. Boundary is clear and irregular to the next horizon     |                                                                                                                  |                                                                                     |                 |                          |         |
| B2                                                                                 | 0.40 – 1.2  | Strong brown (7.5YR 5/8) strong consistence medium to heavy clay that has massive structure. It has a neutral pH (7.1), slight dispersion (EAT Class 5) and very low salinity (0.03 dS/m). Large stones at 50% content. Approx. sample depth 0.50 m                                                                                                |                                                                                                                  |                                                                                     |                 |                          |         |
| Analytical Description: Representative Pit <sup>1</sup>                            |             |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |                                                                                     |                 |                          |         |
| Analyte                                                                            | Units       | A1                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                  | A2                                                                                  |                 | B2                       |         |
| Depth                                                                              | m           | 0 – 0.10                                                                                                                                                                                                                                                                                                                                           |                                                                                                                  | 0.10 – 0.25                                                                         |                 | 0.40 – 1.2               |         |
| Colour <sup>2</sup>                                                                | Munsell     | 7.5YR 3/3 (Dark brown)                                                                                                                                                                                                                                                                                                                             |                                                                                                                  | 5YR 3/4 (Dark reddish-brown)                                                        |                 | 7.5YR 5/8 (Strong brown) |         |
| pH                                                                                 | pH scale    | 5.4                                                                                                                                                                                                                                                                                                                                                | Strongly acidic                                                                                                  | 6.2                                                                                 | Slightly acidic | 7.1                      | Neutral |

|                                   |          |        |                                     |      |           |      |          |
|-----------------------------------|----------|--------|-------------------------------------|------|-----------|------|----------|
| EC                                | dS/cm    | 0.05   | Very low                            | 0.02 | Very low  | 0.03 | Very low |
| CEC                               | meq/100g | 8.7    | Low                                 | 21.3 | Moderate  | 38.5 | High     |
| Exchangeable Sodium Percent (ESP) | %        | 3.1    | Non-sodic                           | 2.8  | Non-sodic | 6.5  | Sodic    |
| EAT                               | class    | 8/3(1) | Negligible/<br>aggregated to slight | 3(1) | Slight    | 5    | Slight   |

1 Interpretations from Hazelton & Murphy (2007) unless otherwise stated.

2 Colour analysed on moist sample unless was a bleached layer.

## Soil Type 2: Yellow Duplex

The Yellow Duplex soil type generally consists of weakly structured brown loams and sandy loams overlying strongly structured yellow to yellowish-brown medium-heavy clay subsoil. Red-grey subsoil mottling is present which indicates restricted internal drainage. These soils range from moderately acidic in the upper layers to moderately alkaline at depth, are non-saline and can have sodic subsoil.

**Table 5: Overview of Soil Type 2**

Site Description

A close-up photograph of a soil profile in a pit. A blue and white marker with the number '05' is placed vertically against the soil face. The soil is a light brown, sandy texture with some darker, more clotted material visible in the upper part of the profile.

Plate 3: Profile (Pit 5)

A wide-angle photograph of a landscape. In the foreground, there is a grassy area with some bare patches of soil. In the background, a line of trees is visible against a clear sky. The terrain appears to be a gentle slope.

Plate 4: Landscape (Pit 5)

|                                |                                                                  |
|--------------------------------|------------------------------------------------------------------|
| Common Name                    | Yellow Duplex                                                    |
| Australian Soil Classification | Yellow-Brown Chromosol and/or Sodosol                            |
| Representative Pit             | 5                                                                |
| Sampled Pit(s)                 | Profile sites 1, 4, 5, 7, 11, 13 and 16                          |
| Soil-stripping Recommendation  | 0.35 m suitable for stripping and re-use in rehabilitation works |

| Physical Characteristics: Representative Pit <sup>1</sup> |             |                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Horizon                                                   | Depth (m)   | Description                                                                                                                                                                                                                                                                                                        |
| A1                                                        | 0.00 – 0.05 | Dark brown (10YR 3/3), weak consistence loam. A moderate pedality (blocky <5 mm peds) soil with moderate acidity (pH 5.6). Moderate dispersion (EAT Class 3(3)), very low salinity (0.05 dS/m), roots many and fine, and nil stones. Approx. sample depth 0.07 m. Boundary is clear and even to the next horizon   |
| A2                                                        | 0.05 – 0.35 | Dark yellowish-brown (10YR 4/6) strong consistence loam. A weak pedality (blocky 20 mm) soil with moderate acidity (pH 5.8). Moderate dispersion (EAT Class 3(3)), very low salinity (0.01 dS/m), roots many and fine, and nil stones. Approx. sample depth 0.20 m. Boundary is clear and even to the next horizon |



|                                            |            |                                                                                                                                                                                                                                                                              |                   |                                 |                   |                                 |                       |
|--------------------------------------------|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------|-------------------|---------------------------------|-----------------------|
| B2                                         | 0.35 – 1.2 | Dark yellowish-brown (10YR 4/6) strong consistence medium-heavy clay. A massive soil that is strongly alkaline (pH 8.8). Negligible/aggregated dispersion (EAT Class 4), low salinity (0.17 dS/m), roots and stones nil. Red-grey mottles (10%). Approx. sample depth 0.60 m |                   |                                 |                   |                                 |                       |
| Analytical Description: Representative Pit |            |                                                                                                                                                                                                                                                                              |                   |                                 |                   |                                 |                       |
| Analyte                                    | Units      | A1                                                                                                                                                                                                                                                                           |                   | A2                              |                   | B2                              |                       |
| Depth                                      | m          | 0 – 05                                                                                                                                                                                                                                                                       |                   | 0 – 0.35                        |                   | 0.35 – 1.2                      |                       |
| Colour <sup>2</sup>                        | munsell    | 10YR 4/6 (Dark brown)                                                                                                                                                                                                                                                        |                   | 10YR 4/6 (Dark yellowish-brown) |                   | 10YR 4/6 (Dark yellowish-brown) |                       |
| pH                                         | pH scale   | 5.6                                                                                                                                                                                                                                                                          | Moderately acidic | 5.8                             | Moderately acidic | 8.8                             | Strongly alkaline     |
| EC                                         | dS/cm      | 0.05                                                                                                                                                                                                                                                                         | Very low          | 0.01                            | Very low          | 1.17                            | Low                   |
| CEC                                        | meq/100g   | 9.7                                                                                                                                                                                                                                                                          | Low               | 6.9                             | Low               | 26.1                            | High                  |
| ESP                                        | %          | 3.1                                                                                                                                                                                                                                                                          | Non-sodic         | 4.3                             | Non-sodic         | 5                               | Non-sodic             |
| EAT                                        | class      | 3(3)                                                                                                                                                                                                                                                                         | Moderate          | 3(3)                            | Moderate          | 4                               | Negligible/aggregated |

1 Interpretations from Hazelton & Murphy (2007) unless otherwise stated.

2 Colour analysed on moist sample unless was a bleached layer.

### Soil Type 3: Grey Skeletal Soil

The Grey Skeletal soil type is characterised by shallow greyish-brown stony-clayey loams associated with the steeper eroded slopes and ridgelines throughout the Project Site. This soil type is poorly structured, strongly to very strongly acidic and non-saline throughout the profile. The topsoil is generally non-sodic with sodicity increasing with depth.

**Table 6: Overview of Soil Type 3**

| Site Description: Soil Type 3                                                       |                                                                                                                                                                    |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                                                                |
| <b>Plate 5: Profile (Pit 15)</b>                                                    | <b>Plate 6: Landscape (Pit 15)</b>                                                                                                                                 |
| <b>Common Name</b>                                                                  | Grey Skeletal                                                                                                                                                      |
| <b>Australian Soil Classification</b>                                               | Grey Tenosol/Rudosol                                                                                                                                               |
| <b>Sampled Pit(s)</b>                                                               | 15                                                                                                                                                                 |
| <b>Soil-stripping Recommendation</b>                                                | Not suitable for stripping and re-use in rehabilitation works due to the limiting factors of prohibitive stone content, moderate to high acidity and high sodicity |



| Physical Characteristics <sup>1</sup> |             |                                                                                                                                                                                                                                                                                                                                              |                                 |                        |                                 |
|---------------------------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------|---------------------------------|
| Horizon                               | Depth (m)   | Description                                                                                                                                                                                                                                                                                                                                  |                                 |                        |                                 |
| A1                                    | 0.00 – 0.15 | Brown (10YR 3/2) weak consistence clay loam. A moderate pedality (blocky <10 mm peds) soil with strong acidity (pH 5.1). Negligible/aggregated to slight dispersion (EAT Class 8/3(1)), low salinity (0.09 dS/m), roots few and medium, and stones 10% (<20 mm). Approx. sample depth 0.15 m. Boundary is clear and even to the next horizon |                                 |                        |                                 |
| B2w                                   | 0.15 – 0.35 | Grey-brown (10YR 5/3) moderate consistence clay loam. A weak pedality (blocky <10 mm) with very strong acidity (pH 4.4). Negligible/aggregated dispersion (EAT Class 6), medium salinity (0.22 dS/m), roots few and medium, and stones 10% (<20 mm). Approx. sample depth 0.20 m                                                             |                                 |                        |                                 |
| BC                                    | 0.35 – 1.2  | 90% stone content; weathering parent material                                                                                                                                                                                                                                                                                                |                                 |                        |                                 |
| Analytical Description                |             |                                                                                                                                                                                                                                                                                                                                              |                                 |                        |                                 |
| Analyte                               | Units       | A1                                                                                                                                                                                                                                                                                                                                           |                                 | B2w                    |                                 |
| Depth                                 | m           | 0.0 – 0.15                                                                                                                                                                                                                                                                                                                                   |                                 | 0.15 – 0.35            |                                 |
| Colour <sup>2</sup>                   | munsell     | 10YR 3/2<br>Brown                                                                                                                                                                                                                                                                                                                            |                                 | 10YR 5/3<br>Grey-Brown |                                 |
| pH                                    | pH scale    | 5.1                                                                                                                                                                                                                                                                                                                                          | Strongly acidic                 | 4.4                    | Very strongly acidic            |
| EC                                    | dS/cm       | 0.09                                                                                                                                                                                                                                                                                                                                         | Low                             | 0.22                   | Medium                          |
| CEC                                   | meq/100g    | 12.4                                                                                                                                                                                                                                                                                                                                         | Moderate                        | 10.5                   | Low                             |
| ESP                                   | %           | 4                                                                                                                                                                                                                                                                                                                                            | Non-sodic                       | 11                     | Strongly sodic                  |
| EAT                                   | class       | 8/3(1)                                                                                                                                                                                                                                                                                                                                       | Negligible/ aggregated – slight | 6                      | Negligible/ aggregated – slight |

1 Interpretations from Hazelton & Murphy (2007) unless otherwise stated.

2 Colour analysed on moist sample unless was a bleached layer.

## Soil Type 4: Friable Soil

This soil type is characterised by friable, self-mulching, reddish-brown, stony-clayey loams and light clays associated with basaltic parent material scattered throughout the Project Site. These well-structured soils are slightly acidic in the upper layers and alkaline at depth. The soils are non-saline with good fertility and are non-sodic.

**Table 7: Overview of Soil Type 4**

| Site Description: Soil Type 4                                                        |         |
|--------------------------------------------------------------------------------------|---------|
|  |         |
| <b>Plate 7: Pit</b>                                                                  |         |
| <b>Common Name</b>                                                                   | Friable |

|                                               |                  |                                                                                                                                                                                                                                                                      |
|-----------------------------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Australian Soil Classification</b>         |                  | Red-Brown Dermosol                                                                                                                                                                                                                                                   |
| <b>Sampled Pit(s)</b>                         |                  | None; minor soil type in the Project Site.                                                                                                                                                                                                                           |
| <b>Soil-stripping Recommendation</b>          |                  | 0.55 m suitable for stripping and re-use in rehabilitation works                                                                                                                                                                                                     |
| <b>Physical Characteristics<sup>1,2</sup></b> |                  |                                                                                                                                                                                                                                                                      |
| <b>Horizon</b>                                | <b>Depth (m)</b> | <b>Description</b>                                                                                                                                                                                                                                                   |
| <b>A1</b>                                     | 0.00 – 0.25      | Dull reddish-brown (5YR 4/4) light clay. A moderate pedality soil with smooth faced peds, (angular blocky <10 mm) and moderate acidity (pH 6.5). Low dispersion, non-saline, many roots and stones 20% (2-6 mm). Boundary is clear and irregular to the next horizon |
| <b>B1</b>                                     | 0.25 – 0.55      | Dark reddish-brown (5YR 3/3) light clay. Moderate pedality (angular blocky peds 10-20 mm) with slight acidity (pH 6.5). Very low to low dispersion, non-saline, roots common and stones 20% (2-20 mm). Boundary is gradual and irregular to the next horizon         |
| <b>B21</b>                                    | 0.55 – 0.80      | Reddish-brown (5YR 4/8) medium clay. A strong lenticular structure soil that is slightly acidic (pH 6.5). Few roots and stones presence of 20-50% (2-50 mm). Clear and even to the next horizon                                                                      |
| <b>B22</b>                                    | 0.80 – 1.1       | Yellowish-red (10YR 5/8) medium clay. A strong lenticular structure soil that is moderately alkaline (pH 9). Few roots and no stones                                                                                                                                 |

<sup>1</sup> Sampling not undertaken as not a major soil type in the Project Site; chemical information sourced from Murphy & Lawrie (1998)

## Soil Type 5: Alluvial Soil

The Alluvial soil type is characterised by a variety of alluvial deposits with sands and loams associated with the lower younger terraces throughout the Project Site and along the Cudgegong River. These alluvial soils range from moderately acidic in the upper layers to slightly alkaline at depth and non-saline throughout the profile. The topsoil is generally non-sodic but can have sodic subsoil.

**Table 8: Overview of Soil Type 5**

| <b>Site Description: Soil Type 5</b>                                                 |                                                                                                                                  |
|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
|  |                                                                                                                                  |
| <b>Plate 8: Landscape</b>                                                            |                                                                                                                                  |
| <b>Common Name</b>                                                                   | Alluvial                                                                                                                         |
| <b>Major Australian Soil Classification</b>                                          | Rudosol/Tenosol                                                                                                                  |
| <b>Sampled Pit(s)</b>                                                                | None; minor soil type in Project Site                                                                                            |
| <b>Soil-stripping Recommendation</b>                                                 | 0.4 m; marginally suitable for stripping and re-use in the rehabilitation works; requires gypsum to improve structural integrity |

| Physical Characteristics <sup>1</sup> |             |                                                                                                                               |
|---------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------|
| Horizon                               | Depth (m)   | Description                                                                                                                   |
| A11                                   | 0.00 – 0.10 | Brownish-black loam, fine sandy with 2-10% stones; weakly structured; neutral pH (pH 7.5). Gradual change to the next horizon |
| A12                                   | 0.10 – 0.40 | Brownish-black loam, fine sandy with 2-10% stones; weakly structured; neutral pH (pH 7.5). Gradual change to the next horizon |
| A13                                   | 0.4 – 1.0   | Dark brown fine sandy loam, massive, neutral pH, dark mottles                                                                 |

<sup>1</sup> Physical information sourced from Murphy & Lawrie (1998)

## Conclusion

In summary, the Project Site and the disturbance footprint are covered by two dominant soil types, Red-Brown Duplex and Yellow Duplex. The Red-Brown Duplex and Yellow Duplex soil types generally consist of brown loams and sandy loams overlying medium-heavy clay subsoil. These soils range from moderately acidic in the upper layers to moderately alkaline at depth, are non-saline and can have sodic subsoil.

The Grey Shallow soil type comprises a minor proportion (7%) of both the Project Site and disturbance footprint and is associated with the steeper eroded slopes and ridgelines. The alluvial and friable soil types comprise a very minor proportion of the Project Site with <3% coverage each.

Please have no hesitation in contacting the undersigned should you have any queries.

Yours Faithfully  
**GSS Environmental**

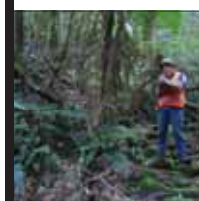


**Adele Calandra**  
*Senior Environmental Scientist*

## REFERENCES

- Hazelton P.A and Murphy B.W. (2007) *Interpreting Soil Test Results* (CSIRO Publication, Australia).
- Murphy B.W., Lawrie, J.M. (1998) *Soil Landscapes of the Dubbo 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.
- National Committee on Soil and Terrain (NCST) (2009) *Australian Soil and Land Survey Field Handbook: third edition* (CSIRO Publishing, Australia).

## Soil Test Results



**ATTACHMENT 1**

**Soil Conservation Service****SOIL TEST REPORT**

Page 1 of 4

**Scone Research Centre**

---

REPORT NO: SCO09/310R1

REPORT TO: Clayton Richards  
GSS Environmental  
PO Box 907  
Hamilton NSW 2303

REPORT ON: Thirty one soil samples  
Cobbara  
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

---



SR Young  
(Laboratory Manager)

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

Page 2 of 4

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<br>cation (me/100g) |     |     | Colour   |          |
|--------|-------------|----------------------------------|------|--------|--------|--------|--------|--------------|-------|------------------------------------|-----|-----|----------|----------|
|        | Sample Id   | clay                             | silt | f sand | c sand | gravel | EAT    | EC<br>(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  |

*SR Young*



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

Page 3 of 4

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<br>cation (me/100g) |     | ESP | Colour   |          |
|--------|--------------|----------------------------------|------|--------|--------|--------|--------|--------------|-------|------------------------------------|-----|-----|----------|----------|
|        | Sample Id    | clay                             | silt | f sand | c sand | gravel | EAT    | EC<br>(dS/m) | pH    | CEC                                | Na  |     | 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  |

*SR Young*

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

Page 4 of 4

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<br>cation (me/100g) |     |     | Colour   |          |
|--------|--------------|----------------------------------|------|--------|--------|--------|--------|--------------|-------|------------------------------------|-----|-----|----------|----------|
|        | Sample Id    | clay                             | silt | f sand | c sand | gravel | EAT    | EC<br>(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

