

## 10.2 Soils and Land Capability

GSSE was engaged by Centennial Mandalong to undertake a soil and land capability assessment for the Mandalong Southern Extension Project. The Study Area adopted by GSSE for this assessment comprised the Southern Extension Area and an additional area external to the Southern Extension Area covering the 26.5 degree of draw from the edge of proposed mine plan, totalling approximately 4,613 hectares. The remainder of the Project Application Area (to the north of the Study Area) was not assessed given that it comprises existing approved workings and infrastructure and there are no additional activities or disturbance proposed.

A field survey at a mapping scale of 1:100,000 was undertaken by GSSE in 2012 and soil samples were analysed for various physical and chemical attributes. The field survey results, along with aerial photography, topographic mapping and other reference materials, was utilised by GSSE in providing the following:

- A description of the soil classification (see **Section 2.8**) in accordance with the *Australian Soil Classification System (ASC)* and appropriate NSW technical guidelines;
- A description of the pre- and post-disturbance land and soil capability classes and agricultural suitability classes in accordance with the appropriate NSW technical guidelines;
- An assessment to determine the presence of biophysical strategic agricultural land (BSAL); and
- Recommendations on disturbance management, including soil stripping depths, topsoil handling and topsoil re-spreading.

A copy of the *Soil and Land Capability Assessment* (GSSE 2013a), which has been prepared to address the DGRs (see **Section 1.7.2**), is contained within **Appendix N**, with significant findings and recommendations summarised in the below sub-sections.

### 10.2.1 Land and Soil Capability Assessment

The land and soil capability classification system adopted by GSSE (2013a) is in accordance with *The Land and Soil Capability Assessment Scheme: Second Approximation* (OEH 2012). This scheme uses the biophysical features of the land and soil to derive detailed rating tables for a range of land and soil hazards. GSSE (2013a) advises that the scheme consists of eight classes (Classes 1 to 8), which classify the land based on the severity of long-term limitations in consideration of:

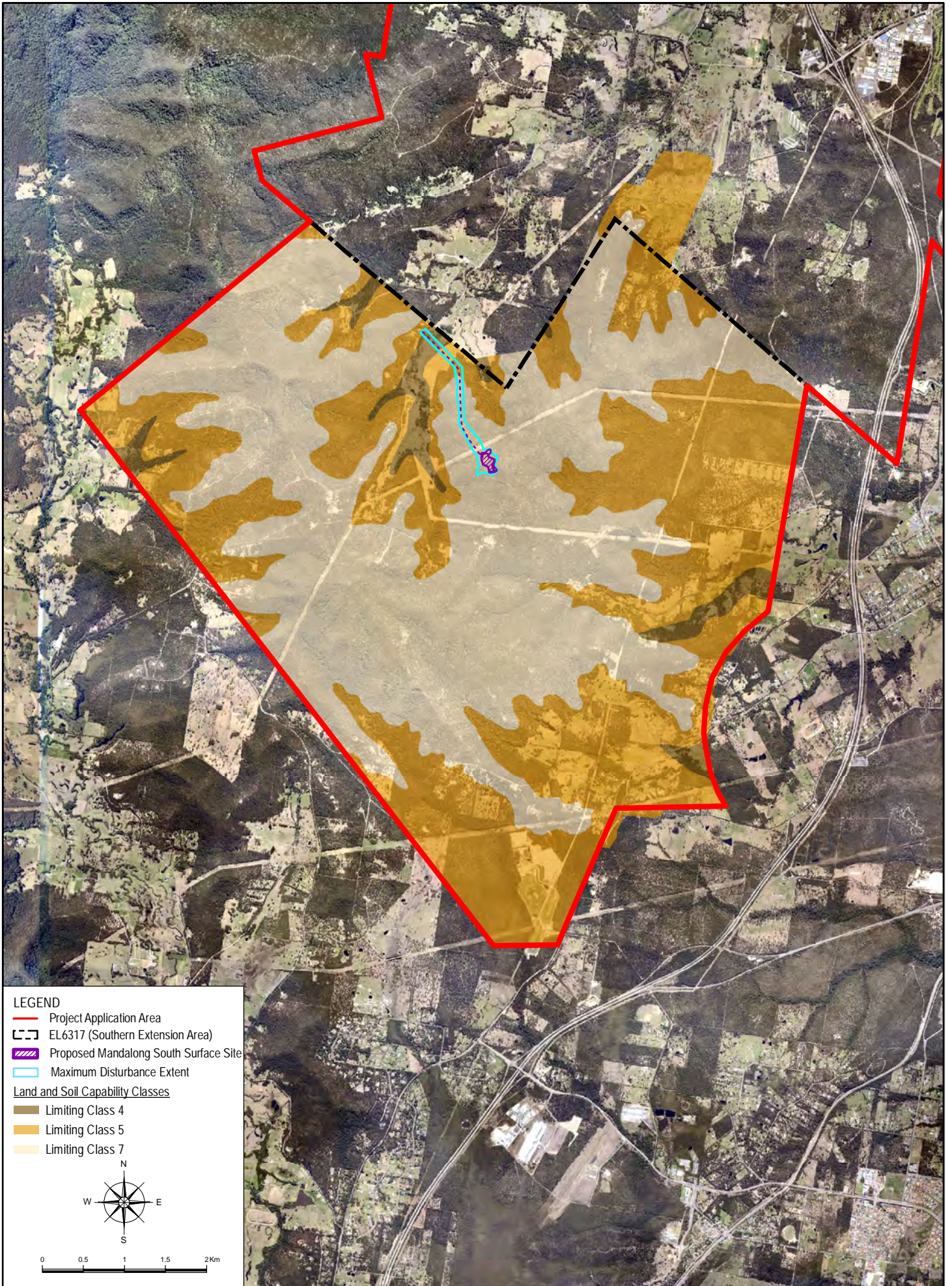
- The biophysical features of the land to derive the land and soil capability classes associated with various hazards; and
- The management of the hazards, including the level of inputs, expertise and investment required to manage the land sustainably.

The land and soil capability classes are described by GSSE (2013a) as listed in **Table 19**.

**Table 19 – Land and Soil Capability Classes**

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

The land and soil capability classes within the Study Area, as determined by GSSE (2013a), are illustrated on **Figure 33** and summarised in **Table 20**. As evident, the pre-disturbance classes range from Class 4 (moderately capable land) to Class 7 (very low capability land), with approximately 90 percent of the Study Area classified as low to very low capability land.

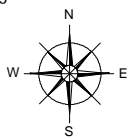


**LEGEND**

- Project Application Area
- EL6317 (Southern Extension Area)
- Proposed Mandalong South Surface Site
- Maximum Disturbance Extent

Land and Soil Capability Classes

- Limiting Class 4
- Limiting Class 5
- Limiting Class 7



0 0.5 1 1.5 2Km

**Table 20 – Land and Soil Capability Areas**

Land and Soil Capability Class	Study Area		Description
	Hectares	Percent (%)	
4	157	3.4	Consist of soil types 6 (Mesotrophic, Brown Kurosol) and 7 (Yellow Sodosol) (see <b>Section 2.8</b> ).  This classification indicates that the land is moderately capable for a range of land uses, and specialised practices are necessary to overcome very severe limitations. The primary constraint to this land class is soil acidity.
5	2,112	45.8	Consists of soils types 1 (Natric, Brown Kurosol), 2 (Magnesic – Natric, Brown Kurosol) and 5 (Mesonatric, Brown Sodosol) (see <b>Section 2.8</b> ).  This classification indicates a moderate to low land capability, with severe limitations to high impact land management uses such as cropping. This land is generally more suitable for grazing with some limitations, or very occasional cultivation for pasture establishment. The primary constraints to this land class are steep slopes (water erosion hazard) and soil structure decline.
7	2,344	50.8	Consists of soil types 3 (Magnesic – Natric, Brown Kurosol) and 4 (Eutrophic, Brown Chromosol) (see <b>Section 2.8</b> ).  This classification indicates very low capability land, with extremely severe limitations for most land uses. It is generally unsuitable for any type of cropping or grazing due to its limitations. The primary constraints of this land class are steep slopes (water erosion hazard) and localised mass movement.
Total	4,613	100	

GSSE (2013a) anticipates the post-disturbance land and soil capability classes to be the same as the pre-disturbance classes listed in **Table 20**. Due to the nature of the Project, the only surface impacts likely to impact on the classification of land resources are identified by GSSE (2013a) to be land clearing, surface water ponding and increases in overbank flood events as a result of subsidence. Surface water ponding can have prohibitive effects on the agricultural ability of the land and increased flooding can result in waterlogging of soils.

In accordance with the subsidence assessment (DGS 2013) and surface water assessment (Umwelt 2013) (see **Sections 9.0** and **10.5**, respectively), there are negligible changes to remnant ponding predicted, with a total increase in area of approximately 3.6 hectares (i.e. an increase of less than 2 percent). The small areas of increased remnant ponding are largely confined to the existing flow paths/watercourses. The flooding analysis indicated that the predicted subsidence had no significant impact on the duration of flooding at the boundary of the Southern Extension Area, with minor flood events remaining in channel and no discernible increase to the time out of bank for larger flood events (Umwelt 2013). This indicates that the potential for flooding impacts on the agricultural value of the surrounding properties are negligible.

GSSE (2013a) concludes that the Project will have no impact on the pre-disturbance land and soil capability classes if appropriate disturbance management strategies are implemented (see **Section 10.2.4**).

## 10.2.2 Agricultural Suitability Assessment

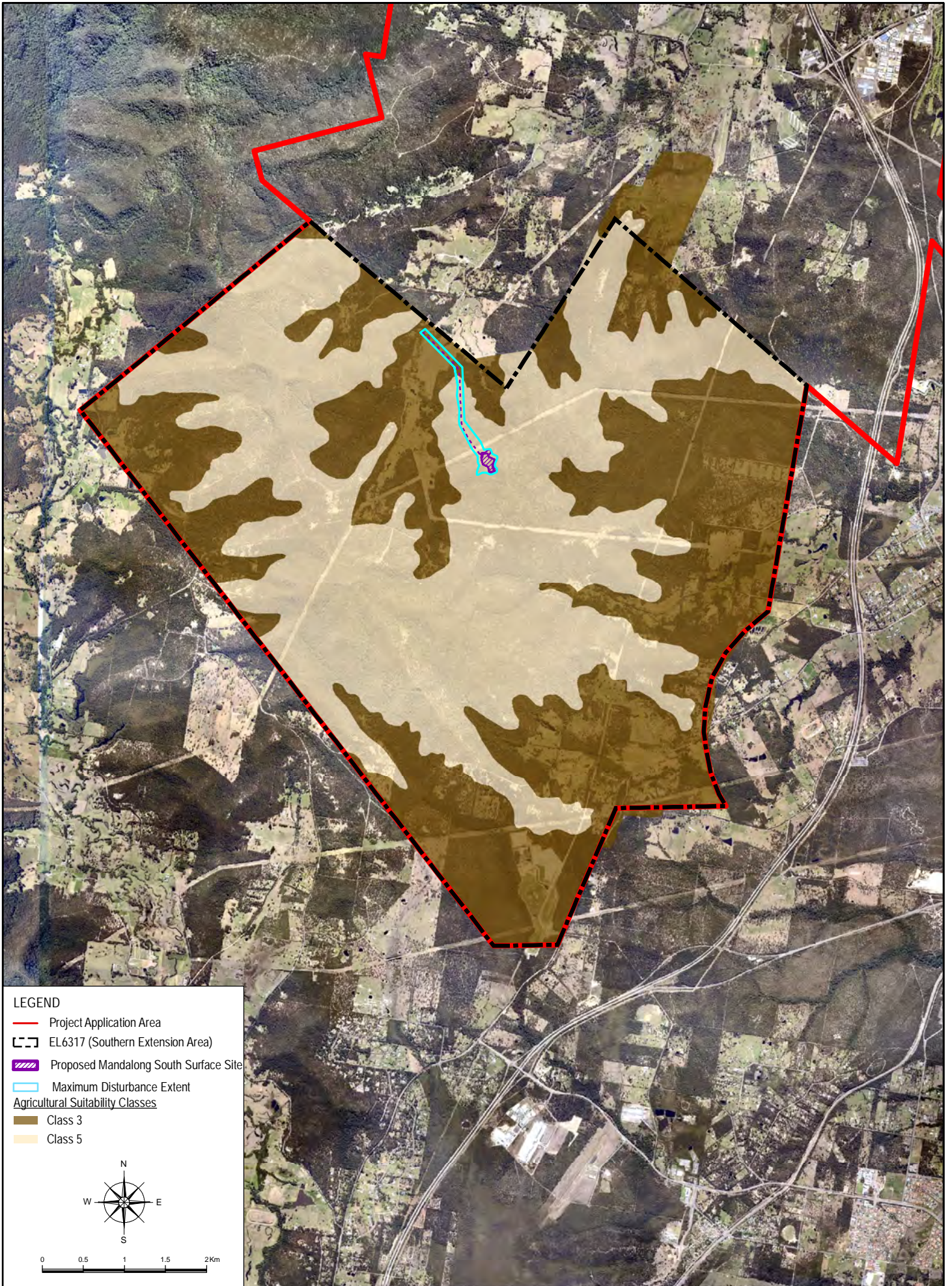
The agricultural suitability system adopted by GSSE (2013a) is in accordance with the *Agricultural Suitability Maps – uses and limitations* (NSW Agricultural and Fisheries 1990). The system consists of five classes (Classes 1 to 5), which provide a ranking of rural lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. A description of each agricultural suitability class, as provided by GSSE (2013a), is listed in **Table 21**.

**Table 21 – Agricultural Suitability Classes**

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

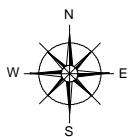
The main soil properties and landform characteristics considered significant for the agricultural suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope, as well as bio-physical factors such as elevation, rainfall and temperature (GSSE 2013a). The overall suitability classification for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations.

The agricultural suitability classes within the Study Area, as determined by GSSE (2013a), are illustrated on **Figure 34** and summarised in **Table 22**. As evident, the pre-disturbance agricultural suitability comprises Class 3 (land suitable for occasional but not continual cultivation) and Class 5 (land best managed by the present of light green timber due to its high erodible soils and steep slopes).



**LEGEND**

- Project Application Area
  - EL6317 (Southern Extension Area)
  - Proposed Mandalong South Surface Site
  - Maximum Disturbance Extent
- Agricultural Suitability Classes
- Class 3
  - Class 5



0 0.5 1 1.5 2Km

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**Table 22 – Agricultural Suitability Class Areas**

Agricultural Suitability Class	Study Area		Description
	Hectares	Percent (%)	
3	2,269	49.2	Consists of soils types 1 (Natric, Brown Kurosol), 2 (Magnesic – Natric, Brown Kurosol), 5 (Mesonatric, Brown Sodosol), 6 (Mesotrophic, Brown Kurosol) and 7 (Yellow Sodosol) (see <b>Section 10.2.1</b> ).  Agricultural activity must be based on improved pastures established using minimum tillage techniques or cropping within a pasture rotation. The production level is low as a result of constraints such as high erodibility associated with slope and the chemical limitation of strong acidity on vegetation growth.
5	2,344	50.8	Consists of soil types 3 (Magnesic – Natric, Brown Kurosol) and 4 (Eutrophic, Brown Chromosol) (see <b>Section 10.2.1</b> ).  This class of land is best managed by the presence of light green timber due to its highly erodible soils and steep slopes. Partial clearing for grazing can occur, however, significant stands of trees are required to maintain soil cover. This soil type is severely constrained by its terrain, physical and chemical characteristics.
Total	4,613	100	

In accordance with the findings for the post-disturbance soil and land capability classes, GSSE (2013a) anticipates the post-disturbance agricultural suitability classes to be the same as the pre-disturbance classes listed in **Table 22**. This is once again due to the negligible changes to remnant ponding and flooding regime predicted within the Southern Extension Area (see **Section 10.5**).

GSSE (2013a) concludes that the Project will have no impact on the pre-disturbance agricultural suitability classes if appropriate disturbance management strategies are implemented (see **Section 10.2.4**).

### 10.2.3 Biophysical Strategic Agricultural Land

The NSW Government recently released the *Strategic Regional Land Use Policy* to assist the development of a long-term strategy for continued progress of the mining industry that also ensures local community sustainability and on-going viability of existing industries. Part of this Policy is the development of Strategic Regional Land Use Plans (SRLUPs), which includes the determination of BSAL. BSAL is defined as areas with unique natural resource characteristics highly suited for agriculture (GSSE 2013a).

An SRLUP covering the Southern Extension Area has not yet been released and, therefore, there is no BSAL reference mapping available. Notwithstanding, Centennial Mandalong adopted a precautionary approach and carried out an assessment of the Study Area against BSAL criteria in accordance with the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH 2012) and *Strategic Regional Land Use Plan for the Upper Hunter* (DP&I 2012). Although there is significant overlap between the two documents, they contain differing BSAL assessment criteria and, therefore, an assessment has been undertaken by GSSE (2013a) using both references.

As summarised below, based on the findings of both assessment procedures, GSSE (2013a) concluded that there is no BSAL present within the Study Area.

### Strategic Regional Land Use Plan for the Upper Hunter

The *Strategic Regional Land Use Plan for the Upper Hunter* (DP&I 2012) contains criteria primarily relating to reliability of suitable water supply, land and soil capability classes and fertility. While the Study Area met the minimum rainfall requirement, the land and soil capability classifications and the fertility class for each soil type indicate that the soil resources within the Study Area do not qualify as BSAL under the provisions of the *Strategic Regional Land Use Plan for the Upper Hunter* (DP&I 2012). The soil fertility and the outcomes of this BSAL assessment undertaken by GSSE (2013a) are shown in **Table 23**.

**Table 23 – Applied BSAL Criteria: SRLUP for the Upper Hunter**

Soil Type		Great Soil Group	Land and Soil Capability Class	Fertility <sup>1</sup>	BSAL	BSAL Limitation
1	Natric, Brown Kurosol	Soloth	5	Moderately low	No	Land and soil capability class and fertility
2	Magnesian – Natric, Brown Kurosol	Soloth	5	Moderately low	No	Land and soil capability class and fertility
3	Magnesian – Natric, Brown Kurosol	Soloth	7	Moderately low	No	Land and soil capability class and fertility
4	Eutrophic, Brown Chromosol	Yellow Podzolic	7	Moderately low	No	Land and soil capability class and fertility
5	Mesonatric, Brown Sodosol	Yellow Solodic	5	Moderately low	No	Land and soil capability class and fertility
6	Mesotrophic, Brown Kurosol	Soloth	4	Moderately low	No	Land and soil capability class and fertility
7	Yellow Sodosol	Yellow Solodic	4	Moderately low	No	Land and soil capability class and fertility

1- Correlated based on Great Soil Group

### Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land

As listed in **Table 24**, the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH 2012) uses a 12 step site verification process to determine the potential presence of BSAL. If the site fails to meet any one of the verification criteria, it is rejected as BSAL and it is not necessary to consider the remaining steps/criteria.

**Table 24 – Twelve Step Site Verification Criteria - Interim Protocol**

Step No.	Criteria	BSAL Definition
1	Reliable water supply	Greater than 350 mm annual rainfall (9 out of 10 years), or underlain by groundwater aquifer with yields greater than 5 litres per second (l/s) and total dissolved solids less than 1,500 milligrams per litre (mg/L)
2	Slope	Less than or equal to 12%
3	Rock outcrop	Less than 30%
4	Soil type	Naturally high, moderately high or moderate fertility
5	Surface rockiness	Less than 20% of the area has unattached rock fragments greater than 60 mm diameter
6	Gilgai	Less than 50% of the area has gilgai depression that are deeper than 500 mm
7	Soil depth	Greater than 750 mm
8	Drainage	Soil must not be poorly or very poorly drained

Step No.	Criteria	BSAL Definition
9	pH	Within 5 to 8.9 when measured in water, of within 4.2 to 8.1 when measured in calcium chloride
10	Soil salinity	Electrical conductivity in a saturate extract (ECe) less than or equal to 4 decisiemens per metre (dS/m), or, if gypsum is present, chlorides less than 800 mg/kg
11	Soil water storage	Soil must be able to store more than or equal to 75 mm of water to effective soil depth of 1 metre or less
12	Minimum area	Soil must have a contiguous area or greater or equal to 20 ha

While the minimum rainfall requirement was met, as evident in **Table 25**, all soil types within the Study Area were rejected as BSAL at various steps of the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH 2012).

**Table 25 – Applied BSAL Criteria: Interim Protocol**

Soil Type		Site Verification Step							BSAL
No.	Name	1	2	3	4	5	6	7	
1	Natric, Brown Kurosol	✓	✓	✓	✗	-	-	-	No
2	Magnesian – Natric, Brown Kurosol	✓	✓	✓	✗	-	-	-	No
3	Magnesian – Natric, Brown Kurosol	✓	✗	-	-	-	-	-	No
4	Eutrophic, Brown Chromosol	✓	✗	-	-	-	-	-	No
5	Mesonatric, Brown Sodosol	✓	✓	✓	✗	-	-	-	No
6	Mesotrophic, Brown Kurosol	✓	✓	✓	✓	✓	✓	✗	No
7	Yellow Sodosol	✓	✓	✓	✗	-	-	-	No

#### 10.2.4 Mitigation and Management

Centennial Mandalong will continue to employ the mitigation measures and management strategies currently adopted at the Mandalong Mine, as relevant to the Project, in order to minimise impact to land resources. The following additional key commitments are also made:

##### Land Management Plan

As a substantial landholder in the Mandalong Valley, Centennial Mandalong will develop a Land Management Plan for land owned by Centennial in the Valley. This plan will include the continuation of the following land management activities:

- Management of weeds and feral animals;
- Establishment and maintenance of suitable fencing for the exclusion of stock from riparian areas;
- Bushfire management;
- A rehabilitation program for riparian areas where an assessment has determined that rehabilitation activities will improve water quality in the creek systems;
- Provision of a nominal funding value towards research over the life of the Project into the habitat values of species likely to be impacted by the Project; and
- Provision of a nominal dollar amount for future maintenance of the land. This is to provide incentive to any future purchaser of the land to continue the land management activities.

Centennial Mandalong will report on the progress of works associated with the Land Management Plan annually in the Annual Review.

### Topsoil Stripping

The soils within the Southern Extension Area are largely consistent texture contrast soils with high acidity and often sodic characteristics in the subsoil (GSSE 2013a). As recommended by GSSE (2013a), these soils will be stripped prior to significant surface disturbance, specifically construction of the Mandalong South Surface Site and access road, and then later re-spread in focused rehabilitation efforts.

The topsoils are generally suitable to facilitate germination and appropriate management of this soil through amelioration (such as treatment with gypsum or lime) will provide an acceptable and stable medium for revegetation (GSSE 2013a). Whilst topsoil structure is generally poor, the material may be stripped and reused in rehabilitation provided appropriate erosion and sediment controls are in place.

As recommended by GSSE (2013a), the topsoil will be stripped to the depths listed in **Table 26**.

**Table 26 – Soil Stripping Depths**

Soil Type		Soil Stripping Depth (cm)
No.	Name	
1	Natric, Brown Kurosol	0 to 50
2	Magnesian – Natric, Brown Kurosol	0 to 35
3	Magnesian – Natric, Brown Kurosol	0 to 15
4	Eutrophic, Brown Chromosol	0 to 20
5	Mesonatric, Brown Sodosol	0 to 30
6	Mesotrophic, Brown Kurosol	0 to 15
7	Yellow Sodosol	0 to 15

### Topdressing Management

Where soil stripping and transportation is required, the following handling techniques, as recommended by GSSE (2013a), will be adopted to prevent excessive soil deterioration:

- Topsoil will be maintained in a slightly moist condition during stripping, and material will not be stripped in either an excessively dry or wet condition.
- Stripping will be timed to take place in unison with any vegetation clearing activity. If planning to mix groundcover/grass with the soil (i.e. not removing groundcover prior to soil stripping), a weed assessment will be undertaken prior to stripping.
- Where possible, grading or pushing soil into windrows with graders or dozers for later collection will be undertaken as a preferential less aggressive soil handling systems.
- The surface of soil stockpiles will be left coarsely structured (as much as possible) in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- Topsoil stockpiles will generally be maintained no higher than 3 metres.
- If long-term stockpiling is planned (i.e. greater than three months), the stockpiles will be seeded and fertilised as soon as possible. An annual cover crop species that produces sterile florets or seeds will be sown. A rapid growing and healthy annual pasture sward will provide sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas, however will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.

- Prior to re-spreading stockpiled topsoil, an assessment of weed infestation on 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 keep track of topsoil materials available for planned rehabilitation activities.

### **Soil Re-Spreading and Seedbed Preparation**

Soil will be re-spread directly onto stripped areas where practical. As recommended by GSSE (2013a), topsoil will be spread, treated with fertiliser and seeded in one consecutive operation, where possible, to reduce the potential for topsoil loss to wind and water erosion. Soil will be re-spread to the approximate depth from which it was stripped.

Thorough seedbed preparation will be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas will be lightly contour ripped (after topsoil spreading) and, where possible, will be ripped when the soil is moist and immediately prior to sowing. If required, the re-spread topsoil surface will be scarified prior to, or during seeding, to reduce run-off and increase infiltration.