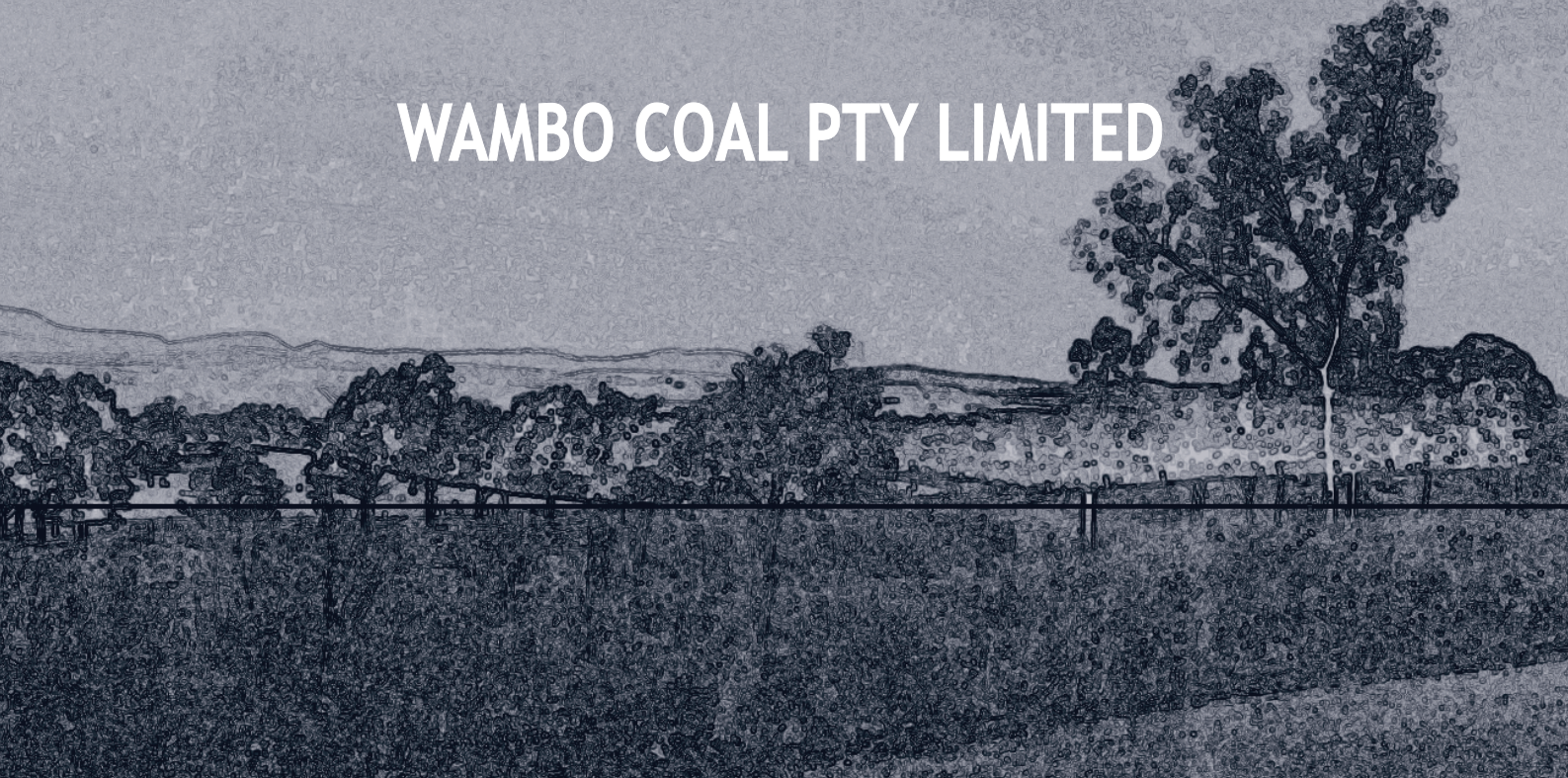




WAMBO COAL PTY LIMITED

SOUTH WAMBO
UNDERGROUND MINE MODIFICATION
ENVIRONMENTAL ASSESSMENT

APPENDIX G
Agricultural Impact Statement



WAMBO COAL PTY LIMITED

SOUTH WAMBO UNDERGROUND MINE MODIFICATION

AGRICULTURAL IMPACT STATEMENT

(Modification 12 to DA 305-7-2003)

PROJECT NO. WAM-09-15

DOCUMENT NO. 00709568

DATE: MARCH 2016

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1 INTRODUCTION

Wambo Coal Mine (Wambo) is situated approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW) (Figure 1). Wambo adjoins grazing land to the south, other coal mining operations to the east and north, grazing land to the north-west and Wollemi National Park to the west and south-west (Figures 1 and 2).

A range of open cut and underground mine operations have been conducted at Wambo since mining operations commenced in 1969. Mining under the Development Consent (DA 305-7-2003) commenced in 2004 and currently both open cut and underground operations are conducted. The maximum approved run-of-mine (ROM) coal production rate is 14.7 million tonnes per annum (Mtpa) and product coal is transported from Wambo by rail.

Wambo Coal Pty Limited (WCPL) is seeking approval for a modification to Development Consent DA 305-7-2003 under section 75W of the *Environmental Planning and Assessment Act, 1979* (EP&A Act).

The purpose of this Agricultural Impact Statement is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) for the Modification, which were issued by the Department of Planning and Environment (DP&E) on 23 October 2015. Relevant to agriculture, the SEARs state the Environmental Assessment (EA) must include:

- *An Agriculture Impact Statement to assess the potential impacts on soils and land capability of the site and surrounds, paying particular attention to any Biophysical Strategic Agricultural Land (BSAL) and DPI's requirements (see Attachment 2)*
- *an assessment of the likely agricultural impacts of the development;*

Furthermore, in accordance with the SEARs for the Modification, this assessment has regard to the Department of Primary Industries Agriculture's (DPI Agriculture) input into the SEARs outlined in Attachment 2 of the SEARs. Specifically, DPI Agriculture provides that an Agricultural Impact Statement should be prepared that includes:

- *detailed assessment of potential impacts of the project on agricultural resources;*
- *detailed assessment of the potential impacts of the project on the local and regional community, paying particular attention to impacts on viticulture.*

The DPI Agriculture's suggested form of this Agricultural Impact Statement, and where each of these requirements is addressed within this document, are summarised in Attachment 1.

1.1 MODIFICATION OVERVIEW

Mining of the South Wambo (Arrowfield and Bowfield Seams) Underground Mine was assessed as part of the *Wambo Development Project Environmental Impact Statement* (WCPL, 2003) and approved under the Development Consent (DA 305-7-2003).

Following further mine planning for the approved South Wambo Underground Mine, which considered recent exploration results, WCPL has identified a modified mine arrangement which can be mined more economically and efficiently than the approved mine arrangement. This proposed rearrangement of South Wambo Underground Mine is referred to as the South Wambo Underground Mine Modification (the Modification).

The Modification would involve a realignment and extension/relocation of the approved South Wambo Underground Mine longwall panels and mining of the Woodlands Hill Seam rather than the Bowfield Seam. The modified layout of Wambo is shown on Figure 3.

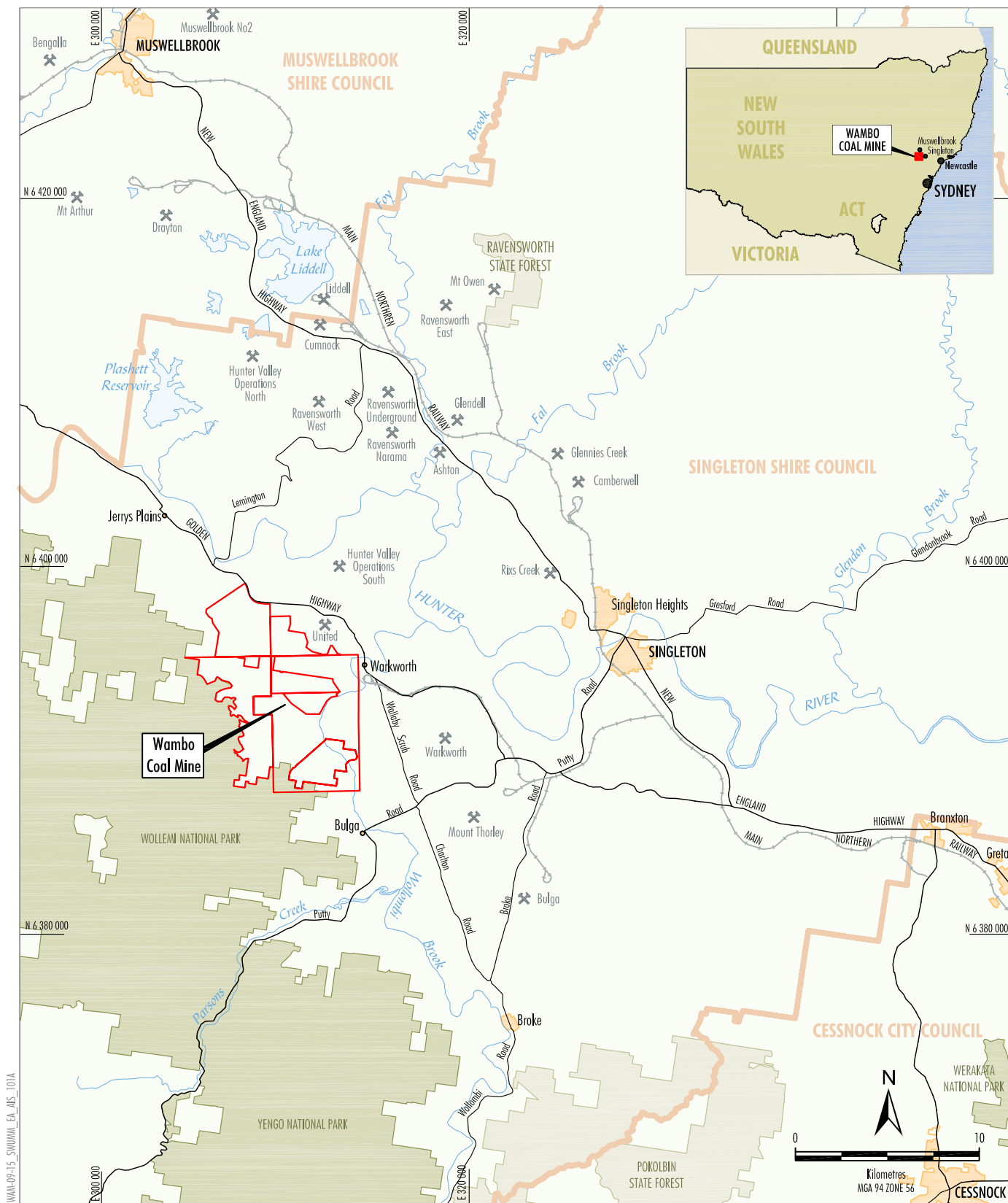
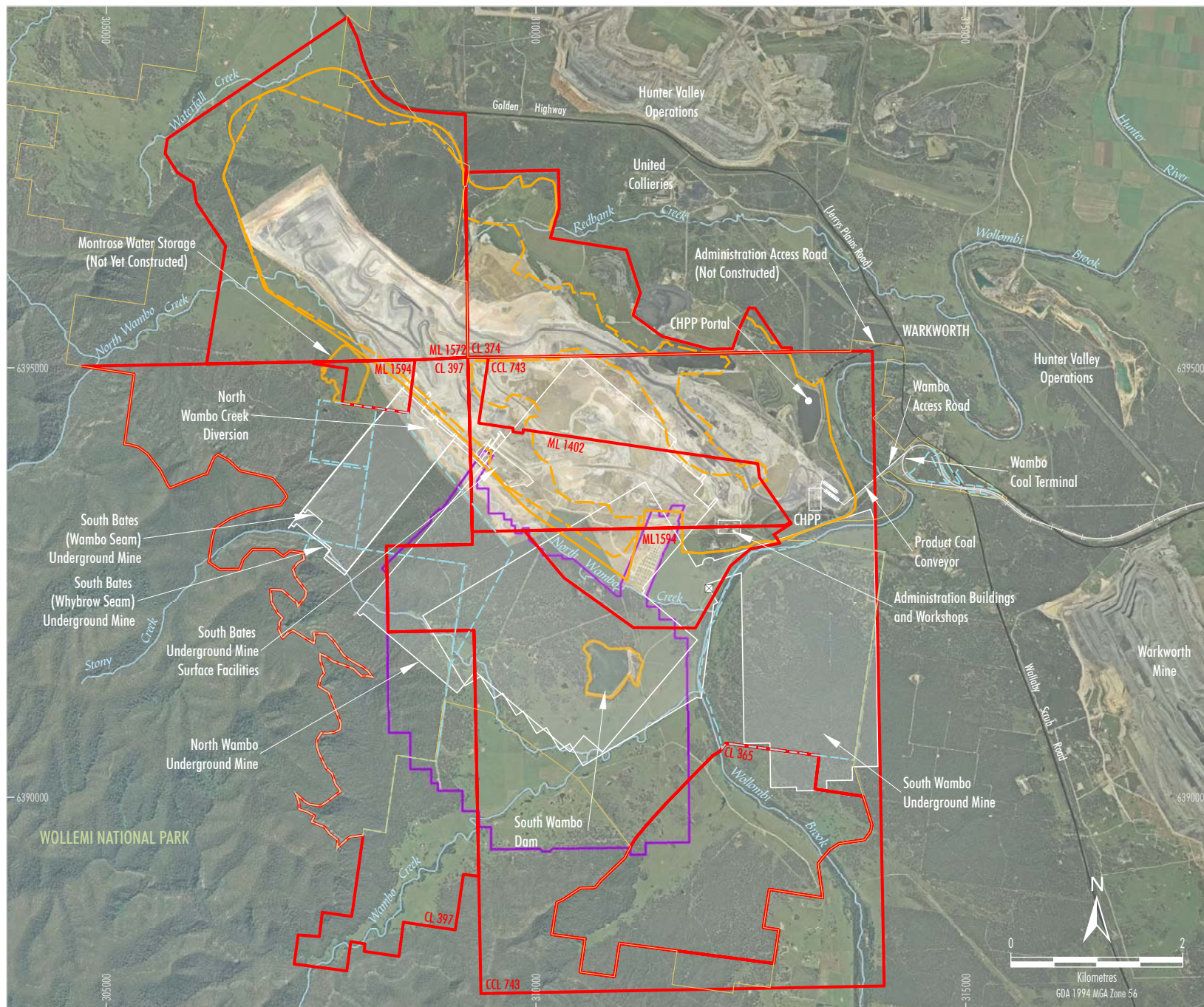
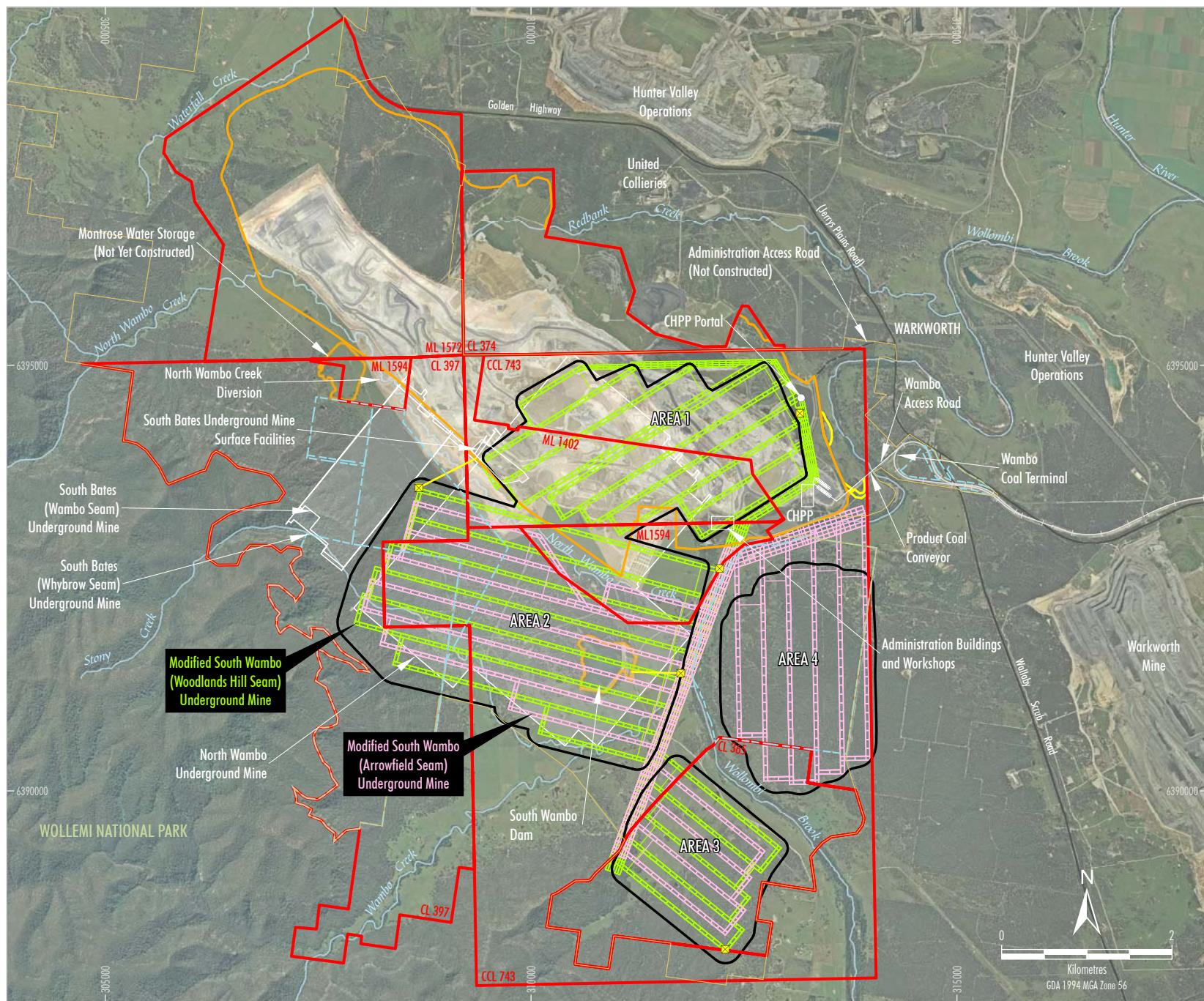


Figure 1



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Figure 2



LEGEND

- Mining and Coal Lease Boundary
- WCPL Owned Land
- Existing/Approved Surface Development Area
- Modified Surface Development Area
- Approved Underground Development
- Modified South Wambo (Woodlands Hill Seam) Underground Mine
- Modified South Wambo (Arrowfield Seam) Underground Mine
- Modified Ventilation Shaft
- Remnant Woodland Enhancement Program (RWEP) Area
- Predicted Extent of Modification Conventional Subsidence

Source: Department of Lands (July 2009); WCPL (2015); WCPL Orthophoto (Apr-Oct 2013)

Peabody
 WAMBO COAL MINE
 Modified Wambo Coal Mine
 General Arrangement

Figure 3

Longwall mining areas associated with the Modification are detailed below (Figure 3):

- **Area 1 (Woodlands Hill Seam)** – The modified mine layout includes additional longwall panels in the Woodlands Hill Seam beneath the approved Surface Development Area.
- **Area 2 (Arrowfield Seam and Woodlands Hill Seam)** – The modified mine layout includes a reorientation and minor extension of the approved Arrowfield Seam mine layout in Area 2. The Woodlands Hill Seam is proposed to replace the Bowfield Seam in this location with a reorientation and minor extension to the approved mine layout.
- **Area 3 (Arrowfield Seam and Woodlands Hill Seam)** – The modified mine layout includes an extension of mining in the Arrowfield Seam and Woodlands Hill Seam into Area 3, comprising three longwall panels in the Arrowfield Seam and four longwall panels in the Woodlands Hill Seam.
- **Area 4 (Approved Arrowfield Seam)** – The Modification does not propose any changes to the approved Arrowfield Seam mine layout to the east of Wollombi Brook. The approved Bowfield Seam mine layout is no longer proposed to be mined in Area 4 and therefore there would be a reduction in subsidence impacts in Area 4.

The rearrangement of the South Wambo Underground Mine would require a minor extension of the approved surface development area (Figure 3) and result in an extension of the approved mine life by 7 years (i.e. to 2032).

The underground mine ROM coal production rate would increase from 7.5 to 9.75 Mtpa. The approved total ROM coal production rate (i.e. 14.7 Mtpa) would remain unchanged.

The Modification would not involve changes to any aspects of the approved North Wambo Underground Mine or South Bates Underground Mine.

The Modification would also include an extension of approved open cut mining operations by 3 years (i.e. up to and including 2020). The Modification would not include any change to the approved total open cut ROM coal production limit.

Additional details of the Modification are provided in Section 3 of the EA.

The “Modification Area” comprises the extent of conventional subsidence resulting from the modified longwall layout and the modified surface development areas (Figure 3).

Subsidence effects resulting from longwall mining in the Arrowfield and Bowfield Seams in Area 4 were assessed as part of the *Wambo Development Project Environmental Impact Statement* (WCPL, 2003). The modified subsidence impacts in Area 4 are predicted to reduce as only the Arrowfield Seam is proposed to be mined as part of the Modification (Mine Subsidence Engineering Consultants [MSEC], 2016). The potential impacts on agricultural resources in Area 4 are therefore also expected to reduce as a result of the Modification and this assessment has not considered Area 4 any further.

1.2 CONSULTATION

WCPL has ongoing community consultation mechanisms and undertook extensive consultation in support of the Modification, including consultation with relevant State and local government agencies and the community. These consultation programs, key issues raised and ongoing consultation mechanisms are described in Section 1.3 of the EA.

WCPL provided a briefing package describing the Modification to the Department of Primary Industries (including DPI Agriculture) in March 2016.

1.3 STRUCTURE OF THIS REPORT

This document is structured as follows:

Section 1	Provides an introduction and overview of the Modification.
Section 2	Provides a description of the existing agricultural resources, production and enterprises in the region.
Section 3	Describes the potential impacts of the Modification on agricultural resources and enterprises, including potential impacts on water resources.
Section 4	Summarises the mitigation and management measures to be implemented with respect to Modification impacts on agricultural resources and enterprises.
Section 5	Provides a conclusion and justification for the changes to agricultural resources that would arise due to the Modification.
Section 6	References.
Attachment 1	Provides a reconciliation of the DPI's input to the SEARs in relation to the Agricultural Impact Statement and where it is addressed in this document.
Attachment 2	Provides supporting information in the form of a detailed Agricultural Resource Assessment prepared by Soil Management Designs (Dr David McKenzie) (2016).

The following reports have also been prepared in support of the Modification and should be read in conjunction with this assessment:

- Subsidence Assessment (MSEC, 2016) (Appendix A of the EA);
- Groundwater Assessment (HydroSimulations, 2016) (Appendix B of the EA);
- Surface Water Assessment (Advisian, 2016) (Appendix C of the EA);
- Flora Assessment (FloraSearch, 2016) (Appendix D of the EA);
- Fauna Assessment (Eco Logical, 2016) (Appendix E of the EA)
- Cultural Heritage Impact Assessment (RPS, 2016) (Appendix F of the EA);
- Noise Review (SLR Consulting Australia, 2016) (Appendix H of the EA);
- Air Quality and Greenhouse Gas Review (Todoroski Air Sciences, 2016) (Appendix I of the EA);
- Road Transport Assessment (GTA Consultants, 2016) (Appendix J of the EA);
- Socio-economic Assessment (AnalytEcon, 2016) (Appendix K of the EA); and
- Environmental Risk Assessment (WCPL, 2016) (Appendix L of the EA).

Where relevant, summary content sourced from these documents is provided in this report.

2 EXISTING AGRICULTURAL RESOURCES, PRODUCTION AND ENTERPRISES

2.1 AGRICULTURAL RESOURCES

2.1.1 Climate

Long-term meteorological data for the region is available from Commonwealth Bureau of Meteorology (BoM) meteorological stations.

Temperature

The nearby Jerrys Plains Post Office meteorological station records (BoM, 2015) show that temperatures are warmest from November to February and coolest from June to August.

The Jerrys Plains Post Office meteorological station records show that monthly-average daily maximum temperatures are highest in January (31.8 degrees Celsius [°C]) and the monthly-average daily minimum temperatures are lowest in July (3.8 °C) (BoM, 2015).

Rainfall

The long-term average annual rainfall at the nearby meteorological stations of Jerrys Plains Post Office and Bulga are 644.5 millimetres (mm) and 665.0 mm, respectively (HydroSimulations, 2016).

The months with the highest monthly-average rainfalls at Jerrys Plains Post Office and Bulga are January and February.

The heaviest daily falls were recorded during winter (June) and in late summer (February) (Advisian, 2016).

2.1.2 Land Use

Wambo adjoins grazing land to the south, other coal mining operations to the east and north, grazing land to the north-west and Wollemi National Park to the west and south-west (Attachment 2).

Land use in the vicinity of the Wambo includes a combination of coal mining operations, Remnant Woodland Enhancement Program (RWEP) areas, agricultural land use and WCPL-owned lands that are not subject to mining operations, utilised for the agistment of beef cattle (Attachment 2). The main agricultural land uses in the Wambo region include dairy and beef cattle and pasture production, horse breeding, viticulture and wine making (NSW Government, 2012).

There is no evidence of recent cropping activities or vineyards in the Modification Area.

2.1.3 Landforms

Local topography in the Upper Hunter Valley region is characterised by gently sloping floodplains associated with the Hunter River and the undulating foothills, ridges and escarpments of the Mount Royal Range and Great Dividing Range (Attachment 2).

The main topographic features of the Modification Area are the alluvial flats and terraces associated with Wollombi Brook, Wambo Creek and its tributary Stony Creek, and North Wambo Creek (Attachment 2).

Elevations in the Modification Area range from approximately 60 m (metres) Australian Height Datum (AHD) near Wollombi Brook to approximately 220 m AHD near the base of the Wollemi Escarpment. To the west of Wambo is steeper land with elevations up to approximately 650 m AHD within the Wollemi National Park (Figure 3) (Attachment 2).

2.1.4 Soil Survey

Soil Management Designs (2016) considered soil survey results from 29 soil pits to characterise and assess the soils in the Modification Area as part of the Agricultural Resource Assessment (Attachment 2).

The 29 soil pits which were assessed cover the main variations in vegetation type, topography and land use in the vicinity of Wambo, with a focus on the areas to be potentially impacted by the Modification. The soil profiles were classified according to the Australian Soil Classification system (Isbell, 2002).

The main soil types mapped in the Modification Area comprise Rudosols (38 percent [%]), Sodosols (28%), Kandosols (14%) and Tenosols (10%), while lesser areas of Dermosols, Vertosols and Anthrosols (disturbed lands) were also observed (Figure 4) (Attachment 2).

Soil Landscape Units containing groupings of the above soil types were identified during the soil survey as including (Attachment 2):

- Wollombi Alluvial Soils: dominated by Stratic Rudosols; sub-dominant Dermosols.
- Bulga Soloths: dominated by Sodosols; sub-dominant Kandosols and Vertosols.
- Benjang Solodic Soils: mosaic of Sodosols, Tenosols and Kandosols.
- Branxton Yellow Podzolic Soils: Sodosols.
- Lees Pinch Shallow Soils: Tenosols.

The extent of these Soil Landscape Units and soil types within the Modification Area mapped by Soil Management Designs (2016) are shown on Figure 4.

Details of the soil surveys are provided in Attachment 2.

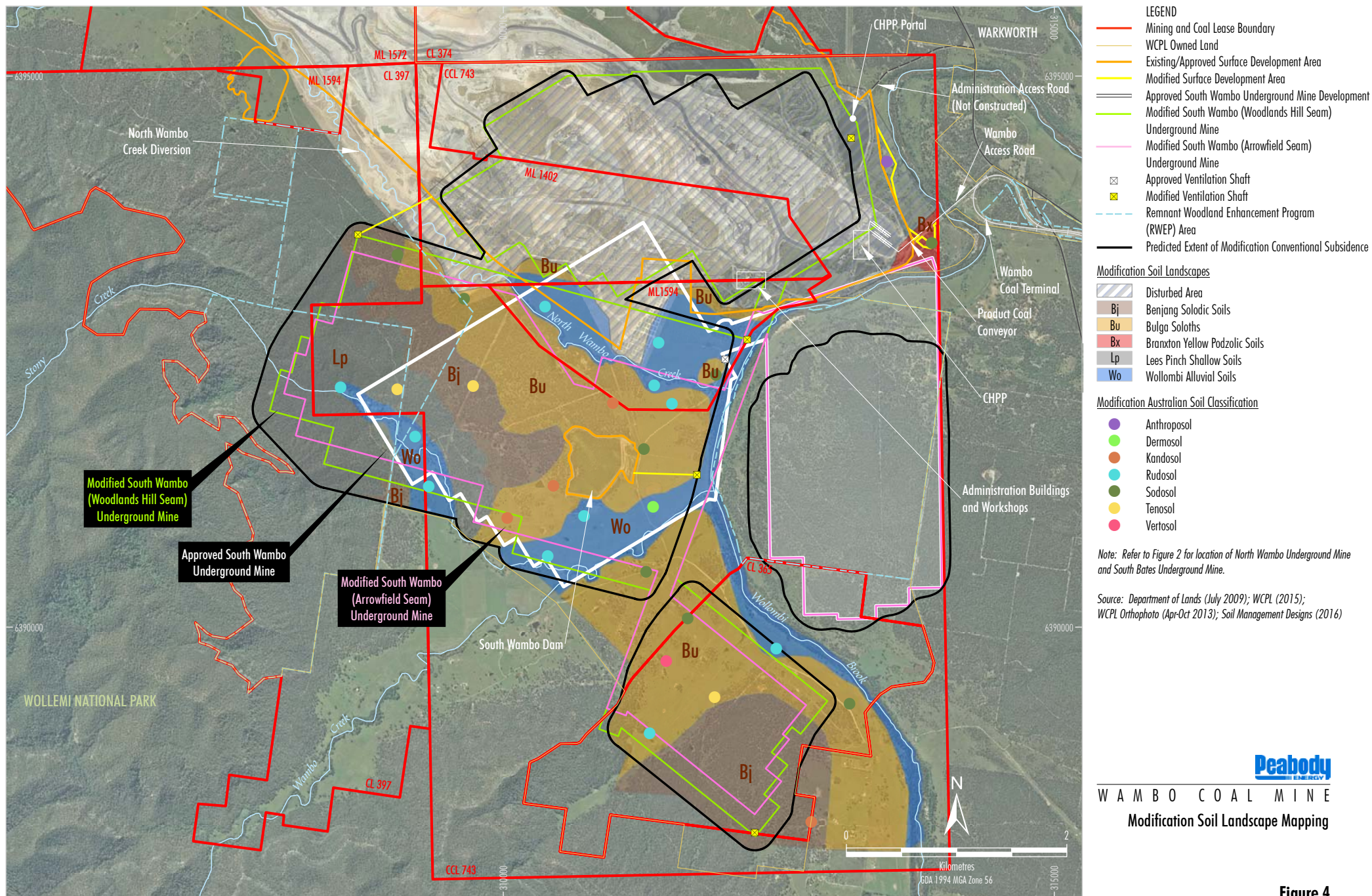


Figure 4

Soil Condition

A broad range of soil physical and chemical constraints for agricultural land use were identified across the non-alluvial sections of the Modification Area including (Attachment 2):

- **Waterlogging in subsoil** which causes several adverse processes to take place (e.g. lack of oxygen, large losses of nitrogen to the atmosphere).
- **Dispersive subsoil** which is much more likely to be lost by water erosion than stable soil.
- **Compaction in subsoil** which can strongly restrict plant growth because of poor water entry, poor efficiency of water storage, waterlogging when moist, and poor access to nutrients by plant roots.
- **Acidity in topsoil and subsoil** which is a major constraint to agricultural productivity.
- **Subsoil salinity** in Sodosols and Kandosols associated with the 'Bulga' and 'Benjang' soil landscape units. Some pasture species, particularly legumes, have a poor ability to extract water from the soil when soil salinity is elevated.
- **Poor water holding capacity in shallow/stony soils.**
- **Nutrient deficiencies**, particularly phosphorus, limit the growth of plants even when other essential requirements such as water and adequate aeration are present in the soil.

The alluvial soil in the Modification Area had much better physical conditions for plant growth (higher water holding capacity, minimal waterlogging, soft when dry) than the non-alluvial areas, but there was a lack of sulphur and possibly potassium.

2.1.5 Land and Soil Capability

The Land and Soil Capability (LSC) Assessment Scheme uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards (Office of Environment and Heritage [OEH], 2012). The LSC class gives an indication of the land management practices that can be applied to a parcel of land. The LSC classes are outlined below (OEH, 2012).

Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)

- Class 1: Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
- Class 2: Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
- Class 3: High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)

- Class 4: Moderate capability land: 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.
- Class 5: Moderate–low capability land: 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.

Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)

- Class 6: Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

Land generally incapable of agricultural land use (selective forestry and nature conservation)

- Class 7: Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
- Class 8: Extremely low capability land: 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.

Soil Management Designs (2016) determined the LSC classification for each test pit of the soil survey. The results of these classifications are shown on Figure 5.

The majority of test pits were allocated as Class 4. There was one test pit each allocated as Class 2 and Class 7, with the remainder of the test pits allocated between Classes 3 and 6.

Adjoining Lands and Modification Biodiversity Offset Areas

Regional LSC mapping prepared by the OEH (2012) is available for surrounding lands and is shown on Figure 5, including land that is owned and managed by WCPL.

The areas associated with the Wollombi Brook were generally allocated as Class 3 land, and the majority of the rest of the Modification Area was allocated as Class 4 and 5 land. Some steeper slopes in the hills to the west of the Modification Area were allocated as Class 7 land.

The extension to the RWEPP areas for the Modification include Classes 4 and 5 land.

2.1.6 Identification of Strategic Agricultural Lands

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) includes mapping of lands identified as Biophysical Strategic Agricultural Land (BSAL). The closest mapped BSAL in the Mining SEPP is associated with the Hunter River and is located more than 4 km to the north-east of the Modification Area (Figure 6).

The Modification Area is not located within any mapped Viticulture Critical Industry Clusters. The closest Viticulture Critical Industry Cluster is located approximately 0.6 km to the south of the Modification Area (Figure 6). This is outside the predicted extent of conventional subsidence for the Modification (MSEC, 2016).

Based on the results of the site soil survey (Section 2.1.4), Soil Management Designs (2016) has identified that one soil pit (Pit 20) may be an area of high value or strategic agricultural land (Attachment 2). This soil pit is located outside the minor extensions to the surface development area and is located within the approved South Wambo Underground Mine predicted extent of conventional subsidence (i.e. is therefore already approved to be impacted by subsidence).

Adjoining WCPL-owned lands (including the proposed extension to the RWEPL areas) do not comprise high value or strategic agricultural lands based on the available mapping information.

2.1.7 Water Resources

Groundwater

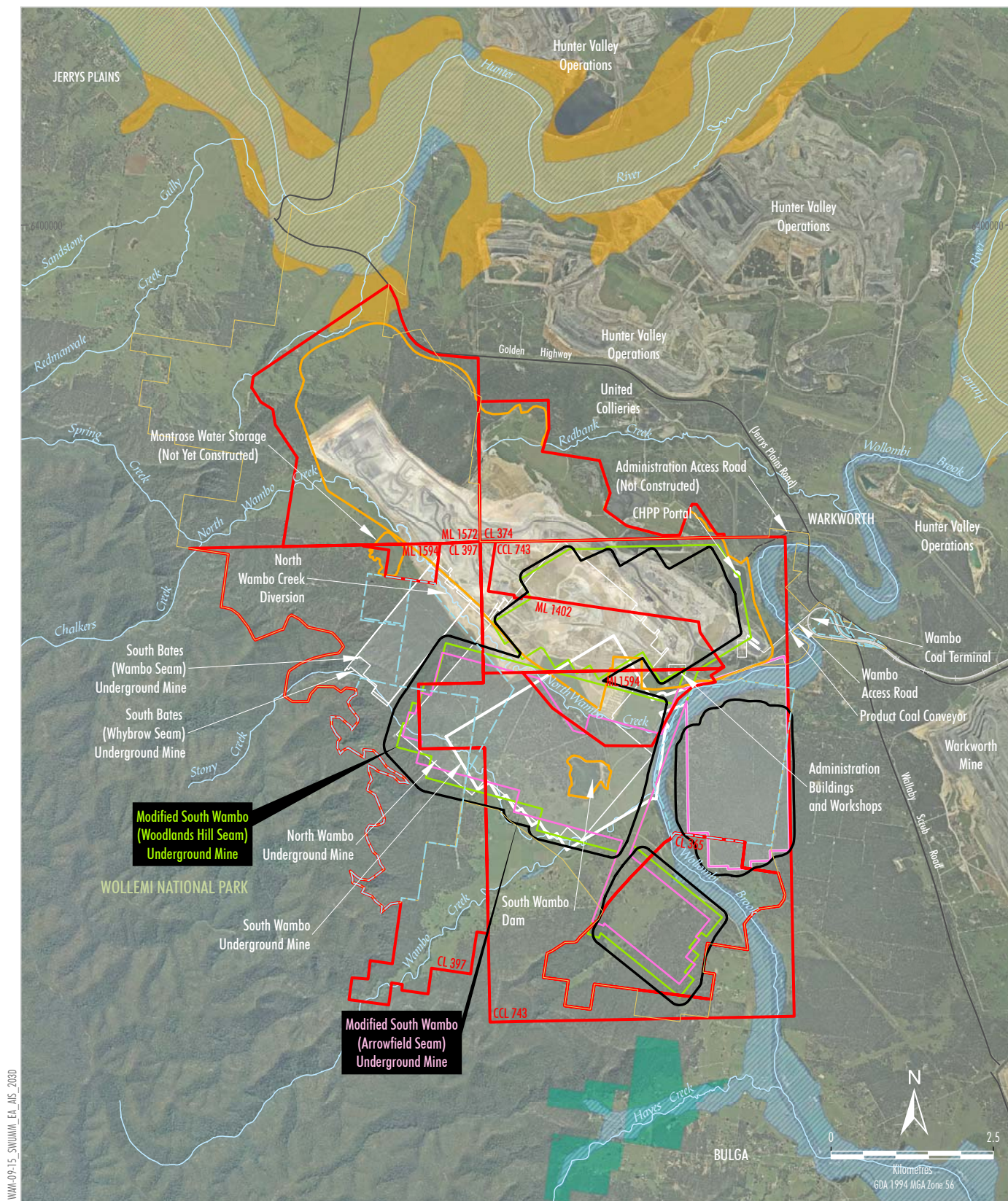
A Groundwater Assessment for the Modification was undertaken by HydroSimulations (2016) and is presented in Appendix B of the EA. The following discussion is based on this Groundwater Assessment.

Existing Groundwater Regime

The two main groundwater systems which exist in the Modification Area and surrounds are:

- Quaternary alluvial aquifer system of channel fill deposits associated with Wollombi Brook, North Wambo Creek, Wambo Creek and Stony Creek.
- Underlying Permian strata consisting of:
 - hydrogeologically “tight” and hence very low yielding to essentially dry sandstone and lesser siltstone; and
 - low to moderately permeable coal seams, which are the prime water-bearing strata within the Permian measures.

Evidence indicates that the alluvial aquifer is responsive to rainfall recharge and it is likely that the alluvium plays an important role in supplying recharge to the underlying Permian strata as well as contributing to baseflow of surface water features.



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Groundwater flow patterns within the shallow alluvial aquifers reflect topographic levels and the containment of alluvium within the principal drainage pathways. Prior to the commencement of mining operations in the region, the piezometric surface within the Permian aquifers of the Wambo area most probably reflected the topography. Historical and ongoing open cut and underground mining within the Wambo area and adjoining mining operations has created a regional zone of depressurisation within the Permian coal measures.

Groundwater monitoring bores in close proximity to Wambo have shown historical and ongoing open cut and underground mining within the Wambo area and adjoining operations has created a regional zone of depressurisation within the Permian coal measures (HydroSimulations, 2016).

HydroSimulations (2016) and previous groundwater assessments for Wambo predict that some privately-owned bores may experience more than 2 m cumulative drawdown as a result of the already approved operations at Wambo. These drawdowns are due to the cumulative effects of all mining in the Wambo district.

Groundwater Quality and Use

HydroSimulations (2016) indicates that groundwater quality in the vicinity of Wambo is variable. The salinity of groundwater recently sampled from within Wambo and surrounding mining leases ranges from 314 milligrams per litre (mg/L) to 15,000 mg/L (approximately 500 microSiemens per centimetre [$\mu\text{S}/\text{cm}$] to 22,000 $\mu\text{S}/\text{cm}$). The highest salinities are reported from the surficial groundwater.

A search of the Department of Primary Industries Water (DPI Water) (formerly NSW Office of Water) PINNEENA Groundwater Works Database identified 78 registered bores and wells within 5 km of Wambo (Figure 7), the majority (48) of these being monitoring/test bores within WCPL tenement boundaries. The remaining bores comprise 10 mine use/dewatering bores; 16 bores registered for irrigation, domestic and/or stock use; and four bores of unknown use.

Surface Water

A Surface Water Assessment for the Modification was undertaken by Advisian (2016) and is presented in Appendix C of the EA. The following discussion is based on this Surface Water Assessment.

Wambo is situated adjacent to Wollombi Brook, south-west of its confluence with the Hunter River. Wollombi Brook drains an area of approximately 1,950 square kilometres (km^2) and joins Hunter River some 5 km north-east of Wambo.

The majority of lands within Wambo mining tenements drain via Wambo (also known as 'South Wambo'), Stony, North Wambo and Redbank Creeks to Wollombi Brook, while Waterfall Creek drains directly to the Hunter River (Figure 2). All creeks within the Modification Area are considered ephemeral waterways, which experience some extended periods of no or negligible flow during dry weather.

North Wambo Creek Diversion

Upstream of the Modification Area, North Wambo Creek flows east to the North Wambo Creek Diversion, a section of North Wambo Creek which has been diverted to avoid the Wambo open cut (Figure 2). A portion of the North Wambo Creek Diversion lies directly above and adjacent to the Modification Area.

As a result of the North Wambo Creek Diversion, the catchment of North Wambo Creek at the confluence with Wollombi Brook has been reduced from 48.5 km^2 to 40.1 km^2 .

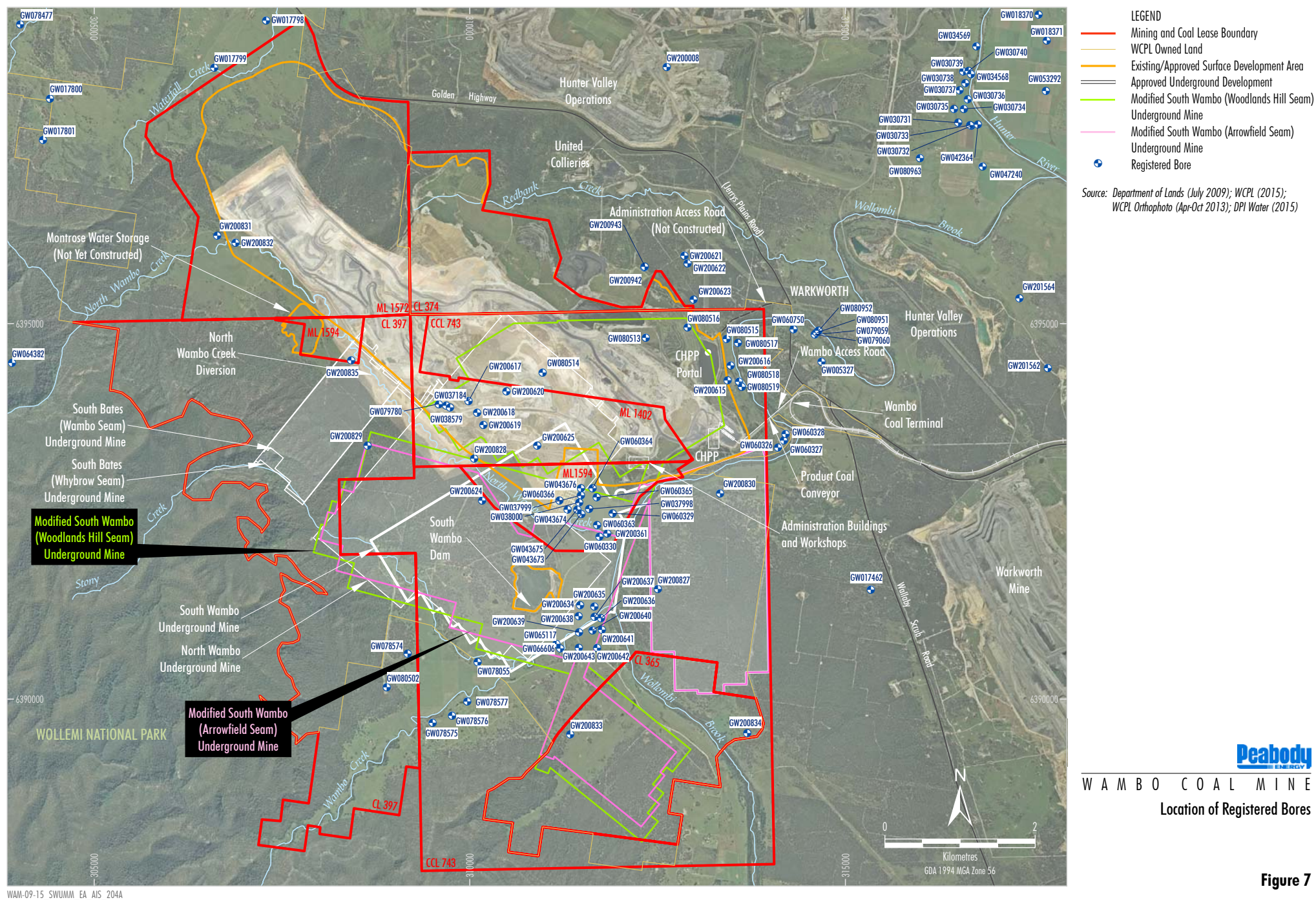


Figure 7

Surface Water Quality

Surface water quality at Wambo for the period July 2003 to May 2015 has been reviewed by Advisian (2016).

Advisian (2016) note that the water quality of Wollombi Brook is generally characterised by moderate salinity (i.e. electrical conductivity [EC]), with increasing salinity downstream, and near neutral to slightly alkaline pH conditions. The available data for North Wambo Creek indicate slightly alkaline pH conditions with moderate salinity upstream and high salinity downstream. Stony Creek and Wambo creek have moderate salinities with pH levels near neutral to slightly alkaline (Advisian, 2016).

Other Surface Water Users

Water in Wollombi Brook is used for stock watering and irrigation purposes. There are 110 surface water licences in the Lower Wollombi Brook water source, with a total volumetric surface water licence of 6,663 million litres per year (ML/year), of which 88% is used for irrigation purposes. There are six (including one WCPL-held) Water Access Licences (WALs) associated with surface water extraction along Wollombi Brook and downstream of Wambo (Figure 8) (Advisian, 2016).

2.2 AGRICULTURAL PRODUCTION AND ENTERPRISES

The Singleton Local Government Area (LGA) is located in the wider Upper Hunter Region. The Upper Hunter Strategic Regional Land Use Plan (SRLUP) describes the wider regional context of agricultural production over an area that comprises an area of some 2.4 million hectares and includes the LGAs of Singleton, Muswellbrook, Dungog, Upper Hunter and Gloucester (NSW Government, 2012). The Upper Hunter SRLUP (NSW Government, 2012) notes that intensive agricultural enterprises are of particular significance in the Singleton, Dungog and Gloucester LGAs.

2.2.1 Agricultural History of the Local Area

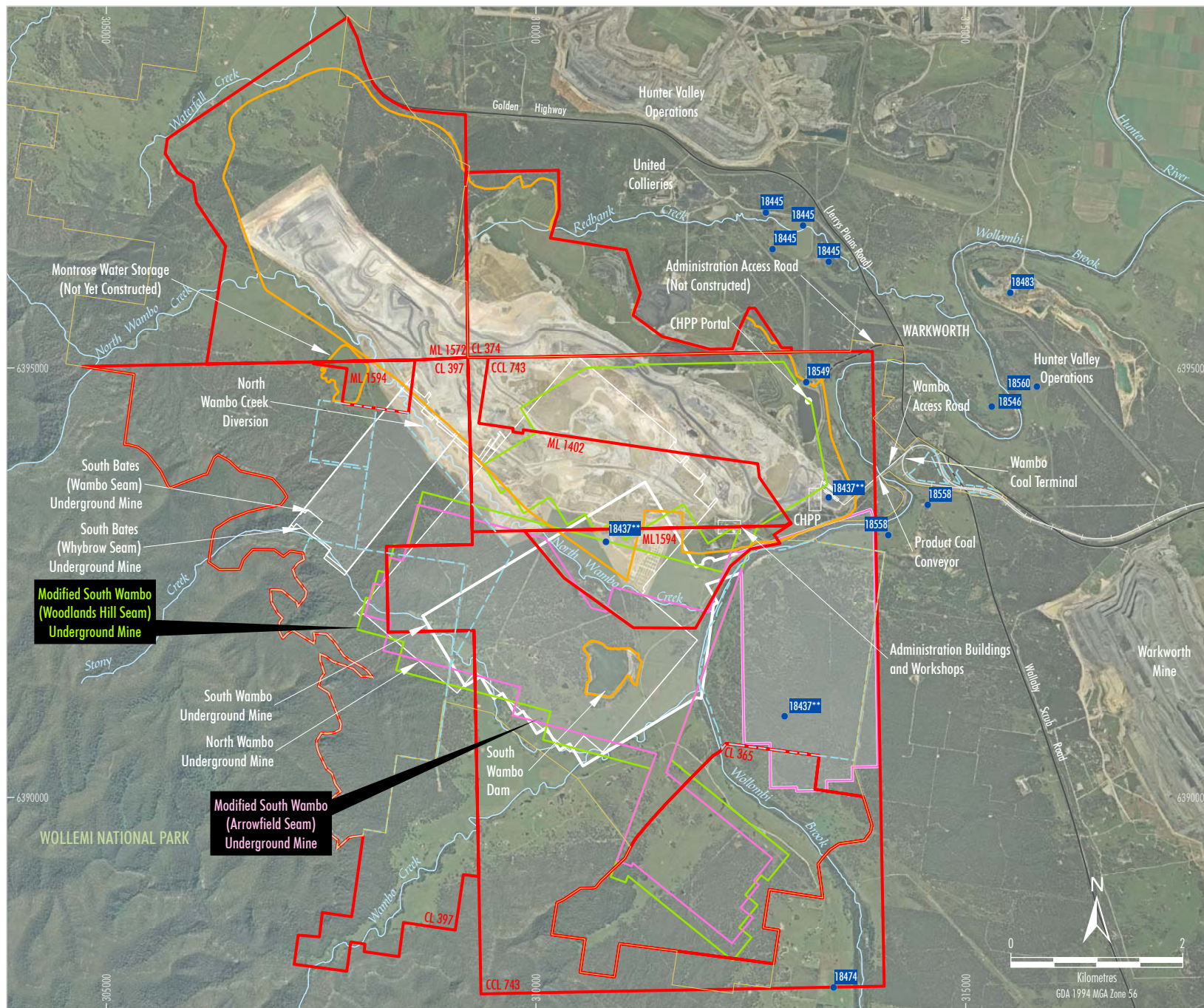
RPS (2016) has prepared a Cultural Heritage Impact Assessment for the Modification (Appendix F of the EA). This report indicates that while the Lower Hunter Region was developed on a foundation of industrial production, the Upper Hunter Region focussed predominately on agricultural production. The Modification Area and surrounds have been highly disturbed by extensive clearing and previous agricultural and mining activities (RPS, 2016).

2.2.2 Local Agricultural Productivity and Enterprises

Soil Management Designs (2016) has identified that agricultural enterprises known to have been conducted in the Modification Area include beef cattle on rain-fed native and introduced pastures (Attachment 2).

Based on Soil Management Designs' (2016) analysis and review of the agricultural operations on surrounding lands, it is considered that the majority of the agricultural lands within the Modification Area and surrounds are unimproved pastures, with some medium productivity "improved" pastures relating to the Wollombi Brook alluvial zone (Attachment 2).

Soil Management Designs (2016) has estimated the gross margins for beef cattle (weaners) production on unimproved and improved pastures in the Modification Area and surrounds as being approximately \$61 and \$177 per hectare, per year respectively (Attachment 2).



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Peabody
 WAMBO COAL MINE
 Lower Wollombi Brook Water Source
 Water Access Licences
 in the Vicinity of Wambo

Figure 8

2.2.3 Support Infrastructure, Suppliers and Services

General agricultural improvements (e.g. stock fences and farm dams) are in place across most of the Modification Area and surrounds that reflect its historical development for beef production.

Local rural suppliers and/or services are located in Singleton and Muswellbrook. The Modification Area and surrounds are well serviced for support infrastructure being located adjacent to the Golden Highway and some 15 km west of Singleton.

Access to regional road transport routes are readily available from the Modification Area via the adjacent Golden Highway. Wambo is located within approximately a one hour drive from the major regional centre of Newcastle and approximately a two hour drive from Sydney.

3 POTENTIAL IMPACTS

This section provides an assessment of the potential impacts of the Modification on agricultural resources and productivity.

3.1 CONSIDERATION OF RISKS

As a component of the analysis of potential environmental impacts of the Modification, an Environmental Risk Assessment has been completed (Appendix L of the EA). The potential impacts of the Modification on groundwater and surface water resources have been considered in the Groundwater and Surface Water Assessments for the Modification (Appendices B and C of the EA). Potential impacts on adjoining lands through the potential impacts of operational noise, air quality emissions and road transport have been considered in the Noise Review, Air Quality and Greenhouse Gas Review and the Road Transport Assessment (Appendices H, I and J of the EA).

3.2 AGRICULTURAL RESOURCES

3.2.1 Land Resources during the Modification Life

Modification Area

Potential impact mechanisms on agricultural resources in the Modification Area as a result of the Modification are likely to be associated with:

- loss of productive agricultural land due to the minor extension to the surface development area; and
- subsidence-related impacts.

Surface Development

The Modification would result in a minor extension (approximately 7.9 hectares [ha]) to the Wambo surface development area to allow for the development of additional surface infrastructure. Approximately 4.5 ha of this surface development area extension consists of derived grassland (FloraSearch, 2016) which would be suitable for agricultural uses (i.e. grazing). The remainder of the surface development area extension is vegetated (FloraSearch, 2016) and would not be suitable for agricultural uses.

This agricultural land in the surface development area extensions consists primarily of LSC Class 4 and 5 (Figure 5) and is not BSAL or Viticulture Critical Industry Cluster mapped in the Mining SEPP (Section 2.1.6). The area of potential high value or strategic agricultural land (Section 2.1.6) is located outside the minor extensions to the surface development area.

Additional disturbance for gas management infrastructure would occur progressively over the life of the modified Wambo. The locations of gas management infrastructure are flexible and would be located in order to minimise potential impacts on agricultural productivity. Any disturbance associated with gas drainage infrastructure would be progressively rehabilitated over the life of the modified Wambo.

Existing agricultural areas in the Modification Area could continue to be used for agricultural activities until they are required for the Modification.

The minor extension to the Wambo surface development area would result in the following potential impacts to soil resources (Attachment 2):

- disturbance of *in situ* soil resources;
- alteration of soil structure beneath infrastructure items, hardstand areas and roads;
- increased erosion and sediment movement due to exposure of soils during construction; and
- alteration of physical and chemical soil properties (e.g. structure, fertility, permeability and microbial activity) due to soil stripping and stockpiling operations.

WCPL would implement mitigation measures to minimise potential risks to soil resources as described in Section 4.

Subsidence

Subsidence is the vertical and horizontal movement of the overburden and land surface as a result of the extraction of underlying coal. These land surface movements are generically referred to as subsidence effects. The type and magnitude of the subsidence effects is dependent on a range of variables (e.g. mine geometry, topography and geology).

Subsidence may impact the integrity of agricultural infrastructure (e.g. fences) and potential impacts on soils and agricultural productivity would be associated with the following potential subsidence impacts (Attachment 2):

- surface cracking;
- slope instability;
- ponding and changes in stream alignment; and
- ponding in poorly drained areas.

MSEC (2016) has assessed the potential subsidence impacts of the Modification. The type and magnitude of predicted subsidence effects for the modified mine layout are generally similar to or less than those of the approved mine layout. This is due to the 'staggered' longwall layout of the Modification compared to the approved 'stacked' layout and slightly reduced extraction heights. It is therefore expected that the potential subsidence impacts above the Modification longwall panels would be generally similar in nature to those associated with the approved layout.

The area of potential high value or strategic agricultural land (Section 2.1.6) is located within the approved South Wambo Underground Mine predicted extent of conventional subsidence and is therefore already approved to be impacted by subsidence. The predicted subsidence impacts in this area would reduce as a result of the Modification due to the modified 'staggered' longwall layout compared to the approved 'stacked' layout.

In addition, it is noted that Frazier et al. (2010) found no significant effect of longwall mining subsidence on agricultural production, including cattle grazing, in the Hunter Valley region.

Given the above, it is considered that the Modification would not have any significant adverse impacts on agricultural production in the Modification Area (Attachment 2).

Notwithstanding the above, WCPL would implement mitigation measures to minimise potential risks to soil resources as described in Section 4.

Adjoining Lands

WCPL-owned lands that adjoin the Modification Area would continue to be used for agricultural uses (e.g. via agistment of stock, leasing or agreements with previous landholders).

Extension to RWEPA Areas for the Modification

The extension to the RWEPA areas for the Modification would be permanently conserved and as a result, approximately 15 ha of existing grazing land in these areas would be sterilised in perpetuity. This grazing land in the extension to the RWEPA areas for the Modification includes LSC Classes 4 and 5.

3.2.2 Land Resources Post-mining

Modification Area

Any disturbance associated with gas drainage infrastructure would be progressively rehabilitated over the life of the modified Wambo.

Following the cessation of mining, surface infrastructure would be decommissioned and the disturbed land would be rehabilitated to woodland or agricultural areas suitable for grazing. As such, disturbance associated with Modification surface infrastructure would result in either temporary or permanent impacts to potential agricultural production on WCPL-owned land, depending on the selected final land use.

Adjoining Lands

At the completion of the Modification, lands that adjoin the Modification Area would continue to be used for agricultural uses (e.g. via agistment of stock, leasing or agreements with previous landholders).

Extension to RWEPA Areas for the Modification

As described in Section 3.2.1, the extension to the RWEPA areas for the Modification would be permanently conserved and as a result, approximately 15 ha of existing grazing land in these areas would be sterilised in perpetuity. This grazing land in the extension to the RWEPA areas for the Modification includes LSC Classes 4 and 5.

3.2.3 Availability of Water for Agriculture

It is not anticipated that the Modification would require any additional groundwater or surface water licence volumetric entitlements beyond the existing groundwater and surface water volumetric entitlements held by WCPL for the existing Wambo.

As described in the Groundwater Assessment and the Surface Water Assessment (Appendices B and C of the EA), there is expected to be no appreciable additional impact on baseflow in North Wambo or Stony Creeks and a small increase in baseflow is expected for Wambo Creek as a result of the Modification. HydroSimulations (2016) predict that, as a result of the Modification, the maximum reduction in baseflow in Wollombi Brook of 125 ML per year which represents less than 1% of the mean annual flow in Wollombi Brook.

As discussed in Section 2.1.7, no privately-owned registered bores are expected to be additionally affected by drawdown caused by the Modification.

Given the above, there is not expected to be a significant impact on the availability of water for agriculture as a result of the Modification.

3.2.4 Amenity Effects

Consideration of the potential impacts of the Modification with respect to human health and amenity criteria for nearby private landholders is considered in the Noise Review and Air Quality and Greenhouse Gas Review (Appendices H and I of the EA). In addition, potential impacts of the Modification on the safety and efficiency of the road network in the vicinity of the Modification has been considered in the Road Transport Assessment (Appendix J of the EA). Consideration of the visual amenity impacts of the Modification are outlined in Section 4.16 of the Main Report of the EA.

No potential impacts have been identified in these assessments that would materially affect the agricultural productivity of adjoining privately-owned lands.

3.3 AGRICULTURAL PRODUCTION, AGRICULTURAL INFRASTRUCTURE, SUPPLIERS AND SUPPORT SERVICES

The area of grazing agricultural lands that would be disturbed by the Modification (approximately 4.5 ha), along with sterilisation of existing grazing agricultural lands in the extension to the RWEP areas for the Modification (approximately 15 ha) can be considered in the context of the area of land under agricultural production in the State of NSW and in the Hunter Valley region.

The potential impact of the Modification on the area of land that is subject to agricultural use in NSW and in the Hunter Valley region would be very small. In addition, the existing agricultural land that has been identified as being potentially impacted by the Modification consists primarily of LSC Classes 4 and 5 (Figure 5) and are not BSAL mapped in the Mining SEPP (Section 2.1.6).

Consideration of the above indicates that the Modification has very little potential to materially affect regional agricultural production or demand for agricultural infrastructure, supplies or services at a local or regional level.

3.4 CONSIDERATION OF POTENTIAL CUMULATIVE IMPACTS

As discussed in Section 3.2.1, the Modification would result in a minor extension to the Wambo surface development area of approximately 7.9 ha (of which 4.5 ha represents land suitable for agricultural production). The currently approved surface development area at Wambo is approximately 2,000 ha. Therefore, the Modification would represent an increase in disturbed land of less than 1%.

Given the above, it is considered that, even accounting for cumulative impacts in the region, the Modification would have a very minor impact on local and regional agriculture.

4 MITIGATION AND MANAGEMENT MEASURES

As described in Section 3, the potential impacts of the Modification on agricultural resources and associated employment and support industries would be small in the context of the existing agricultural activities in the region.

In addition, consideration of the cumulative impacts of approved mining operations in the region also indicates that, even accounting for these other approved developments, the potential cumulative impacts on local and regional agriculture would be minor.

Notwithstanding, WCPL would implement a number of mitigation and management measures that would reduce the potential impacts of the Modification on agriculture, as described below.

4.1 MINIMISATION OF DISTURBANCE TO AGRICULTURAL LANDS

The area of agricultural land disturbed by the Modification at any one time would be minimised so that beneficial agricultural uses (i.e. cattle grazing) can continue to be undertaken on available Modification grazing lands. As demonstrated by Wambo and other mining operations in the region, grazing agricultural activities can be readily undertaken in conjunction with the operation of a mine.

Surface disturbance associated with gas management infrastructure would be progressively rehabilitated as the gas management infrastructure is no longer required.

4.2 MANAGEMENT OF SUBSIDENCE IMPACTS

An Extraction Plan would be developed for the modified South Wambo Underground Mine that would include the following subsidence management measures to minimise potential agricultural impacts:

- Notification to agistees of areas of longwall mining and active subsidence, and exclusion of agistment grazing from areas where surface cracking presents a reasonable risk to people and/or livestock.
- Remediation of surface cracks¹ where practicable using conventional earthmoving equipment (e.g. a backhoe), including:
 - infilling of surface cracks with soil or other suitable materials; or
 - local regrading and re-constructing the surface where hill steepness and water erosion hazard has increased.
- Stabilisation of any areas of surface fissuring using erosion protection measures (e.g. vegetation planting, gypsum application in erosion-prone sodic areas).
- Deep ripping in soil profiles that are part of compression zones created during subsidence.
- Drainage works and rehabilitation of subsidence troughs (i.e. areas of induced ponding) as necessary. Where new ponds are useful as stock watering points, however, consider their retention.
- Repair of stock fences prior to allowing access for agistment grazing.
- Remediation of farm dams where it presents a risk to people, livestock and/or the environment.
- Management measures in accordance with the Erosion and Sediment Control Plan.

¹ Minor cracks that develop are not expected to require remediation as weathering processes will result in the natural filling of these cracks over time.

Trigger Action Response Plans would be developed as part of the Extraction Plan process to outline appropriate triggers and remedial actions for subsidence impacts, including a contingency process to respond to unforeseen impacts.

4.3 MANAGEMENT OF ADJOINING WCPL-OWNED LANDS

To minimise the potential direct impacts of the Modification on agricultural production, WCPL-owned agricultural lands that adjoin Wambo would continue to be subject to agricultural use, where practicable.

An Extraction Plan would be developed for the Modified South Wambo Underground Mine with management measures to allow these lands to continue to be used for agriculture (e.g. repair of stock fences prior to allowing access for agistment grazing).

4.4 RE-ESTABLISHMENT OF AGRICULTURAL LANDS

Following the cessation of mining, surface infrastructure would be decommissioned and the disturbed land would be rehabilitated to woodland or agricultural areas suitable for grazing.

Any disturbance associated with gas drainage infrastructure would be progressively rehabilitated over the life of the modified Wambo.

Existing rehabilitation success at Wambo and other mining operations in the region provides a working demonstration of the practical application of rehabilitating mining operation disturbance areas to productive agricultural land uses. Further detail on the rehabilitation strategy for the Modification is provided in Section 3.10 of the Main Report of the EA.

4.5 WATER RESOURCES

Measures to minimise the potential impacts of the Modification on water resources, including water resources used by other licensed users of water for agriculture, are provided in Appendices B and C and Sections 4.4 and 4.5 of the Main Report of the EA.

The existing Wambo Site Water Management Plan would be reviewed and, if necessary, revised to incorporate the Modification. This Site Water Management Plan outlines measures to respond to any potential exceedances of surface water or groundwater related criteria, and to provide contingent mitigation/compensation/offset measures that would be implemented in the event that downstream surface water users or groundwater users were adversely affected by Wambo operations.

4.6 OTHER MEASURES

Section 4 of the Main Report of the EA describes a range of management and mitigation measures for potential environmental impacts arising from the Project, including relevant contingency measures.

Consideration of alternatives and justification for the Modification are also discussed in Section 6 of the Main Report of the EA.

5 JUSTIFICATION OF PROPOSED CHANGES TO AGRICULTURAL LANDS

The results of the site specific soil survey, LSC Mapping and review of regional mapping of strategic agricultural land in the Mining SEPP indicate that the Modification Area does not comprise significant strategic value or high productivity agricultural lands.

Similarly, adjoining WCPL-owned lands also do not comprise strategic value or high productivity agricultural lands.

In summary:

- The Modification would at maximum disturb some 4.5 ha of existing grazing agricultural lands that are used for pasture for beef production.
- Following the cessation of mining, surface infrastructure would be decommissioned and the disturbed land would be rehabilitated to woodland or agricultural areas suitable for grazing.
- The Modification residual impacts on agricultural lands would, at State and regional levels, be very minor.
- The Modification cumulative impacts on local or regional agriculture support industries would not be material.

The Socio-economic Assessment (AnalytEcon, 2016) indicates that the economic benefits of the Modification far outweigh the potential economic costs associated with the reduction in regional agricultural production.

6 REFERENCES

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ATTACHMENT 1

RECONCILIATION OF DPI'S INPUT TO THE SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Table A1-1
Reconciliation of DPI's Input to the Secretary's Environmental Assessment Requirements

DPI's Considerations for an Agriculture Impact Statement	Agricultural Impact Statement Section
<i>1.0 AIS Introduction</i>	Section 1
<i>2.0 Detailed assessment of the agricultural resources and agricultural production of the project area</i>	Sections 2 and 3
2.1 Soil information	Section 2.1.4
2.2 Slope and land characteristics	Section 2.1.5
2.3 History of agricultural enterprises within project areas	Section 2.2.1
2.4 Location and areas of land to be temporarily removed from agriculture	Section 3.2.1
2.5 Location and area of land to be returned to agricultural use post project	Section 3.2.2
2.6 Location of area of land that will not be returned to agriculture, including areas to be used for environmental plantings or biodiversity offsets	Section 3.2.2
2.7 Agricultural enterprises to be undertaken on any buffer and/or offset zone lands for the life of the project	Section 3.2.1
<i>3.0 Identification of the agricultural resources and current enterprises within the surrounding locality of the project</i>	Section 2
3.1 Agricultural resources within the locality	
3.1.1 Soil characteristics including soil type and depth	Section 2.1.4
3.1.2 Topography – land capability tabulated	Section 2.1.5
3.1.3 Agricultural support infrastructure	Section 2.2.3
3.1.4 Water resources and extraction locations	Section 2.1.7
3.1.5 Location and type of agricultural industries	Section 2.2.2
3.1.6 Vegetation	Section 3.2.1
3.1.7 Climate conditions	Section 2.1.1
3.2 Current agricultural enterprises within the surround locality	Section 2.2.2
<i>4.0 Assessment of impacts</i>	Section 3
4.1 Identification and assessment of the impact of the project on agricultural resources or industries	
4.1.1 Effects on agricultural resources	Section 3.2
4.1.2 Consequential productivity effects on agricultural enterprises	Section 3.3
4.1.3 Uncertainty associated with the predicted impacts and mitigation measures	Section 3
4.1.4 Further risks	Section 3
4.2 Account for physical movement of water away from agriculture	Section 3.2.3
4.3 Assessment of socio-economic impacts	Section 3.3
4.3.1 Agricultural land values	Appendix K of the Main Report
4.3.2 Local and regional agricultural enterprises	Section 3
4.3.3 Agricultural support services, local and regional employment	Section 3
4.3.4 Regional communities	Section 3
4.3.5 Visual amenity, landscape values and tourism infrastructure	Section 3.2.4
4.3.6 Economic analysis of project scenarios	Section 3.3 and Appendix K of the Main Report
<i>5.0 Suggested references for methodologies</i>	Section 6 and Attachment 2

Table A1-1 (Continued)
Reconciliation of DPI's Input to the Secretary's Environmental Assessment Requirements

DPI's Considerations for an Agriculture Impact Statement	Agricultural Impact Statement Section
6.0 <i>Mitigation measures</i>	Section 4
6.1 <i>Project alternatives</i>	Section 4.5
6.2 <i>Proposed monitoring programs to assess predicted versus actual impacts as the project progresses</i>	Section 4.2
6.3 <i>Trigger response plans and trigger points at which operations will cease or be modified or remedial actions will occur to address impacts including a process to respond to unforeseen impacts</i>	Section 4.2
6.4 <i>The proposed remedial actions to be taken in response to a trigger event</i>	Section 4.2
6.5 <i>The basis for assumptions made about the extent to which remedial actions will address and respond to impacts</i>	Section 4
6.6 <i>demonstrated capacity for the rehabilitation of disturbed lands to achieve the final land use and restore natural resources</i>	Section 4.3
6.7 <i>demonstrated planning for progressive rehabilitation that minimises the extent of disturbance</i>	Section 4.1
7.0 <i>Consultation</i>	Section 1.2
8.0 <i>Further information</i>	This report
9.0 <i>Appendix I checklist of maps and information</i>	N/A

ATTACHMENT 2

AGRICULTURAL RESOURCE ASSESSMENT

March
2016

Agricultural Resource Assessment: South Wambo Underground Mine Modification; Singleton, NSW

Prepared for Wambo Coal Pty Limited



DOCUMENT CONTROL

Prepared for client:	Wambo Coal Pty Limited
First draft preparation:	Author: D McKenzie Reviewer: Lucas Burns Date: 11 February 2016
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INFORMATION SOURCES AND REFERENCING

This report was derived from an extensive range of information sources including literature review and discussions with colleagues. The author has sought to ensure that sources for his use of text, diagrams, maps and images are provided in the report. If the author inadvertently has failed to adequately acknowledge a source of material used, he would appreciate prompt notification so that the matter can be corrected in the electronic version of the document and a full acknowledgement provided.

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1. INTRODUCTION

1.1. Background

The Wambo Coal Mine (Wambo) is situated approximately 15 kilometres (km) west of Singleton, near the village of Warkworth, New South Wales (NSW) (Figure 1). Wambo is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited.

A range of open cut and underground mine operations have been conducted at Wambo since mining operations commenced in 1969. Mining under the Development Consent (DA 305-7-2003) commenced in 2004 and currently both open cut and underground operations are conducted. An aerial photograph of Wambo, illustrating the proposed modified layout and locations of key infrastructure, is provided on Figure 2.

1.2. Scope and Objectives

WCPL is seeking to modify Development Consent (DA 305-7-2003) to allow for the realignment and extension/relocation of the approved South Wambo (Arrowfield Seam) Underground Mine longwall panels and mining of the Woodlands Hill Seam rather than the Bowfield Seam (the South Wambo Underground Mine Modification [the Modification]) (Figure 2).

Soil Management Designs¹ was commissioned by WCPL to carry out an Agricultural Resource Assessment for the Modification. This assessment has been prepared to assist with addressing of the following components of the Secretary's Environmental Assessment Requirements (SEARs) for the Modification:

The EA must address the following specific issues:

- *An Agriculture Impact Statement to assess the potential impacts on soils and land capability of the site and surrounds, paying particular attention to any Biophysical Strategic Agricultural Land (BSAL) and DPI's requirements (see Attachment 2)*
- *an assessment of the likely agricultural impacts of the development;*

In accordance with the SEARs for the Modification, this assessment has regard to the Department of Primary Industries (DPI) input into the SEARs outlined in Attachment 2 of the SEARs. Table 1 summarises where in the Environmental Assessment (EA) the DPI's comments are addressed.

Table 1. DPI Requirements Addressed in the EA

EA Requirements	Section
<i>The Environmental Impact Statement should include impacts of subsidence on agricultural infrastructure and water resources used for agriculture.</i>	Appendices A, B, C and G of the EA
<i>An Agricultural Impact Statement would suffice to cover:</i> • <i>detailed assessment of potential impacts of the project on agricultural resources;</i> • <i>detailed assessment of potential impacts of the project on the local and regional community, paying particular attention to impacts on viticulture.</i>	Appendix G of the EA

¹ 'Soil Management Designs' is the new trading name for McKenzie Soil Management Pty Ltd.

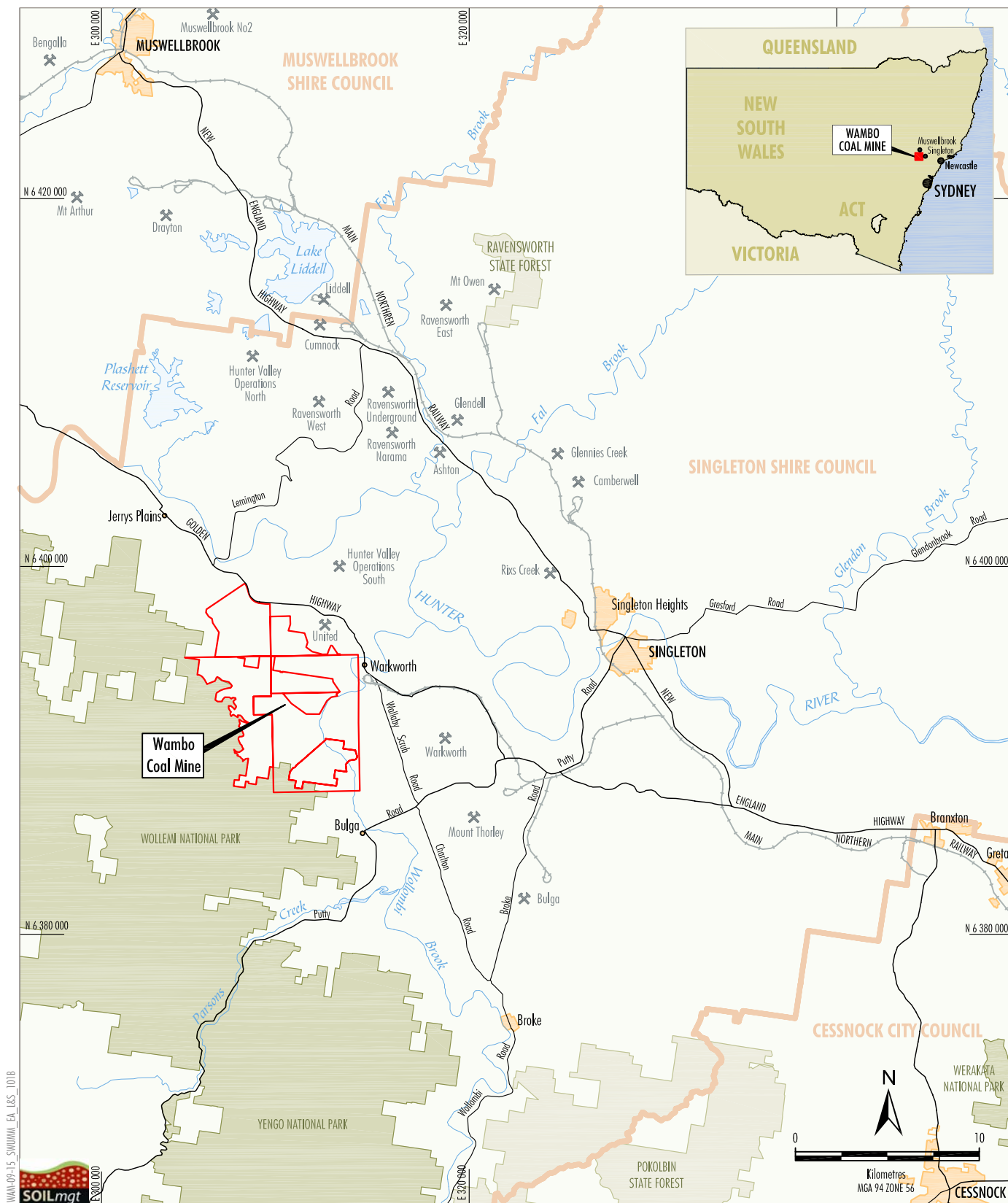


Figure 1

2. MODIFICATION OVERVIEW

The Modification would involve a realignment and extension/relocation of the approved South Wambo Underground Mine longwall panels and mining of the Woodlands Hill Seam rather than the Bowfield Seam. Longwall mining areas associated with the Modification are detailed below (Figures 2 and 3):

- **Area 1 (Woodlands Hill Seam)** – The modified mine layout includes additional longwall panels in the Woodlands Hill Seam beneath the approved Surface Development Area.
- **Area 2 (Arrowfield Seam and Woodlands Hill Seam)** – The modified mine layout includes a reorientation and minor extension of the approved Arrowfield Seam mine layout in Area 2. The Woodlands Hill Seam is proposed to replace the Bowfield Seam in this location with a reorientation and minor extension to the approved mine layout.
- **Area 3 (Arrowfield Seam and Woodlands Hill Seam)** – The modified mine layout includes an extension of mining in the Arrowfield Seam and Woodlands Hill Seam into Area 3, comprising three longwall panels in the Arrowfield Seam and four longwall panels in the Woodlands Hill Seam.
- **Area 4 (Approved Arrowfield Seam)** – The Modification does not propose any changes to the approved Arrowfield Seam mine layout to the east of Wollombi Brook. The approved Bowfield Seam mine layout is no longer proposed to be mined in Area 4 and therefore there would be a reduction in subsidence impacts in Area 4.

The rearrangement of the South Wambo Underground Mine would require a minor extension of the approved surface development area (Figure 2) and result in an extension of the approved mine life by 7 years (i.e. to 2032).

The underground mine run-of-mine (ROM) coal production rate would increase from 7.5 to 9.75 million tonnes per annum (Mtpa). The approved total ROM coal production rate (i.e. 14.7 Mtpa) would remain unchanged.

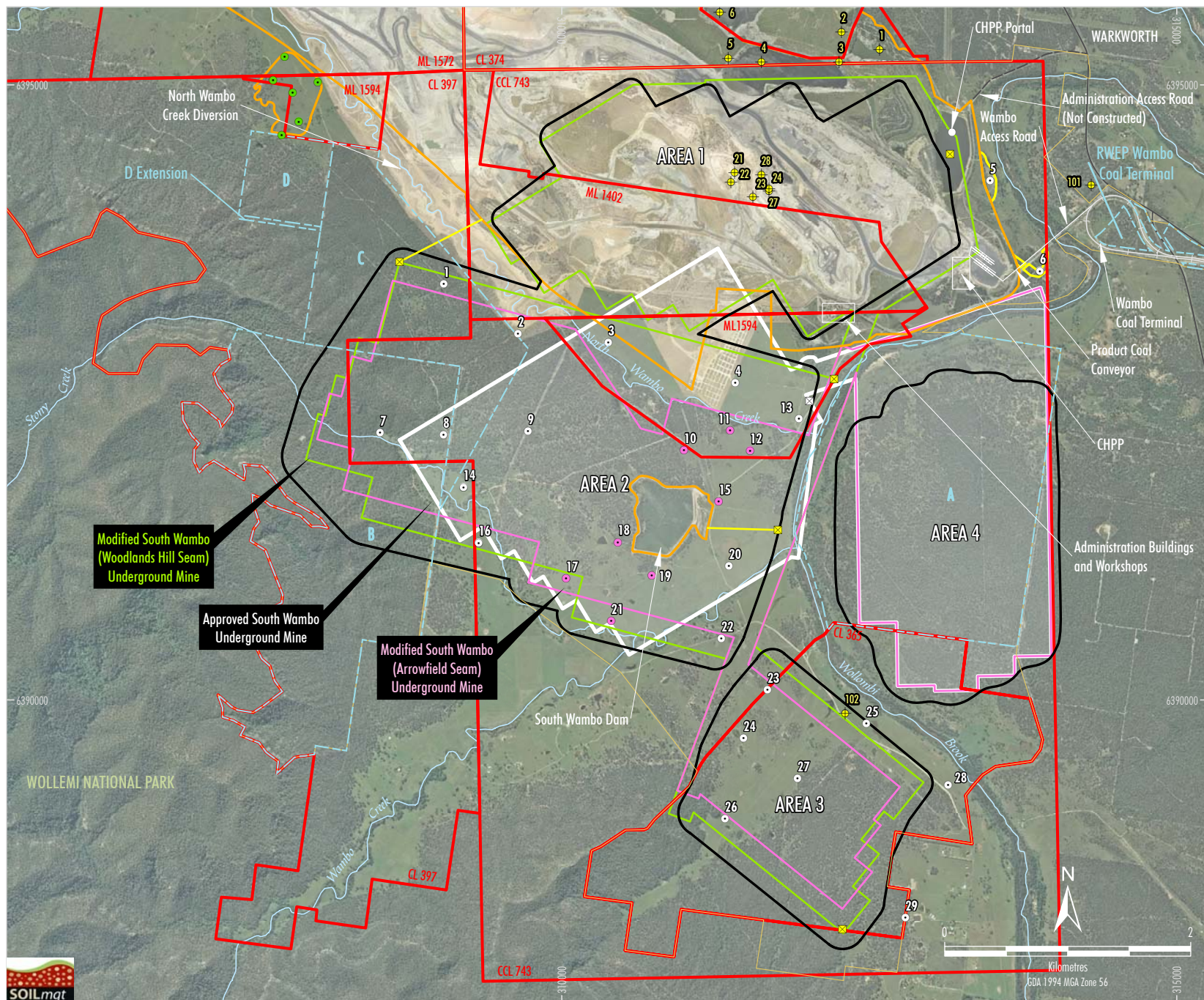
The Modification would not involve changes to any aspects of the approved North Wambo Underground Mine or South Bates Underground Mine.

The Modification would also include an extension of approved open cut mining operations by 3 years (i.e. up to and including 2020). The Modification would not include any change to the approved open cut ROM coal production limit.

Additional details of the Modification are provided in Section 3 of the EA.

The "Modification Area" comprises the extent of conventional subsidence resulting from the modified longwall layout and the modified surface development areas (Figure 3).

Subsidence effects resulting from longwall mining the Arrowfield and Bowfield Seams in Area 4 were assessed as part of the Wambo Development Project Environmental Impact Statement (WCPL, 2003). The modified subsidence impacts in Area 4 are predicted to reduce as only the Arrowfield Seam is proposed to be mined as part of the Modification (Mine Subsidence Engineering Consultants [MSEC], 2016). The potential impacts on agricultural resources in Area 4 are therefore also expected to reduce as a result of the Modification and therefore this assessment has not considered Area 4 any further.



LEGEND

- Mining and Coal Lease Boundary
- WCPL Owned Land
- Existing/Approved Surface Development Area
- Modified Surface Development Area
- Approved South Wambo Underground Mine Development
- Modified South Wambo (Woodlands Hill Seam) Underground Mine
- Modified South Wambo (Arrowfield Seam) Underground Mine
- ⊠ Approved Ventilation Shaft
- ⊠ Modified Ventilation Shaft
- - - Remnant Woodland Enhancement Program (RWEPP) Area
- Predicted Extent of Modification Conventional Subsidence
- ⊕ SPADE Soil Pit
- McKenzie Soil Management (2012a) Soil Pit
- McKenzie Soil Management (2012b) Soil Pit
- Modification Soil Pit

Note: Refer to Figure 2 for location of North Wambo Underground Mine and South Bates Underground Mine.

Source: Department of Lands (July 2009); WCPL (2015); WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Soil Pit Locations

Figure 3

3. DESCRIPTION OF THE WAMBO AREA

Wambo is located in the Upper Hunter Valley region where landforms are characterised by gently sloping flood plains associated with the Hunter River and the undulating foothills, ridges and escarpments of the Mount Royal Range and Great Dividing Range. Wambo adjoins grazing land to the south, other coal mining operations to the east and north, grazing land to the north-west and Wollemi National Park to the west and south-west (Figure 2).

The main topographic features of the Modification Area are the alluvial flats and terraces associated with the north flowing Wollombi Brook, north-east flowing Wambo Creek and its tributary Stony Creek, and south-east flowing North Wambo Creek.

Elevations in the Modification Area range from approximately 60 metres Australian Height Datum (m AHD) near Wollombi Brook to approximately 220 m AHD near the base of the Wollemi Escarpment. To the west of Wambo is steeper land with elevations up to approximately 650 m AHD at Mount Wambo within the Wollemi National Park (Figure 2).

Land use in the vicinity of Wambo is characterised by a combination of coal mining operations, Remnant Woodland Enhancement Programme (RWEPP) areas, agricultural land use and WCPL-owned lands that are not subject to mining operations. The latter areas are utilised for the agistment of beef cattle. The main agricultural land uses in the Wambo region include dairy and beef cattle and pasture production, horse breeding, viticulture and wine making (NSW Government, 2012).

The majority of the Modification Area is located on WCPL-owned land. Land uses include coal mining operations, RWEPP Areas A, B and C, remnant vegetation and agriculture (beef cattle).

Mean annual rainfall figures over a period of approximately 120 years at the nearby towns of Jerrys Plains and Bulga (Figure 1), respectively, are 645 millimetres (mm) (ranging from 234 to 1,191 mm) and 665 mm (ranging from 276 to 875 mm) (Bureau of Meteorology 2016).

4. SOIL RESOURCES

4.1. Review of Existing Soil Survey Information

The following existing soil resource information relevant to the Modification Area was reviewed for this report:

- *Hunter Coalfield Regional 1:100,000 Geology Map* (Glen and Beckett 1993);
- regional soil type and landscape mapping (Kovac and Lawrie 1991);
- *Agricultural Resource Assessment: "Montrose Water Storage"*, Wambo NSW (McKenzie Soil Management 2012a);
- *Agricultural Resource Assessment: "North Wambo Underground Mine Modification"*, Wambo NSW (McKenzie Soil Management 2012b);
- Soil Profile Attribute Data Environment (eSPADE) soil profiles (part of the NSW Natural Resource Atlas); and
- acid sulfate soil risk map data (part of the NSW Natural Resource Atlas).

A summary of relevant information from these sources is provided in the following subsections.

Geology / Parent Materials for Soil Formation

The Hunter Coalfield Regional 1:100,000 Geology Map shows the rock types that are the parent material for soil formation in the vicinity of the Modification Area (Figure 4).

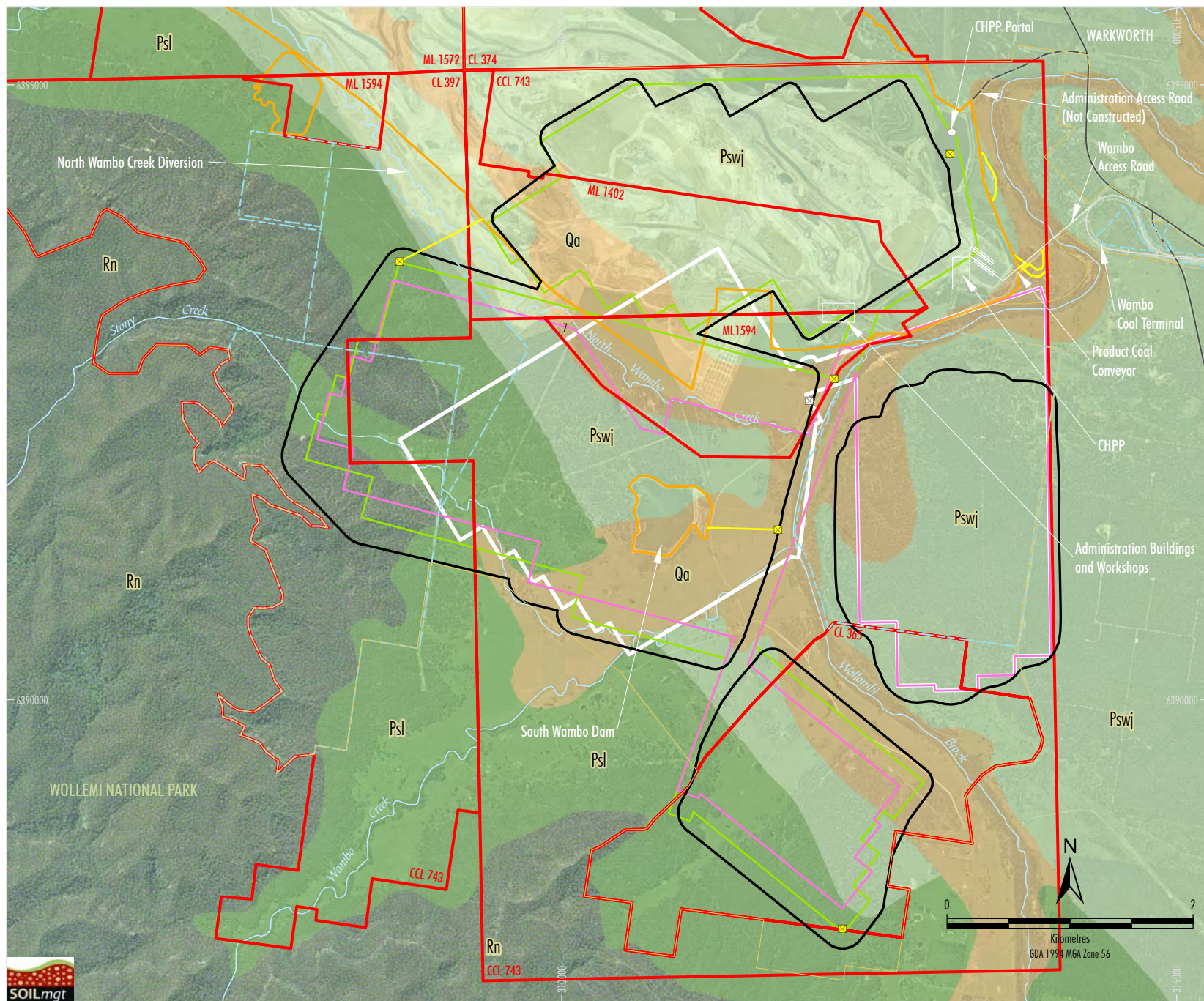
The presence of siltstone and tuffaceous claystone in the 'Newcastle Coal Measures' and 'Wittingham Coal Measures' units indicates that there may be pockets of soil within the Modification area with soil conditions significantly better than those derived from conglomerate and sandstone.

Soil Types and Landscapes

Figure 5 shows the location of soil landscape units as mapped and described by Kovac and Lawrie (1991) in the vicinity of the Modification Area. Six soil landscape units are mapped in the Modification Area and these are described in Table 2. The descriptions of these units indicate the presence of soil conditions that generally are poor for plant growth (Table 2).

The McKenzie Soil Management (2012a) study included six soil pits across the Montrose Water Storage located to the north-west of the Modification Area (Figure 3). The soil types mapped by McKenzie Soil Management (2012a) included Sodosols, Kandosols and Anthrosols. As these soil pits are located outside the Modification Area, they have not been considered further in this report.

The McKenzie Soil Management (2012b) study included eight soil pits within the vicinity of Longwalls 9 and 10 of the North Wambo Underground Mine which forms part of the Modification Area (Figure 3). The soil types mapped included Stratic Rudosols, Grey, Brown and Red Kandosols, Brown Sodosols and Black-Orthic Tenosols. These soil pits are discussed further in this report as they are located inside the Modification Area.



LEGEND

- Mining and Coal Lease Boundary
- WCPL Owned Land
- Existing/Approved Surface Development Area
- Modified Surface Development Area
- Approved South Wambo Underground Mine Development
- Modified South Wambo (Woodlands Hill Seam) Underground Mine
- Modified South Wambo (Arrowfield Seam) Underground Mine
- Approved Ventilation Shaft
- Modified Ventilation Shaft
- Remnant Woodland Enhancement Program (RWEPP) Area
- Predicted Extent of Modification Conventional Subsidence

Quaternary

- Qa Silt, Sand, Gravel

Triassic

- Rn Widden Brook Conglomerate - Conglomerate and Sandstone

Late Permian

- Psl Newcastle Coal Measures - Coal Seams, Claystone (tuffaceous) Siltstone, Sandstone, Conglomerate
- Pswj Wittingham Coal Measures - Coal Seams, Claystone, Tuff, Siltstone, Sandstone, Conglomerate

Note: Refer to Figure 2 for location of North Wambo Underground Mine and South Bates Underground Mine.

Source: Department of Lands (July 2009); WCPL (2015); DMR (1993); WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Geology Mapping

Figure 4

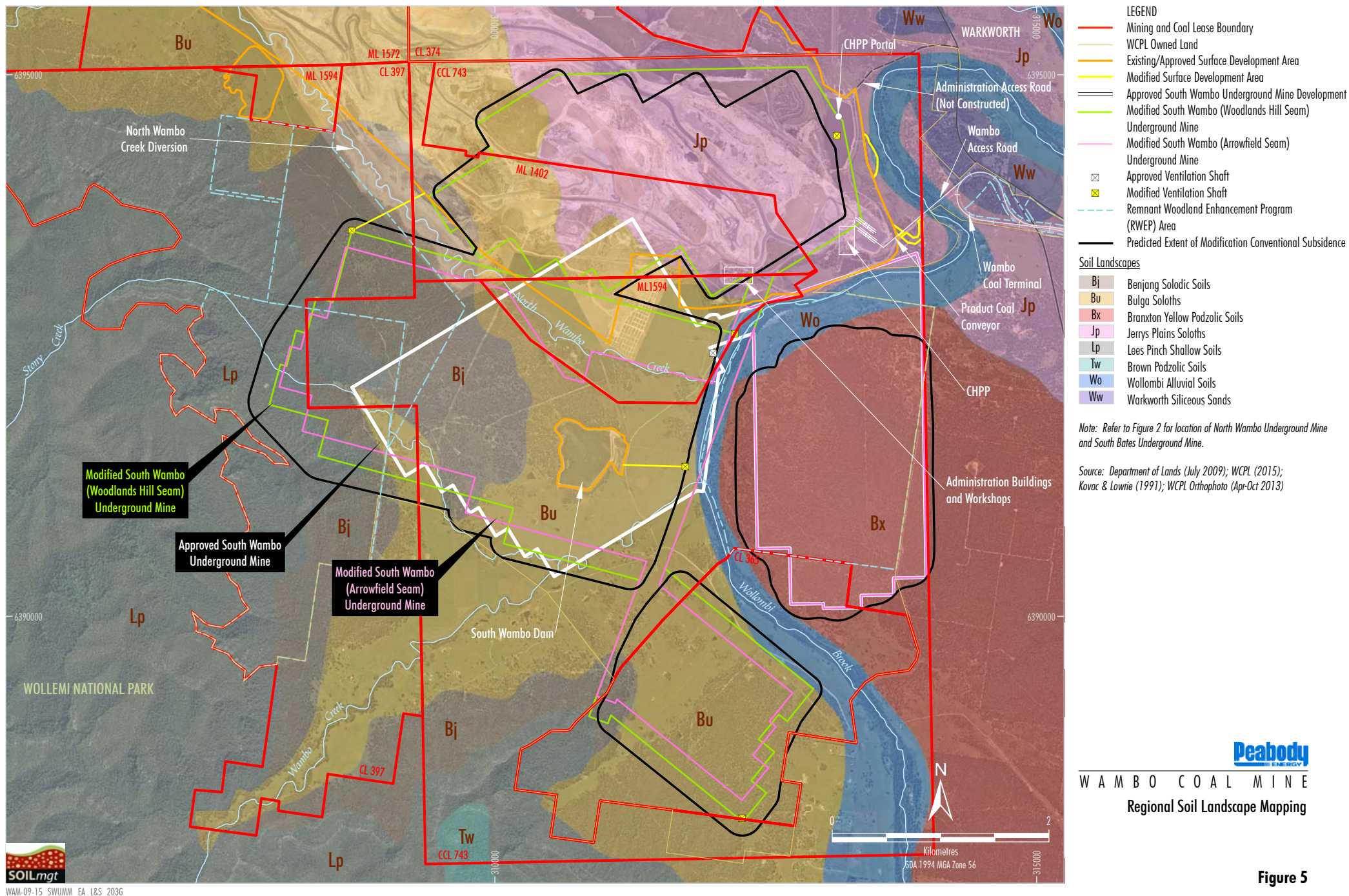


Figure 5

Table 2. Soil Landscape Units (Kovac and Lawrie 1991) Mapped in the Modification Area

Soil Landscape Unit	Soil Types Present	Likely Constraints for Agricultural Production Based on these Descriptions
Wollombi Alluvial Soil (Wo)	Layered alluvial soils (sands and earthy sands).	Poor water holding capacity, acidity and a lack of nutrients. Prone to wind erosion.
Bulga Soloths (Bu)	Yellow Soloths on upper to midslopes; sometimes Yellow and Brown Solodic Soils and Brown Earths on lower slopes.	Poor aeration in subsoils when wet, very hard when dry. Prone to water erosion when bare.
Benjang Solodic Soils (Bj)	Yellow, Red and Brown Solodic Soils on imperfectly drained benched slopes, with Brown Podzolic Soils on upper slopes and Non-calcic Brown Soils on lower parts of flatter slopes.	Poor aeration in subsoils when wet, very hard when dry. Prone to water erosion when bare.
Branxton Yellow Podzolic Soils (Bx)	Yellow Podzolic Soils on midslopes with Red Podzolic Soils on crests; Yellow Soloths on lower slopes.	Poor aeration in subsoils when wet, very hard when dry. Prone to water erosion when bare.
Lees Pinch Shallow Soils (Lp)	Shallow Silicious Sands, some Yellow and Brown Earths on footslopes. Yellow and Grey Soloths in breaks of slope. Yellow Podzolic Soils and Earthy Sands on some upper slopes.	Very poor water holding capacity, acidity and a lack of nutrients. Prone to water erosion when bare.
Jerrys Plains Soloths (Jp)	Soloths on crests to midslopes with Solodic Soils on lower slopes and in drainage lines. Red Earths on some upper slopes, Brown Clays in midslope depressions and some Solodised Solonetz on poorly drained slopes.	Poor aeration in subsoils when wet, very hard when dry. Prone to water erosion when bare.

eSPADE Soil Profile Database

A search of the NSW Government’s eSPADE website (part of the NSW Natural Resource Atlas) was conducted to identify any existing soil profile information. Seven soil profiles were identified within the Modification Area (Figure 3). Six of these soil profiles are located on land now disturbed by the Wambo Open Cut (SPADE Test Pits 21-24, 27 and 28). The remaining soil profile (SPADE Test Pit 102) did not have laboratory data. Therefore, no eSPADE soil profiles with adequate profile descriptions or laboratory analyses are available for the Modification.

Acid Sulfate Soil Mapping

The acid sulfate soil risk map data (part of the NSW Natural Resource Atlas) were reviewed for the Modification. No acid sulfate soils are mapped within the vicinity of the Modification Area and therefore mapping has not been reproduced in this report.

Given the above, the *Acid Sulfate Soils Manual* (Stone *et al.* 1998) and the *Acid Sulfate Soils Laboratory Methods Guidelines* (Ahern *et al.* 2004) have not been considered further.

4.2. Soil Survey Methodology

Field Survey

The field survey was conducted in three stages:

- Stage 1 (11-13 April 2012) – Pits 8-10, 13, 15, 16, 19-21, 23, 25, 28, 29 (13 soil inspection pits);
- Stage 2 (30 May 2012) – Pits 11, 12, 17 and 18 (four soil inspection pits); and
- Stage 3 (13-14 October 2015) – Pits 1-7, 14, 22, 24, 26, 27 (12 soil inspection pits).

Pits 10, 11, 12, 15, 17, 18, 19 and 21 were included in the McKenzie Soil Management (2012b) study.

The soil survey stages were carried out by Dr David McKenzie. He has Certified Professional Soil Scientist Stage 3 accreditation from Soil Science Australia and a PhD in soil science. Dr McKenzie also has 'Chartered Scientist' accreditation with the British Society of Soil Science.

The soil pits (Figure 3) were located in order to cover as many of the major variations in geology, vegetation type, elevation and topography as possible. However, the main focus was on cleared agricultural land.

A backhoe was used to excavate the soil pits (approximately 1.4 m deep; shallower where hard rock was encountered) across the Modification Area.

A Garmin 'GPSmap 62S' instrument with an accuracy of approximately ± 4 m was used to record the pit coordinates (Appendix 1).

The soil pits were trimmed with a geological pick to allow photography (Appendix 2) and description of the undisturbed structure and root growth. On the alluvial areas, additional pits were dug to a greater depth and immediately refilled to allow collection of deeper soil samples (where possible, to a depth of 3 m).

The field description methods were as described in the 'Australian Soil and Land Survey Field Handbook' (National Committee on Soil and Terrain 2009) and the 'Guidelines for Surveying Soil and Land Resources, Chapter 29' (McKenzie *et al.* 2008). The soil profiles have been classified (Appendix 1) according to the Australian Soil Classification (ASC) (Isbell 2002).

Field Soil Observations/Testing

The following characteristics were assessed for the layers identified in each of the soil profiles (Appendix 3):

- thickness of each layer (horizon);
- soil moisture status at the time of sampling;
- pH (using Raupach test kit);
- colour of moistened soil (using Munsell reference colours);
- pedality of the soil aggregates;
- amount and type of coarse fragments (gravel, rock, manganese oxide nodules);
- texture (proportions of sand, silt and clay), estimated by hand;
- presence/absence of free lime and gypsum;

- root frequency; and
- dispersibility and the degree of slaking in deionised water (after 10 minutes).

The soil structure information (Appendix 4) has been summarised to give SOILpak 'compaction severity' scores (McKenzie 2001). This allows deep tillage recommendations to be made from the structure observations. The score is on a scale of 0.0 to 2.0, with a score of 0.0 indicating very poor structure for crop root growth and water entry/storage. Ideally, the SOILpak score of the root zone should be in the range 1.5 to 2.0.

Hand texturing (National Committee on Soil and Terrain 2009) provides an approximation of the clay content of a soil. In conjunction with the estimation of coarse fragment (gravel) content, it provides a low-cost alternative to particle size analysis.

Total available water (TAW) for the upper 1 m of soil (Appendix 2) has been estimated using texture, structural form and coarse fragment content data (McKenzie *et al.* 2008).

Laboratory Soil Testing

All of the pits were sampled for laboratory analysis. The sampling intervals for laboratory analysis were 0-15 centimetres (cm); 15-30 cm; 30-60 cm; 60-90 cm; and in some cases 2 m and 3 m.

The soil from these pits was analysed by Incitec-Pivot Laboratory, Werribee Victoria for exchangeable cations, pH, electrical conductivity, chlorides, nutrient status (nitrate-nitrogen, phosphorus, sulfur, zinc, copper, boron) and organic matter content. An ammonium acetate method was used for the extraction of exchangeable cations. The cation exchange capacity (CEC) values are the sum of exchangeable sodium, potassium, calcium, and magnesium. Phosphorus was determined using the Colwell method, sulphur by the CPC method, boron by a calcium chloride (CaCl₂) extraction and zinc/copper by a DTPA extraction (see Rayment and Lyons [2011] for further details). The conversion factors of Slavich and Petterson (1993) allowed the electrical conductivity of saturated paste extracts (EC_e) to be calculated from the electrical conductivity of 1:5 soil:water suspensions (EC_{1:5}) and texture.

Soil dispersibility, as measured by the Aggregate Stability in Water (ASWAT) test (Field *et al.* 1997), was assessed by Soil Management Designs in Orange, NSW. The results are presented in Appendix 5. The ASWAT test has been related to the well-known Emerson aggregate stability test by Hazelton and Murphy (2007) (Table 3). An advantage of the ASWAT test is that the results can be linked with management issues such as the need for gypsum application and avoidance of wet working (McKenzie 2013) (Figure 6).

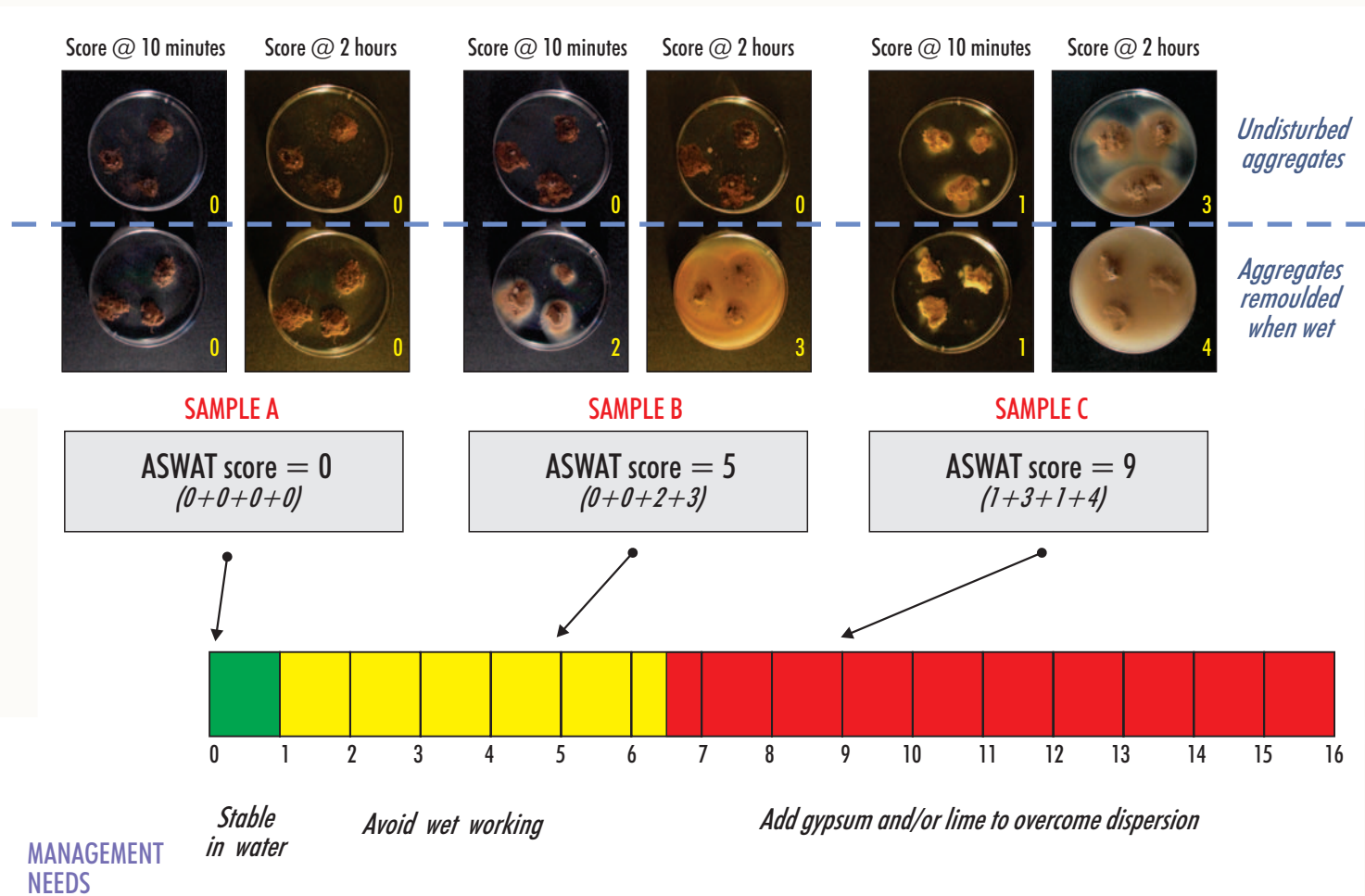


Table 3. The Relationship between the Emerson Aggregate Stability Test and the ASWAT Test

Dispersibility	Emerson Aggregate Classes	Probable Score for the ASWAT Test (Field <i>et al.</i> 1997)
Very high	1 and 2(3)	12-16
High	2(2)	10-12
High to moderate	2(1)	9-10
Moderate	3(4) and 3(3)	5-8
Slight	3(2), 3(1) and 5	0-4
Negligible/aggregated	4, 6, 7, 8	0

The laboratory results are presented in Appendix 5.

The following key soil factors are attached in the form of colour coded maps (see back of report):

Map 1. Soil Types (Australian Soil Classification).

Map 2. Depth to Rock.

Map 3. Plant Available Water (TAW).

Map 4. Depth to Mottled Layer.

Map 5. Depth to Layer with Lime.

Map 6a. Dispersion (ASWAT score).

Map 6b. Dispersion (ESP value).

Map 6c. Dispersion (ESI value).

Map 7. Compaction Severity (SOILpak scores).

Map 8. Cation Exchange Capacity.

Map 9. Salinity (Electrical Conductivity).

Map 10. pH (CaCl₂).

Map 11. Phosphorus (Colwell P).

Map 12. Organic Carbon.

4.3. Soil Types and Mapping

Soil Landscape Units

Soil Landscape Units within the Modification Area that host the soil types described in the next section are described in Table 4 and presented on Figure 7. The Soil Landscape Unit is an association of soils described and delineated by means of landforms (Dent and Young 1981). The names of the Soil Landscape Units are as per Kovac and Lawrie (1991) but the boundaries are different based on the more detailed data collected for this report.

ASC Soil Types

The ASC (Isbell 2002) has been used to determine soil types at each of the 29 soil pits (Map 1). Photographs of representative soil profiles identified during the survey are presented in Figure 8 (for each Soil Landscape Unit and ASC soil type described below).

Table 4. Soil Types Associated with the Soil Landscape Units

Soil Landscape Unit	Number of Sites	Map Code	Dominant Soil Types	Sub-dominant Soil Types	Additional Comments
Wollombi Alluvial Soil (Wo)	11	Wo	Stratic Rudosol	Dermosol	Deep young soil with favourable subsoil conditions for root growth
Bulga Soloths (Bu)	12	Bu	Sodosol	Kandosol, Vertosol	Poor root growth in subsoil due to sodicity
Benjang Solodic Soils (Bj)	3	Bj	Sodosol, Tenosol, Kandosol	-	Poor root growth in subsoil due to sodicity
Branxton Yellow Podzolic Soils (Bx)	1	Bx	Sodosol	-	Poor root growth in subsoil due to sodicity
Lees Pinch Shallow Soils (Lp)	1	Lp	Tenosol	-	Mostly shallow soil with poor water holding capacity

Soil profile photographs for the 29 sites are presented in Appendix 2.

Total numbers of the contrasting ASC soil types, and the equivalent Great Soil Group (Stace *et al.* 1968) terminologies used by Kovac and Lawrie (1991), are shown in Table 5.

The soil types in Table 5 have the following characteristics:

- Rudosols are derived from recently deposited materials that have only minimal profile development.
- Sodosols have strong texture contrast between topsoil and subsoil, and the B horizon is sodic (Exchangeable Sodium Percentage [ESP] of 6 or greater).
- Kandosols lack strong textural contrast and have a massive or only weakly structured B horizon.
- Tenosols at this location are shallow and have only weak pedological development.
- Dermosols lack a strong texture contrast between the A and B horizons and have moderately to strongly structured B2 horizons.
- Vertosols are clay soils with shrink-swell properties that exhibit strong cracking when dry.
- Anthrosols are soils strongly modified by human activity.

Table 5. Soil Types Identified; Classified According to the ASC and Great Soil Groups

ASC Soil Type	Number of Sites	Great Soil Group Equivalent
Rudosol	11	Alluvial Soils
Sodosol	8	Solodic Soils, Soloths
Kandosol	4	Calcareous Red Earths
Tenosol	3	Lithosols
Dermosol	1	Red Podzolics
Vertosol	1	Red, Brown and Grey Clays
Anthrosol	1	n/a

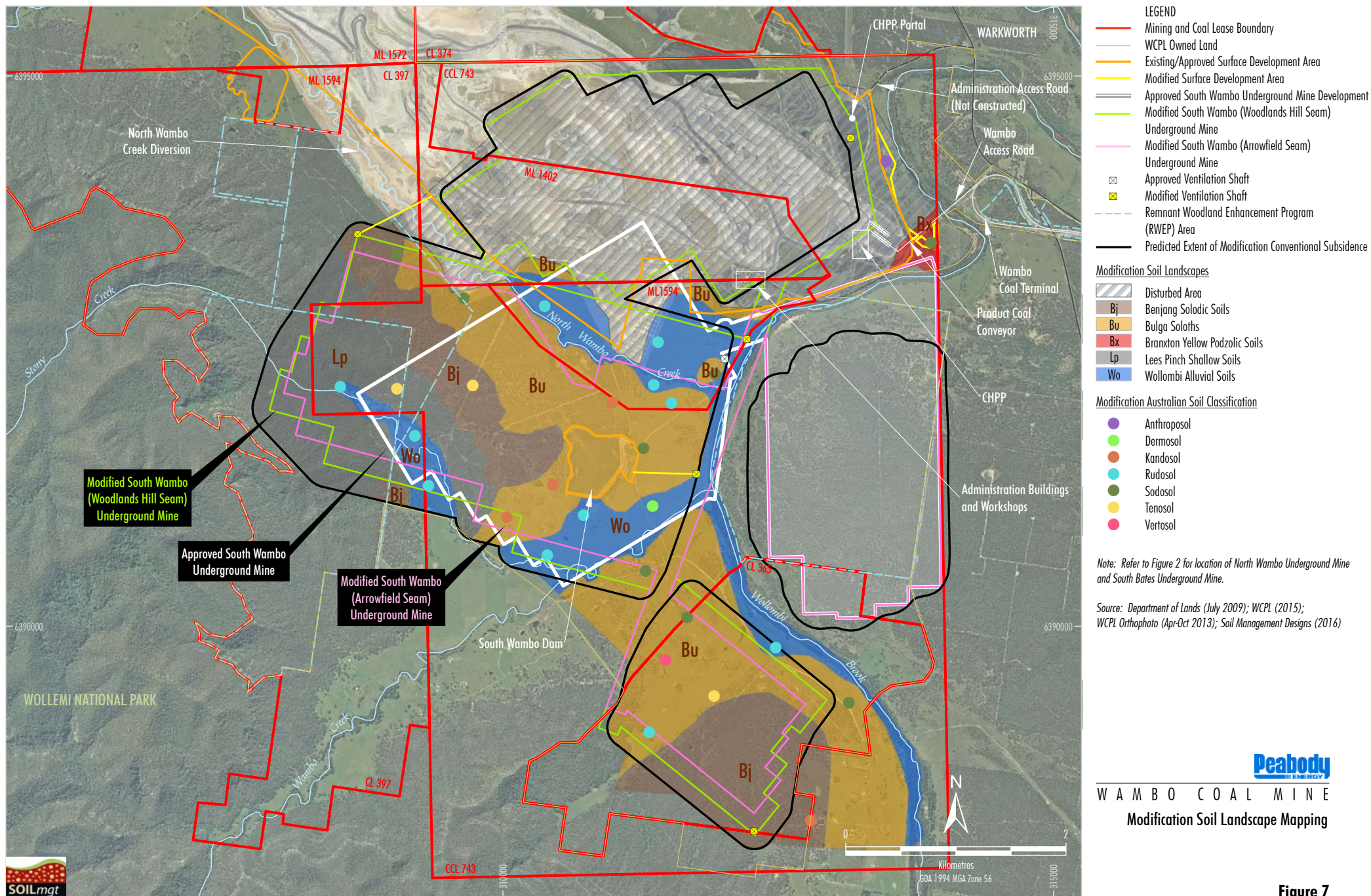


Figure 7

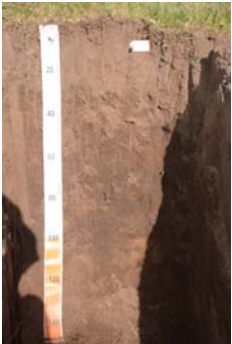
Soil Landscape Unit	Dominant soil	Sub-dominant soil	Landscape view
Wollombi Alluvial Soil	Pit 14: Stratic Rudosol 	Pit 20: Dermosol 	Site 14 
Bulga Soloths	Pit 22: Sodosol 	Pit 18: Kandosol Pit 24 Vertosol  	Site 22 
Benjang Solodic Soils	Pit 1 Sodosol 	Pit 9 Tenosol  Pit 29 Kandosol 	Site 1 
Branxton Yellow Podzolic Soils	Pit 6 Sodosol 		Site 6 
Lees Pinch Shallow Soils	Pit 8 Tenosol 		Site 8 

Figure 8. Photographs of Soil Types and Landscapes Associated with each Soil Landscape Unit.

4.4. Soil Conditions for Plant Growth

Soil Depth, Texture and Waterholding Capacity

The impact across the Modification Area of profile shallowness/stoniness and sandiness on the ability of the soil to store plant available water (measured as TAW) is shown in Appendix 1 and on Map 3. As soil becomes shallower, stonier and/or sandier, its ability to store water declines (White 2005).

Plants are more likely to suffer drought stress where soil has a poor water storage capacity, particularly in hot weather with extended dry periods between rainfall events. Within the Modification Area, the lack of water holding capacity in shallow/stony soils is a significant constraint to agricultural productivity.

The deeper alluvial soil tended to have very good water holding capacity because of a combination of minimal coarse fragments and favourable soil structure.

Waterlogging Hazard

Much of the sodic subsoil in the Modification Area showed signs of waterlogging. When soil is waterlogged, several adverse processes take place (Batey 1988):

- The lack of oxygen reduces the ability of plant roots to function properly.
- Anaerobic conditions can cause large losses of soil nitrogen to the atmosphere.
- Near-surface waterlogging is associated with inefficient storage of water due to excessive evaporation losses.

An indicator of waterlogging in the field is the presence of mottling (Map 4). Mottles are blotches of sub-dominant colours different from the matrix colour; for example, grey or yellow blotches within a reddish-brown subsoil. The impedance of internal drainage that creates mottling is usually caused either by impermeable rock close to the surface or dispersive subsoil. Mottling sometimes is associated with the presence of black manganiferous nodules or concretions.

Slow deep drainage is associated with accumulation of naturally occurring lime. Depth to lime is shown in Map 5.

Soil Stability in Water – Dispersion and Slaking

Poor soil structure in the Modification Area was associated with instability in water caused by dispersion. Dispersion is the separation of soil micro-aggregates into sand, silt and clay particles, which tend to block soil pores and create problems with poor aeration (Levy 2000). Excessive hardness then becomes a problem when the soil is dry. Dispersion is a process with the potential to reduce root growth and adversely affect profitability of most crop and pasture enterprises.

Dispersion may be associated with slaking, which is the collapse of soil aggregates to form micro-aggregates under moist conditions (So and Aylmore 1995). Slaking is associated with a lack of organic matter, which is important for the binding of soil micro-aggregates.

Soil prone to slaking, and particularly dispersion, is much more likely to be lost by water erosion than stable soil. This is because the soil tends to seal over under moist conditions and lose water as runoff, rather than taking in the water for storage in the subsoil (So and Aylmore 1995).

Three maps relating to soil stability in water are presented (Maps 6a, 6b and 6c). The ASWAT score (Map 6a) shows how prone the soil is to dispersion under conditions that existed when the soil was sampled (Field *et al.* 1997). The 'working when wet' procedure that is part of the ASWAT test is a simulation of processes such as raindrop impact on wet soil and the cutting/stockpiling of moist soil. Dispersion was evident in the sub-surface (15-30 cm) and subsoil (30-60 cm) across much of the Modification Area. The near-surface dispersion problems can be overcome in a cost-effective manner through gypsum application, or by use of gypsum-lime blends where soil pH is acidic or neutral.

An important chemical factor influencing the behaviour of clay particles in unstable soils is moderate amounts of ESP (Map 6b), aggravated by low electrolyte concentrations (Levy 2000). Map 6c (electrochemical stability index [ESI]; $EC \div ESP$) highlights sites affected by this process.

Compaction Status

Compaction was assessed in this study using the SOILpak scoring system (Map 7). Most of the alluvial soil (Stratic Rudosols) in the Modification Area had a favourable soil structural form (i.e. high SOILpak score). However, most of the non-alluvial soil had subsoil compaction problems, caused apparently by the natural dispersion problems.

Compaction can strongly restrict plant growth because of poor water entry, poor efficiency of water storage, waterlogging when moist, and poor access to nutrients by plant roots (McKenzie 1998).

Structure Self-repair Ability

The ability of a soil to overcome compaction through shrinking and swelling induced by wet-dry cycles (soil structural resilience) can be estimated via CEC values (Map 8) (McKenzie 1998). Much of the soil in the Modification Area had a moderately favourable capacity for self-repair capacity via shrink-swell processes, but the benefits are short-lived when the soil develops poor structural form because of dispersion in water.

Salt Concentrations

Subsoil salinity (Map 9) was an important constraint to plant growth in Sodosols and Kandosols associated with the 'Bulga' and 'Benjang' soil landscape units in the Modification Area.

pH Imbalance

Much of the topsoil and some subsoil in the Modification Area was acidic (Map 10) and are likely to respond well to the application of agricultural lime.

Nutrients

The topsoil and subsoil in the Modification Area was strongly deficient (from an agricultural point of view) in phosphorus (Map 11). Application of P-fertiliser is likely to produce significant improvements in pasture productivity. Nutritional data in Appendix 5 indicates a lack of sulphur and possibly potassium in some of the alluvial soil, copper deficiency in some of the Sodosols, and a widespread lack of nitrogen.

Soil Carbon and Soil Biological Health

The relatively high organic carbon concentrations in much of the topsoil (0-15 cm) in the Modification Area (Map 12) provide beneficial soil organisms with a ready supply of food. However, the organic carbon content of deeper layers was mostly poor, particularly in the non-alluvial soil.

Summary of Soil Limitations

The following soil limitations were identified across the non-alluvial sections of the Modification Area:

- poor waterholding capacity in shallow/stony soils;
- waterlogging in subsoil;
- dispersive subsoil;
- compaction in subsoil;
- salt concentrations in some areas;
- acidic topsoil and subsoil;
- nutrient deficiency in topsoil and subsoil; and
- poor organic content in deeper layers of soil.

The alluvial soil in the Modification Area had much better physical conditions for plant growth (higher water holding capacity, minimal waterlogging, soft when dry) than the non-alluvial areas, but there was a lack of sulphur and possibly potassium.

5. AGRICULTURAL RESOURCES

Strategic Agricultural Land

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) includes mapping of lands identified as Biophysical Strategic Agricultural Land (BSAL). The closest mapped BSAL in the Mining SEPP is associated with the Hunter River and is located more than 4 km to the north-east of the Modification Area (Figure 9).

The Modification Area is not located within mapped Viticulture Critical Industry Clusters (Figure 9). The closest Viticulture Critical Industry Cluster is located approximately 0.6 km to the south of the Modification Area (Figure 9).

The alluvial soil examined in this study has favourable characteristic for plant growth (see next section). However, only one site (Pit 20; Red Dermosol) had BSAL characteristics (Appendix 1). It is noted that Pit 20 is located inside the approved South Wambo Underground Mine area. The other alluvial sites were classified as Stratic Rudosols which, according to the 'Interim Protocol' (NSW Government 2013), are not BSAL.

Land and Soil Capability

The *Land and Soil Capability Assessment Scheme – Second Approximation* (OEH 2012) (the LSC Assessment Scheme) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards (OEH 2012). The LSC class gives an indication of the land management practices that can be applied to a parcel of land. The LSC classes are outlined below (OEH 2012).

Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)

Class 1: Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.

Class 2: Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.

Class 3: High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)

Class 4: Moderate capability land: 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.

Class 5: Moderate–low capability land: 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.

Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)

Class 6: Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.

Land generally incapable of agricultural land use (selective forestry and nature conservation)

Class 7: Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.

Class 8: Extremely low capability land: 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.

Regional land and soil capability mapping prepared by the OEH (2012) is presented in Figure 10.

Based on the results of the soil survey, each soil pit was allocated an LSC rating. LSC ratings for the Modification Area are shown on Figure 10. Much of the alluvial soil has LSC Class 3.

Agricultural Land Uses

All cleared areas were under pasture. Both native and introduced pasture species were observed. Pasture productivity was greater on the deep well-drained alluvial soil (Stratic Rudosols) than on the upslope sodic areas.

Some of the timbered areas appeared to be revegetation zones following failed attempts at pasture production, for example the sodic area represented by Pit 1.

Agricultural Productivity

The main agricultural land uses in the vicinity of Wambo include dairy and beef cattle and pasture production, horse breeding, viticulture and wine making (NSW Government, 2012).

Agricultural enterprises known to have been conducted on the Modification Area include cattle grazing for beef production on rain-fed pastures. The DPI Gross Margin Budget for ‘North Coast Weaners – Unimproved Land’ (DPI 2012) provides the best published estimate of productivity in most of the non-alluvial Modification Area. The productivity of these agricultural enterprises is summarised in Table 6.

Table 6. Approximate Productivity of the Agricultural Enterprises on the South Wambo Underground Mine Modification Area

Enterprise	Stocking Rate (Dry Sheep Equivalents per hectare)	Gross Margin (Dollars per hectare per year)
Beef cattle grazing (weaners) on unimproved pastures or low productivity improved pastures; conducted on the majority of agricultural areas within the Modification	4	61.33
Beef cattle grazing (weaners) on medium productivity “improved” pastures; alluvial zones (‘Wollombi Alluvial Soils’)	8	176.57

It was observed during the field work in 2012 and 2015 that the alluvial zone (‘Wollombi Alluvial Soils’; LSC Class 3) had much better growth of native and introduced pasture species than the shallower sodic soil. This occurred despite the alluvial zone nutritional limitations noted in Section 4.4. Therefore, two contrasting categories have been included in Table 6.

6. AGRICULTURAL RESOURCES IMPACT ASSESSMENT

6.1. *Potential Impacts*

Potential impact mechanisms on agricultural resources as a result of the Modification are likely to be associated with:

- loss of productive agricultural land due to the minor extension to the surface development area; and
- subsidence-related impacts.

Surface Development

The Modification would result in a minor extension (approximately 7.9 hectares [ha]) to the Wambo surface development area to allow for the development of additional surface infrastructure. Approximately 4.5 ha of this surface development area extension consists of derived grassland (FloraSearch, 2016) which would be suitable for agricultural uses (i.e. grazing). The remainder of the surface development area extension is vegetated (FloraSearch, 2016) (i.e. trees) and would not be suitable for agricultural uses. This agricultural land in the surface development areas consists primarily of LSC Class 4 and 5 (Figure 10).

Following the cessation of mining, surface infrastructure would be decommissioned and the disturbed land would be rehabilitated to woodland or agricultural areas suitable for grazing. As such, disturbance associated with the Modification surface infrastructure would result in either temporary or permanent impacts to potential agricultural production on WCPL owned land depending on the selected final land use.

Additional disturbance for gas management infrastructure would occur progressively over the life of the modified Wambo. The locations of gas management infrastructure are flexible and would be located in order to minimise potential impacts on agricultural productivity. Any disturbance associated with gas drainage infrastructure would be progressively rehabilitated over the life of the modified Wambo.

These potentially impacted agricultural lands are not Biophysical Strategic Agricultural Land mapped in the Mining SEPP (Section 5). The area of potential high value or strategic agricultural land is located outside the minor extensions to the surface development area.

The minor extension to the Wambo surface development area would result in the following potential impacts to soil resources:

- disturbance of *in situ* soil resources;
- alteration of soil structure beneath infrastructure items, hardstand areas and roads;
- increased erosion and sediment movement due to exposure of soils during construction; and
- alteration of physical and chemical soil properties (e.g. structure, fertility, permeability and microbial activity) due to soil stripping and stockpiling operations.

Subsidence

Subsidence is the vertical and horizontal movement of the overburden and land surface as a result of the extraction of underlying coal. These land surface movements are generically referred to as subsidence effects. The type and magnitude of the subsidence effects is dependent on a range of variables (e.g. mine geometry, topography and geology).

MSEC (2016) has assessed the potential subsidence impacts of the Modification. Table 7 presents a comparison of the predicted cumulative subsidence effects from the approved mining layout (Arrowfield and Bowfield Seams) and the modified mining layout (Arrowfield and Woodlands Hill Seams), including the associated reactivation of existing workings in both the Whybrow and Wambo Seams.

Table 7. Comparison of Predicted Subsidence Effects for the Approved and Modified Mining Layouts

Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Hogging Curvature (km ⁻¹)	Maximum Predicted Sagging Curvature (km ⁻¹)
Approved Mining Layout (Arrowfield and Bowfield Seams)	9,000	90	> 3.0	> 3.0
Modified Mining Layout (Arrowfield and Woodlands Hill Seams)	6,250	75	> 3.0	> 3.0

Source: MSEC (2016).

mm = millimetre.

mm/m = millimetre per metre.

km⁻¹ = per kilometre.

The type and magnitude of predicted subsidence effects for the modified mine layout are generally similar to or less than those of the approved mine layout. This is due to the 'staggered' longwall layout of the Modification compared to the approved 'stacked' layout and slightly reduced extraction heights. It is therefore expected that the potential subsidence impacts above the Modification longwall panels would be generally similar in nature to those associated with the approved layout. The area of potential high value or strategic agricultural land is located within the approved South Wambo Underground Mine predicted extent of conventional subsidence and is therefore already approved to be impacted by subsidence. The predicted subsidence impacts in this area would reduce as a result of the Modification due to the modified 'staggered' longwall layout compared to the approved 'stacked' layout.

Subsidence may impact the integrity of agricultural infrastructure (e.g. fences) and potential impacts on soils and agricultural productivity would be associated with the following potential subsidence impacts:

- surface cracking;
- slope instability;
- ponding and changes in stream alignment; and
- ponding in poorly drained areas.

Notwithstanding, it is noted that Frazier et al. (2010) found no significant effect of longwall mining subsidence on agricultural production, including cattle grazing, in the Hunter Valley region. Given the above, there is a low potential for material impact to agricultural productivity in the Modification area.

WCPL would implement mitigation measures and management to minimise potential risks to land uses as described in Section 6.2.

Given the above, it is considered that the Modification would not have any significant adverse impacts on agricultural production in the Modification area.

6.2. Management Measures

Agricultural land resource management would include the following key components:

- minimisation of disturbance to agricultural lands, where practicable;
- continued use of adjoining WCPL-owned land for agricultural uses, where practicable;
- management of soil resources so that they can be used for rehabilitation; and
- inclusion of agricultural lands in the Wambo rehabilitation strategy.

The area of agricultural land disturbed at any one time would be minimised so that beneficial agricultural uses can continue to be undertaken on available WCPL grazing lands. As demonstrated by WCPL at Wambo, grazing agricultural activities can be readily undertaken in conjunction with the operation of a mine.

To minimise the potential direct impacts of the Modification on agricultural production, WCPL-owned agricultural lands that adjoin Wambo would continue to be subject to agricultural use.

Soil resource management measures that would be used are described below.

Following the cessation of mining, surface infrastructure would be decommissioned and the disturbed land would be rehabilitated to woodland or agricultural areas suitable for grazing.

Subsidence Impact Management

The existing North Wambo Underground Mine Extraction Plan (WCPL 2015) includes the following management measures in relation to potential land resource impacts:

- Notification to agistees of areas of longwall mining and active subsidence, and exclusion of agistment grazing from areas where surface cracking presents a reasonable risk to people and/or livestock.
- Remediation of surface cracks² where practicable using conventional earthmoving equipment (e.g. a backhoe), including:
 - infilling of surface cracks with soil or other suitable materials; or
 - local regrading and re-constructing the surface where hill steepness and water erosion hazard has increased.

² Minor cracks that develop are not expected to require remediation as weathering processes will result in the natural filling of these cracks over time.

- Stabilisation of any areas of surface fissuring using erosion protection measures (e.g. vegetation planting, gypsum application in erosion-prone sodic areas).
- Drainage works and rehabilitation of subsidence troughs (i.e. areas of induced ponding) as necessary. Where new ponds are useful as stock watering points, however, consider their retention.
- Repair of stock fences prior to allowing access for agistment grazing.
- Remediation of farm dams where it presents a risk to people, livestock and/or the environment.
- Management measures in accordance with the Erosion and Sediment Control Plan.

An Extraction Plan would be developed for the modified South Wambo Underground Mine with similar management measures.

Soil Resource Management

General soil management practices for the Modification surface development areas would include the stripping and stockpiling of soil resources for use in rehabilitation. The objectives of soil resource management for the Wambo site would be to:

- identify and quantify potential soil resources for rehabilitation;
- optimise the recovery of usable soil reserves during soil stripping operations;
- preferentially replace stripped soil directly on completed sections of the final landform;
- manage soil reserves so as not to degrade the resource when stockpiled; and
- establish effective soil amelioration procedures to maximise the availability and suitability of soil reserves for future rehabilitation works.

The following management measures would be implemented during the stripping of soils at the Project:

- Areas of disturbance requiring soil stripping would be clearly defined following vegetation clearing.
- Areas of disturbance would be stripped progressively, as required, to reduce potential erosion and sediment generation, and to minimise the extent of topsoil stockpiles and the period of soil storage.
- Topsoil and subsoil stripping during periods of high soil moisture content (i.e. following heavy rain) would be avoided to reduce the likelihood of damage to soil structure.
- In preference to stockpiling, wherever practicable, stripped soil would be directly replaced on completed sections of the final landforms.

Any long-term soil stockpiles would be managed to maintain long-term soil viability through the implementation of the following management practices as listed below:

- Soil stockpiles would be retained at a height of 2 m, with slopes no greater than 1:2 (vertical:horizontal) and a slightly roughened surface to minimise erosion.
- Topsoil stockpiles would be constructed to minimise erosion, encourage drainage, and promote revegetation.
- Wherever practicable, soil would not be trafficked, deep ripped or removed in wet conditions to avoid breakdown in soil structure.

- All topsoil and subsoil stockpiles would be protected with a non-persistent cover crop to reduce erosion potential as soon as practicable after completion of stockpiling. Where seasonal conditions preclude adequate development of a cover crop, stockpiles would be treated with a straw/vegetative mulch to improve stability.
- Soil stockpiles would be located in positions to avoid surface water flows. Silt stop fencing would be placed immediately down-slope of stockpiles until stable vegetation cover is established.
- An inventory of soil resources (available and stripped) on the Wambo site would be maintained and regularly reconciled with rehabilitation requirements.
- Weed control programmes would be implemented on soil stockpiles if required.

The Mining Operations Plan would be updated to describe the soil resource management measures that would be used during the Project life.

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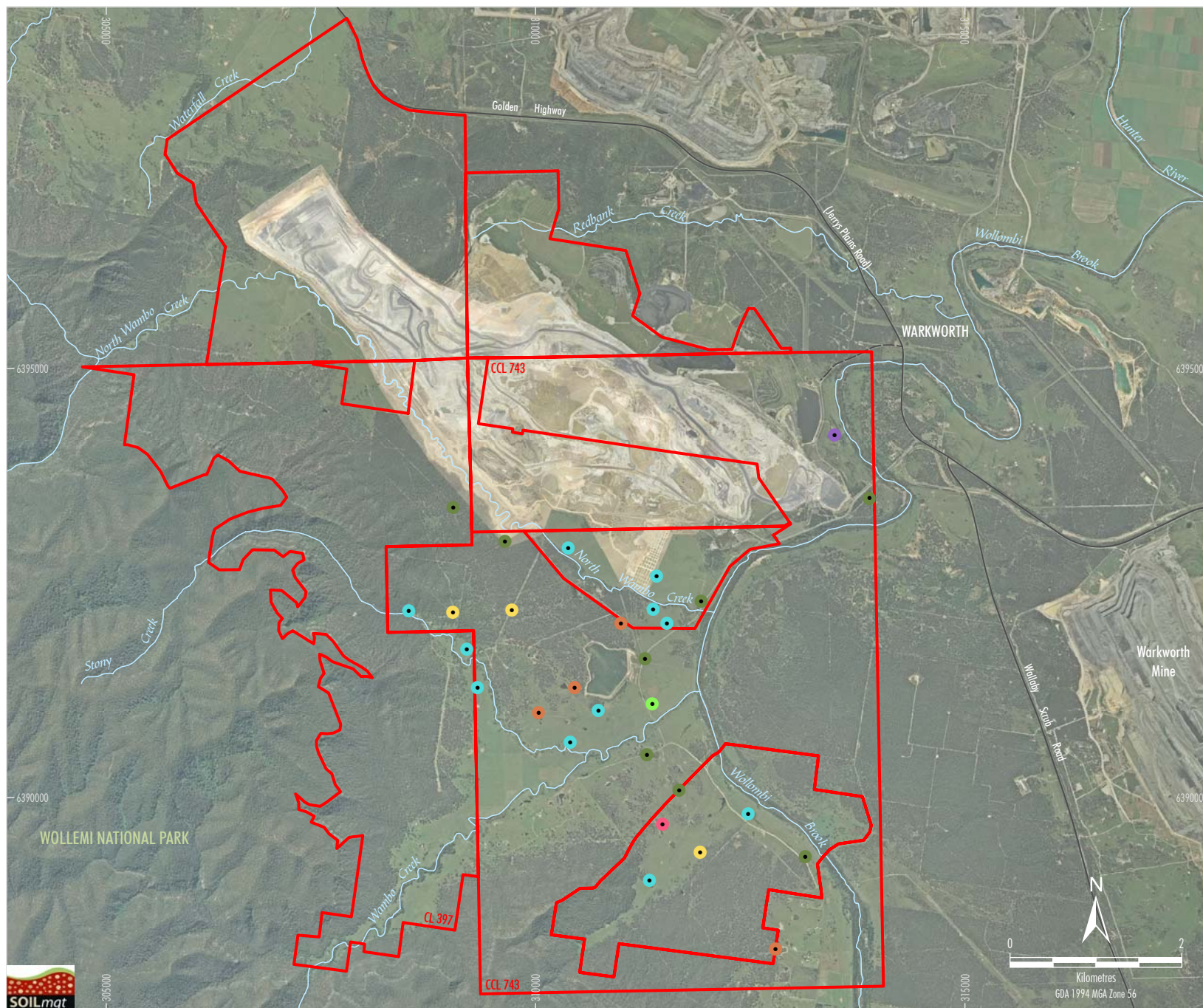
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- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - Anthroposol
 - Dermosol
 - Kandosol
 - Rudosol
 - Sodosol
 - Tenosol
 - Vertosol

Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody

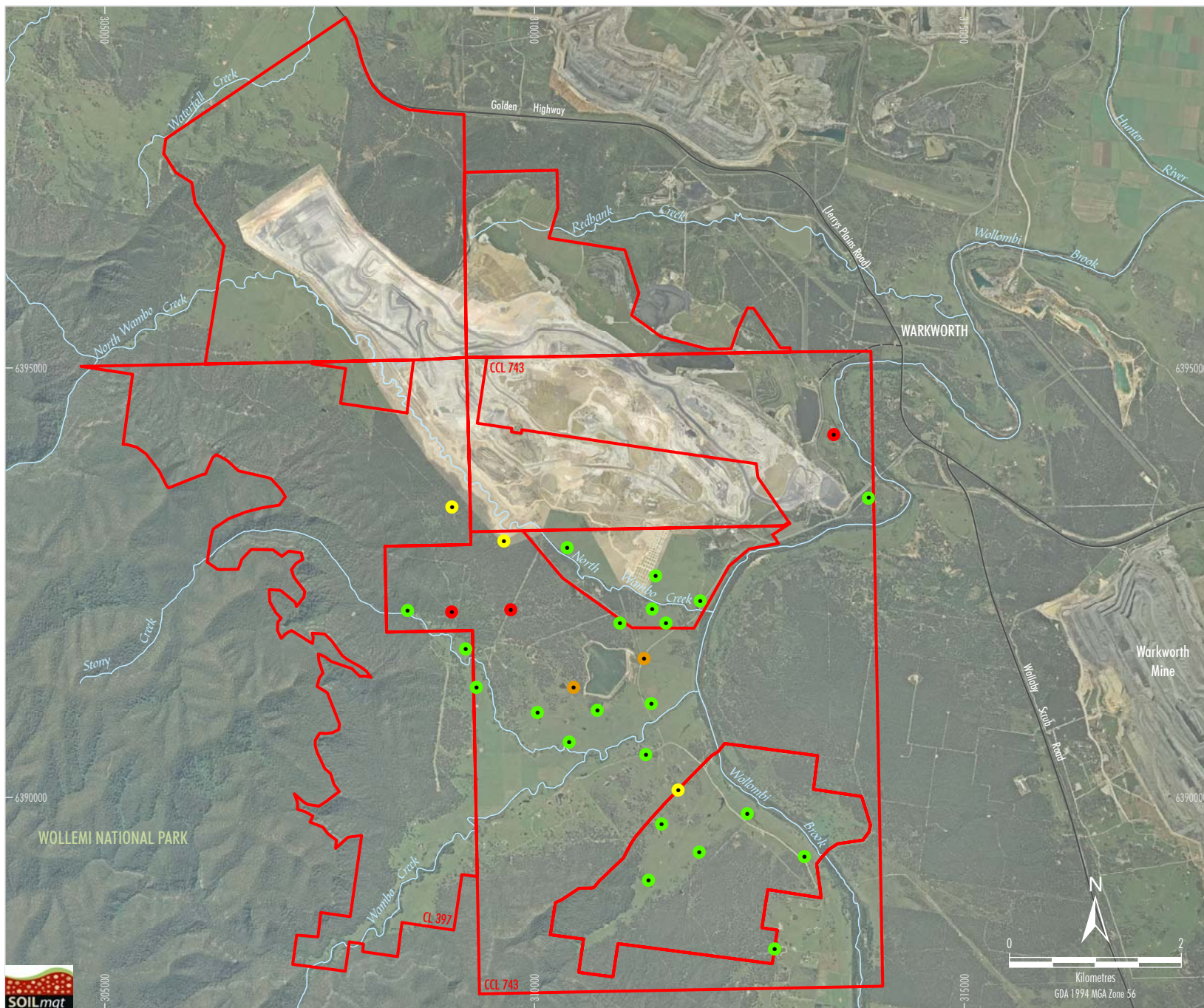
WAMBO COAL MINE

Soil Types - Australian Soil Classification

Map 1



WAM-09-15_SWUMM_EA_L&S_Soil_201C

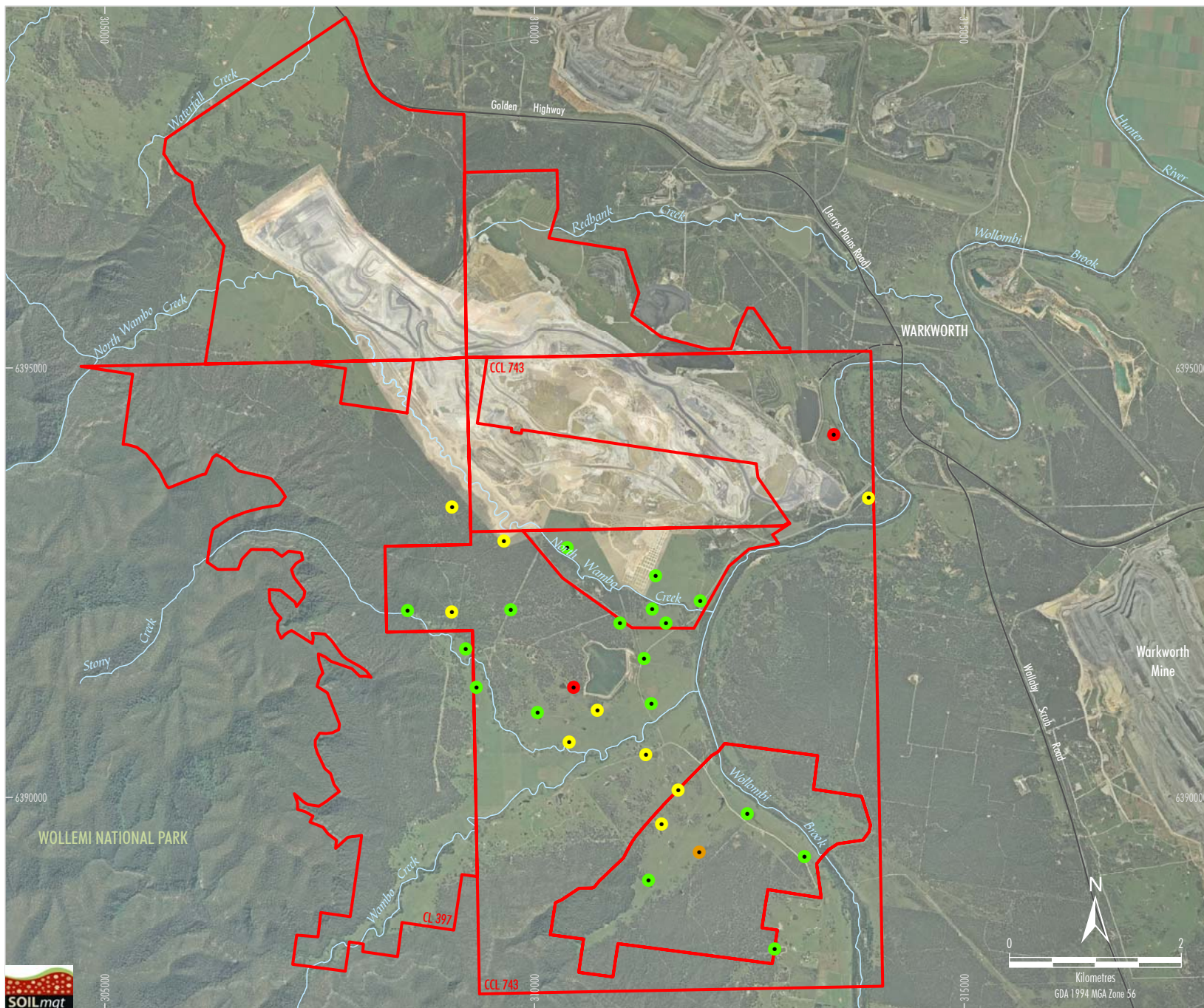


- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - < 50 cm
 - 50-75 cm
 - 76-100 cm
 - > 100 cm

Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Depth to Rock

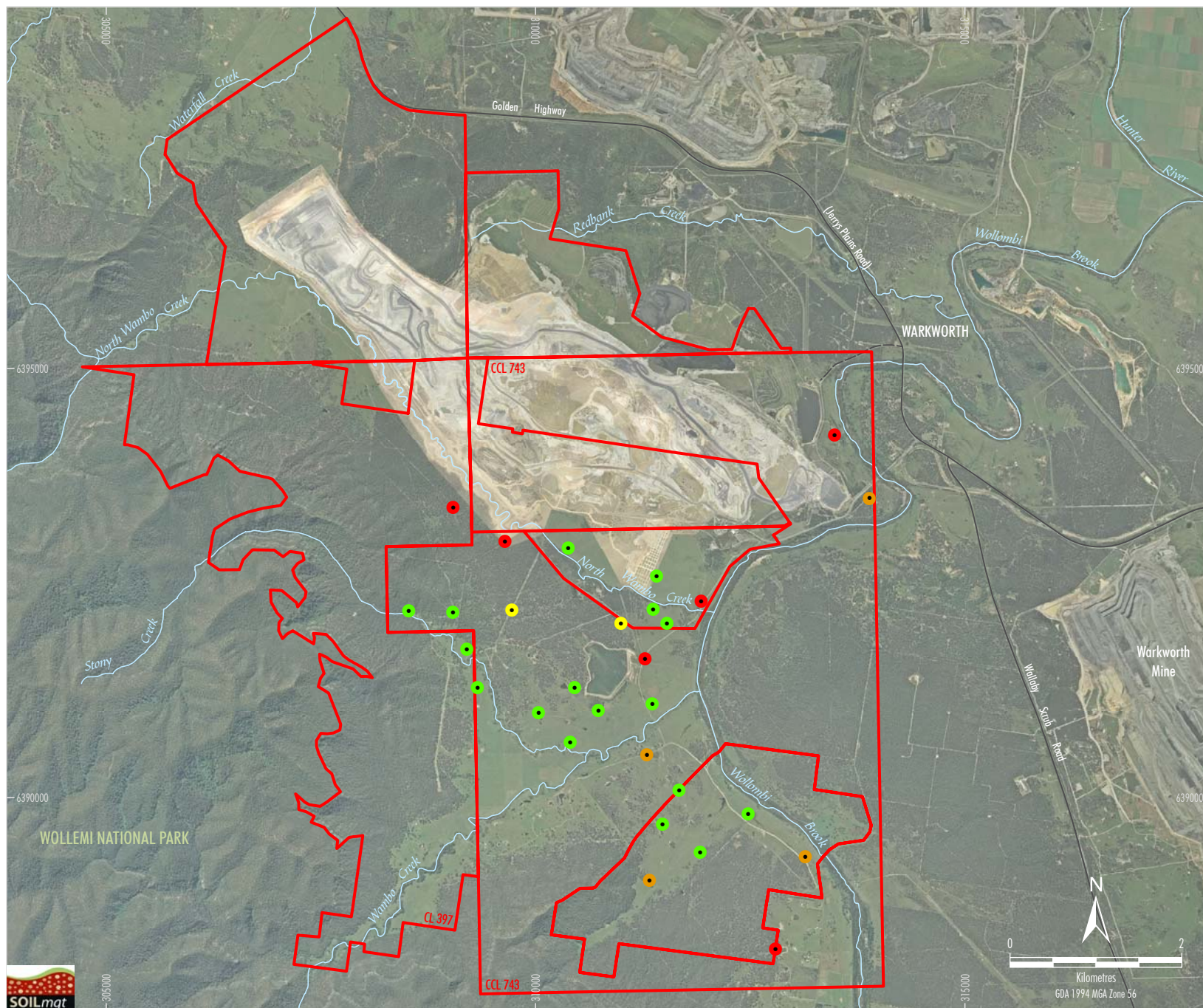




- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <50 mm/m
 - 50-75 mm/m
 - 76-100 mm/m
 - >100 mm/m

Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Plant Available Water (TAW)

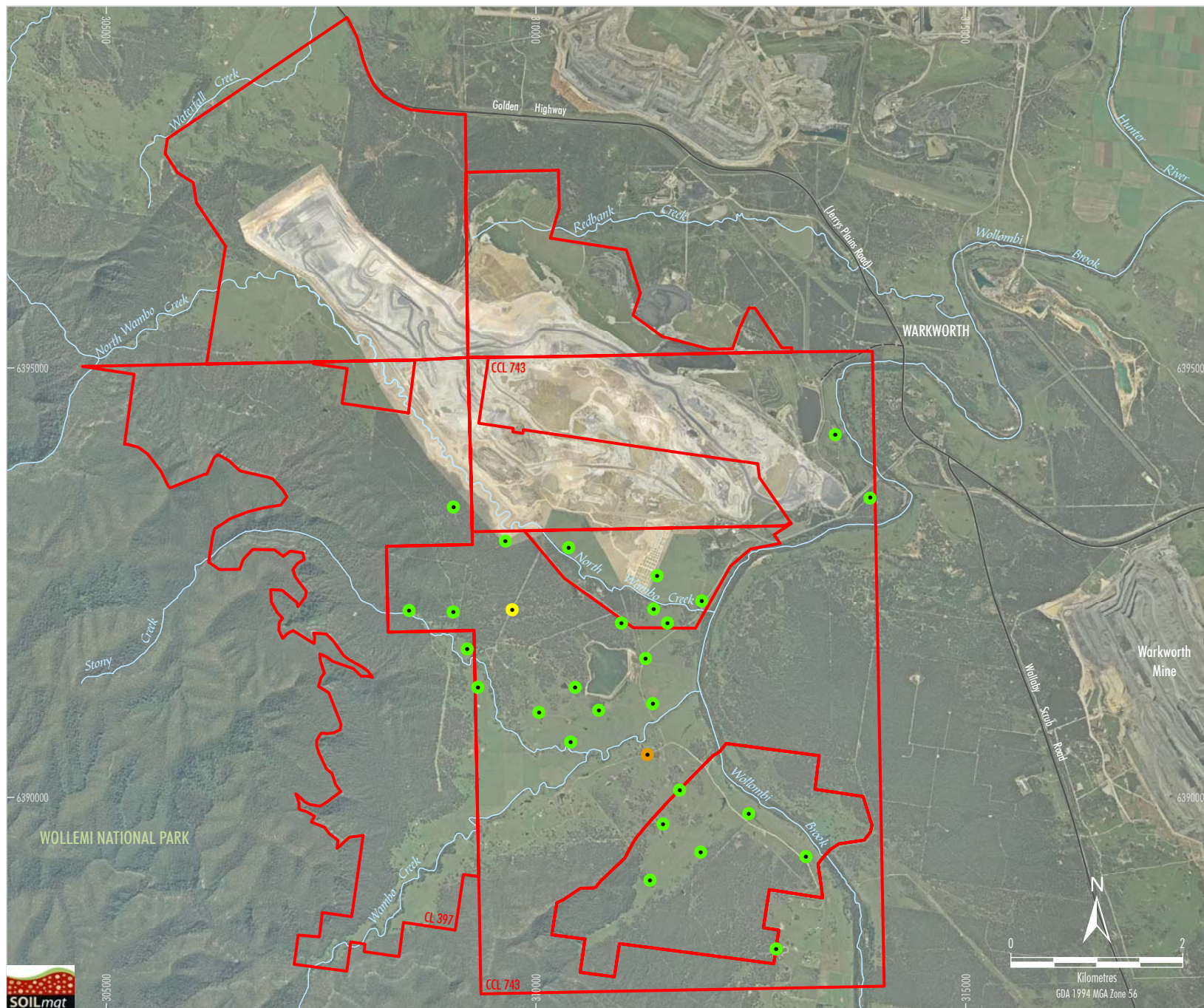


- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <50 cm
 - 50-75 cm
 - 76-100 cm
 - >100 cm

Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Depth to Mottled Layer



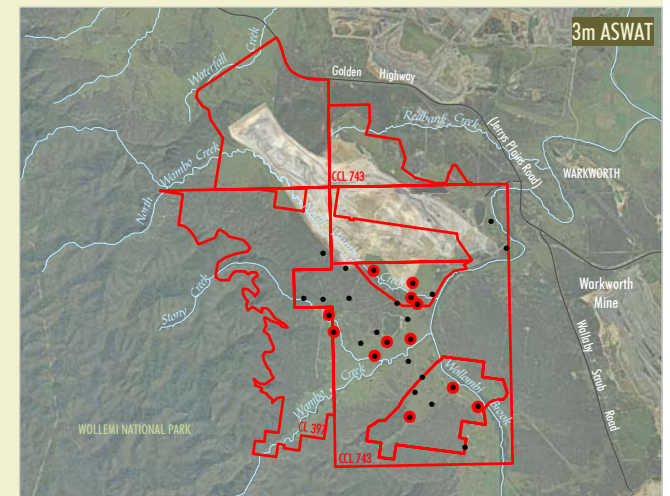
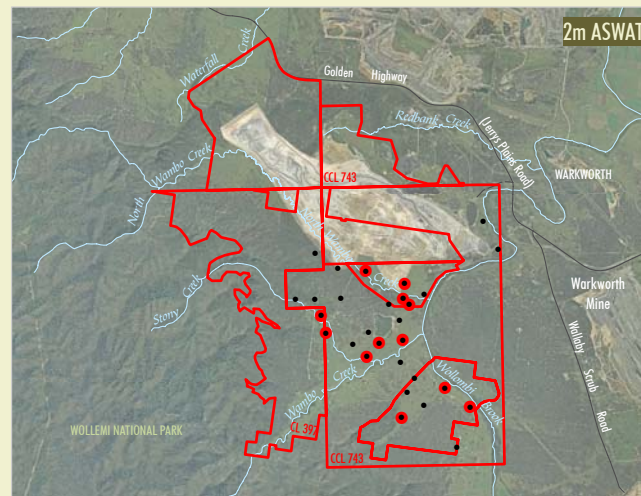
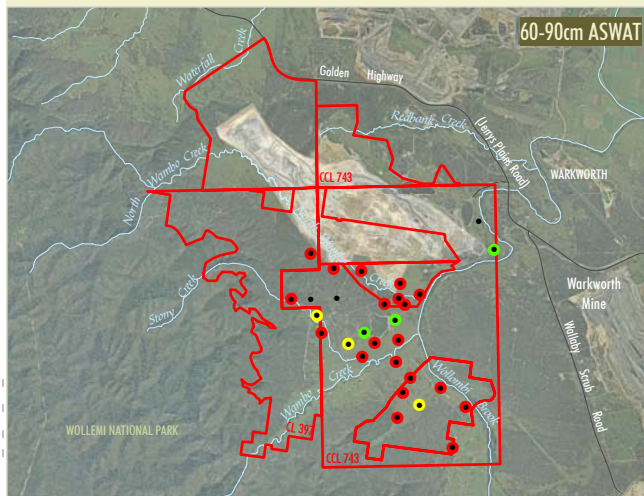
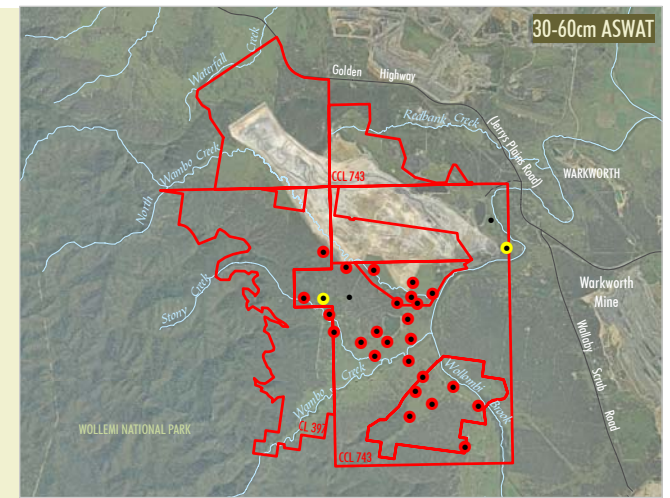
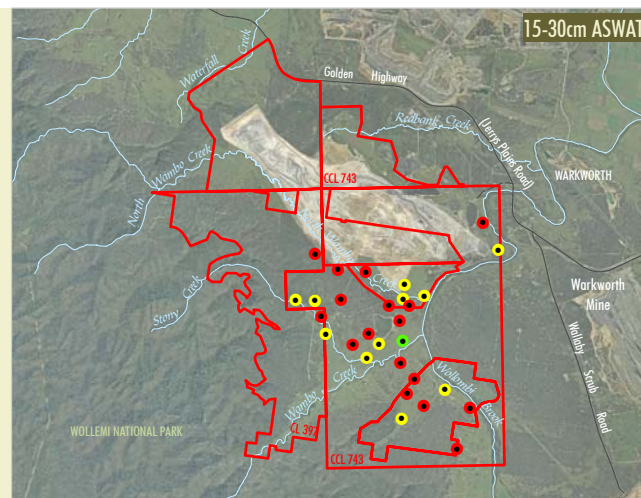
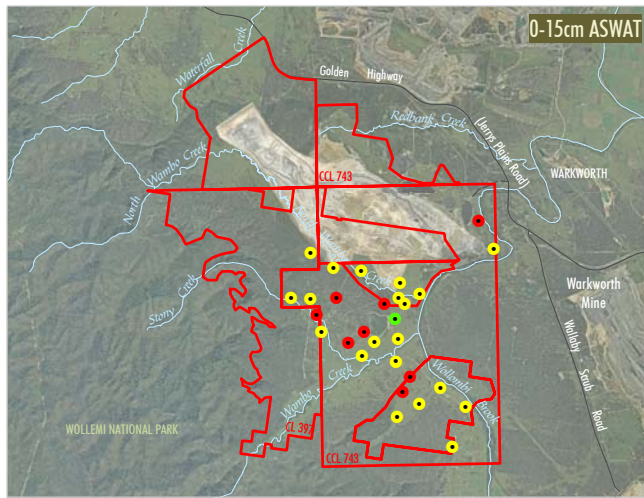


- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - 50-75 cm
 - 76-100 cm
 - >100 cm

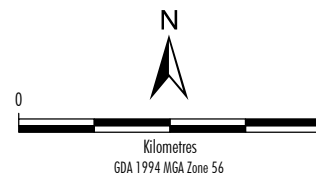
Source: Department of Lands (July 2009); WCPL (2015);
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Peabody
WAMBO COAL MINE
Depth to Layer with Lime

WMA-09-15 SWUMM EA_L&S_Soil_2068



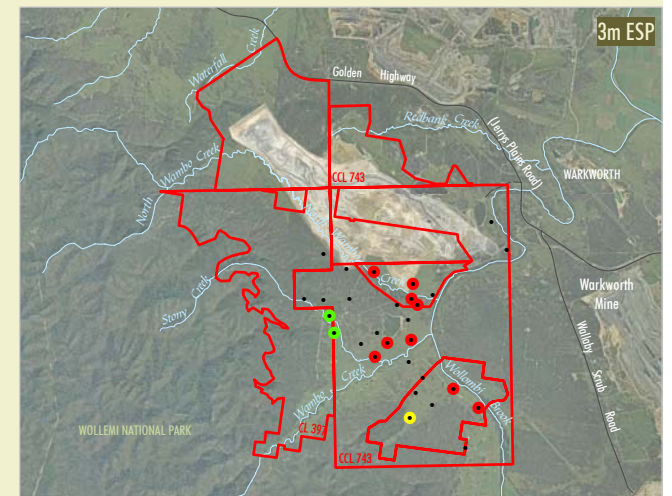
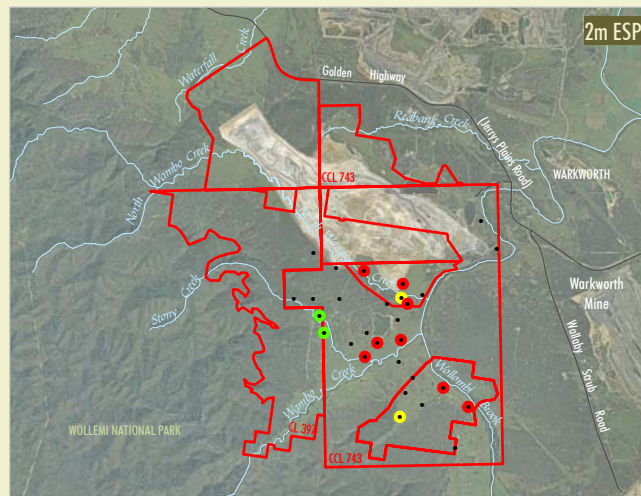
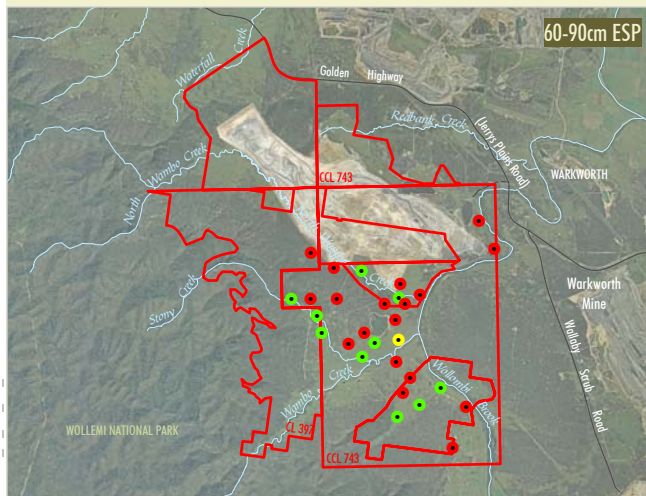
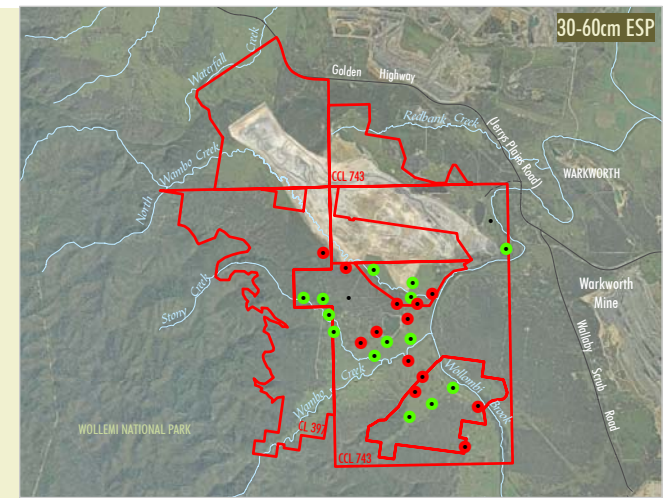
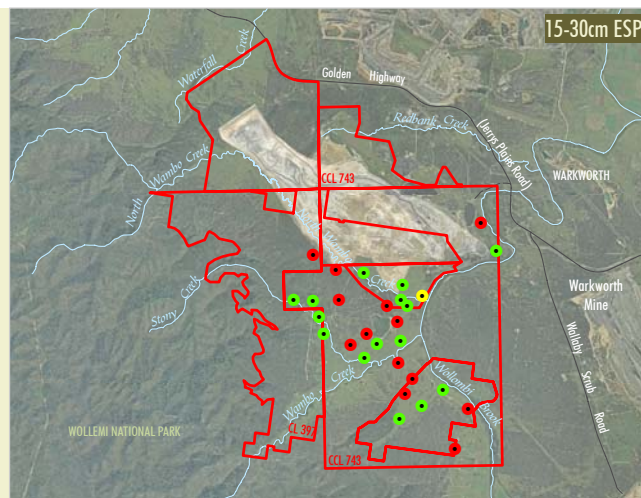
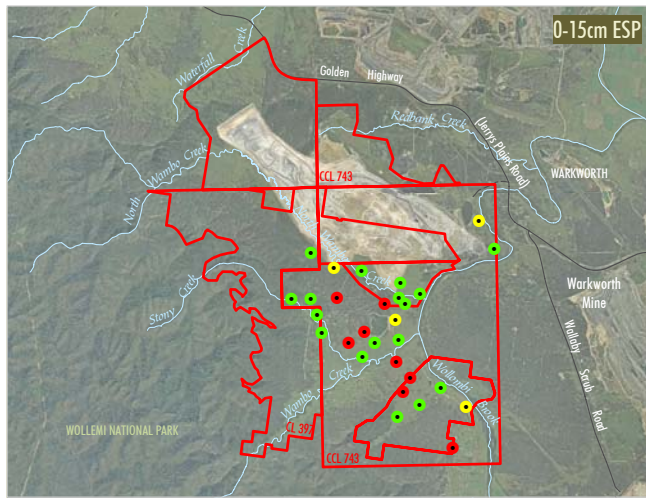
- LEGEND
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - >6
 - 2-6
 - <2



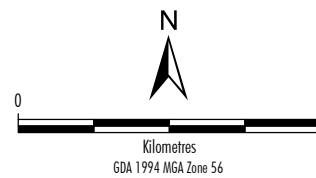
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Peabody
WAMBO COAL MINE
Dispersion (ASWAT Scores)

WMA-09-15 SWUMW EA_L&S_Soil_2078



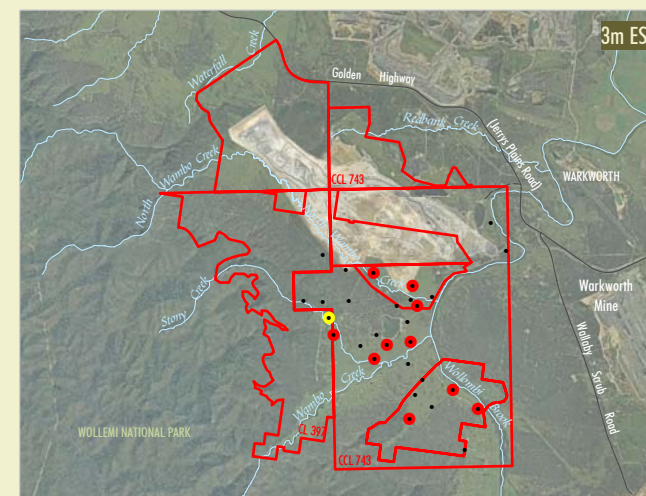
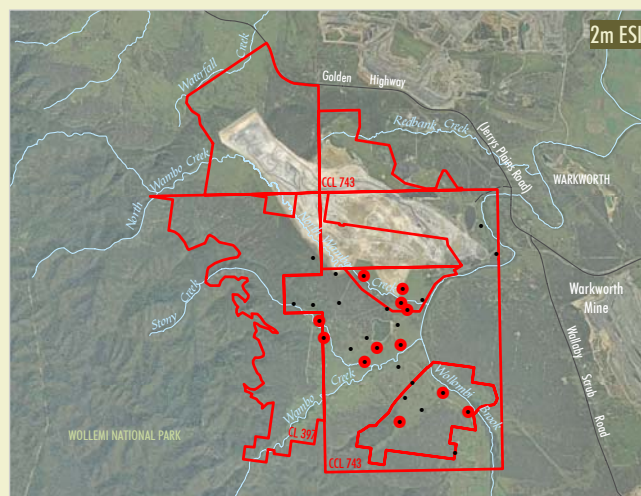
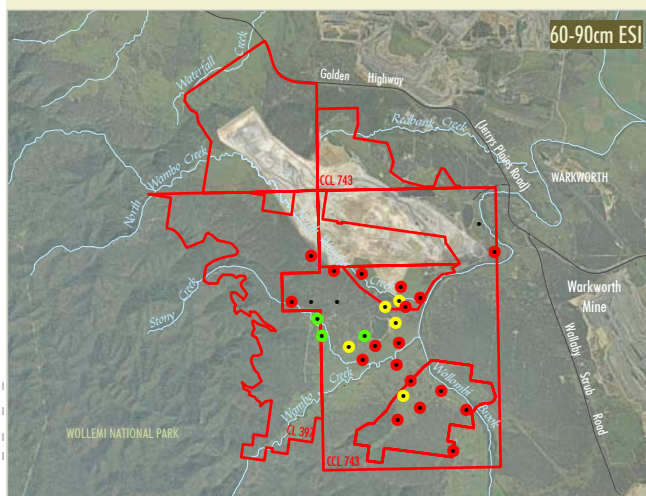
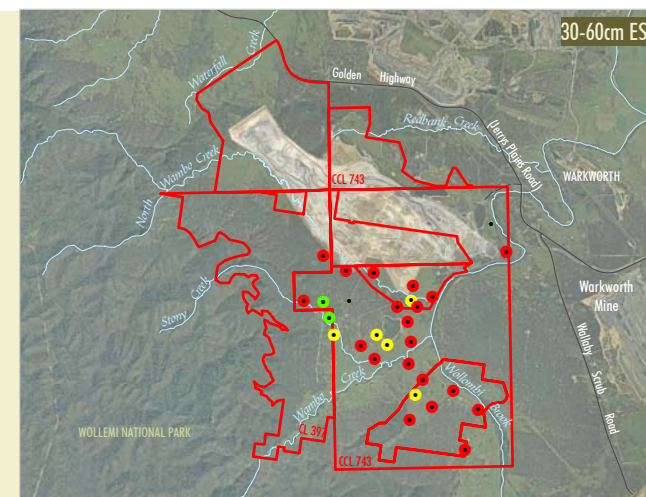
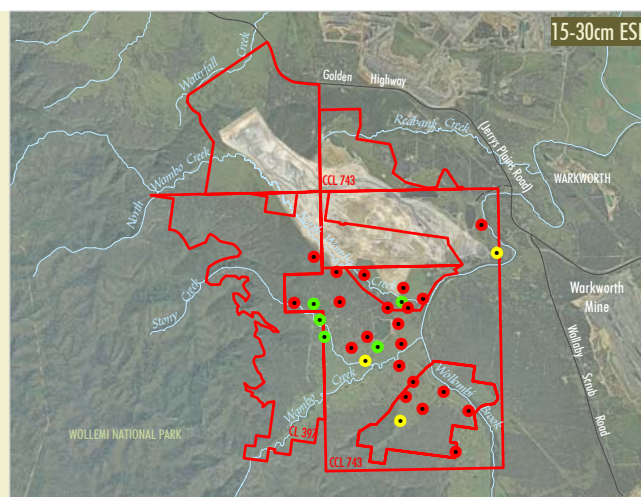
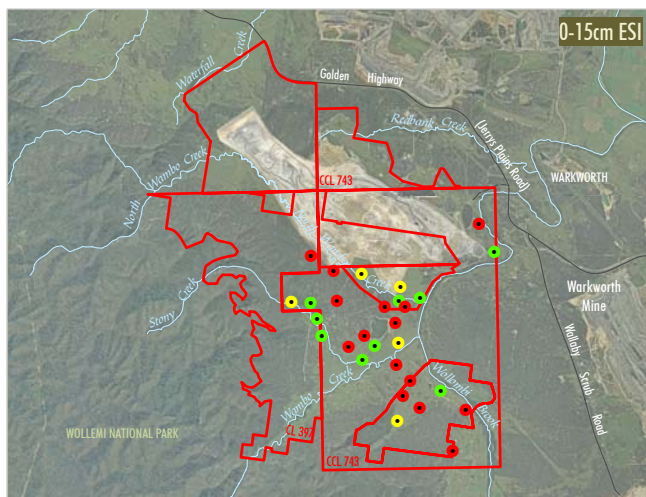
- LEGEND
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - > 6 %
 - 3-6 %
 - < 3 %



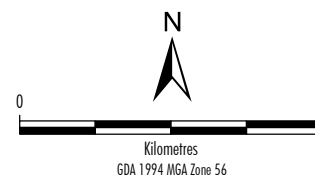
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Peabody
WAMBO COAL MINE
Dispersion (ESP Value)

WMA-09-15 SWUMW EA_L&S_Soil_2088

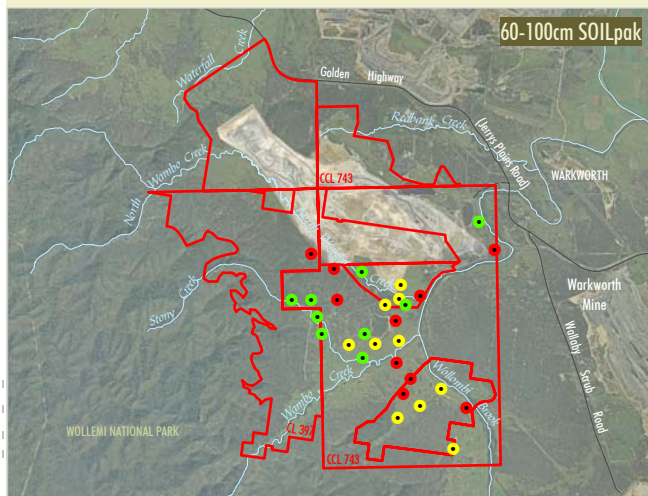
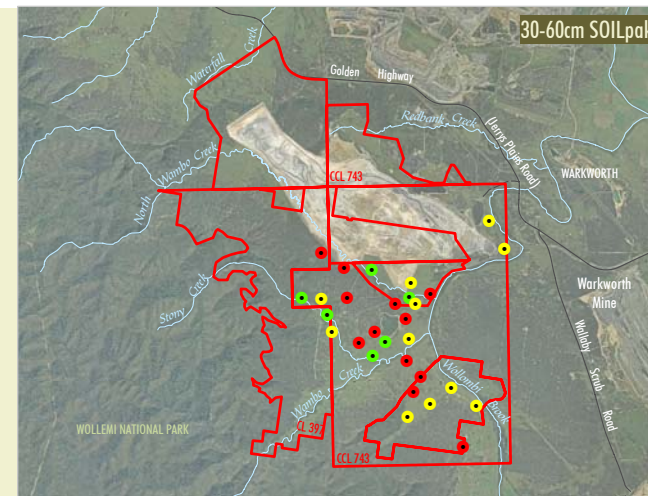
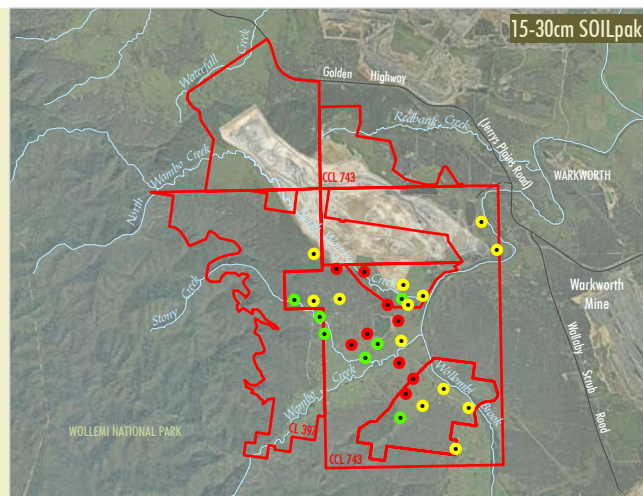
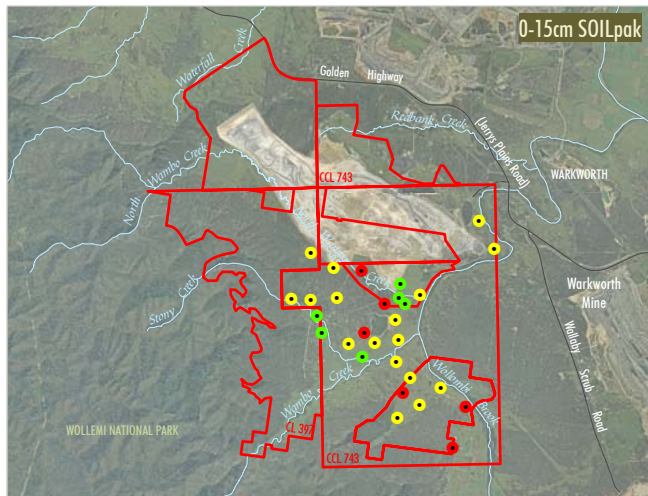


- LEGEND
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <0.03
 - 0.03-0.05
 - >0.05



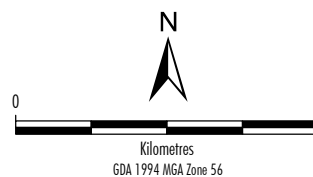
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Peabody
WAMBO COAL MINE
Dispersion (ESI Value)



WMA-09-15 SWUMW EA_L&S_Soil_2018

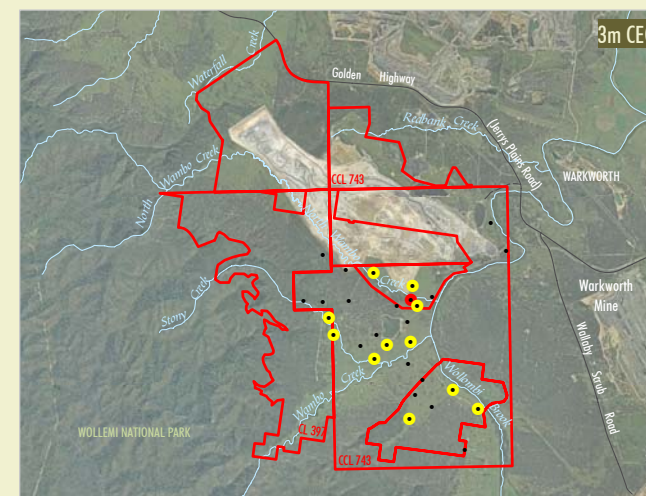
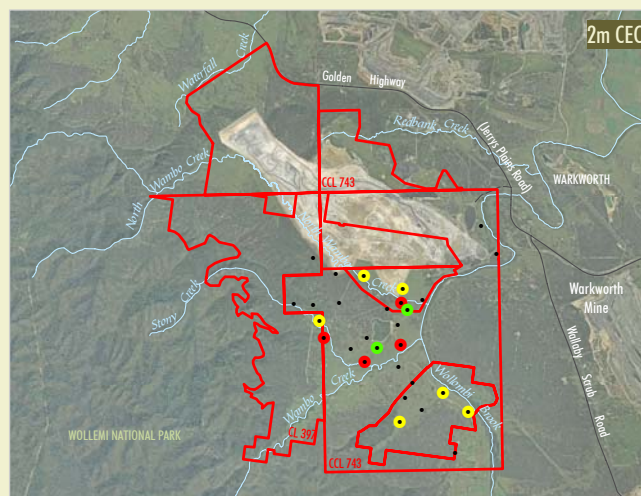
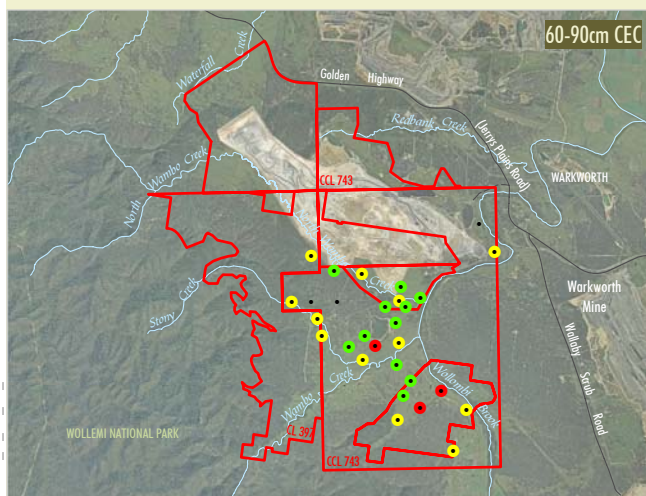
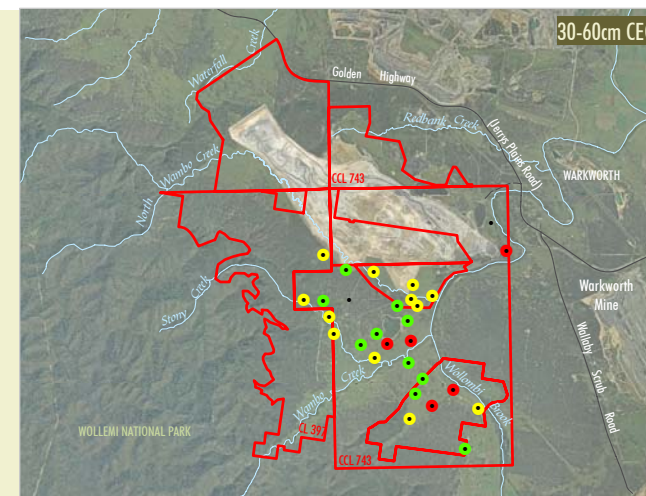
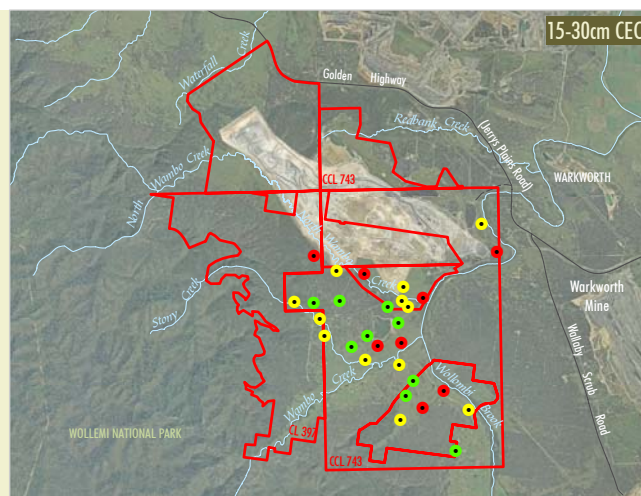
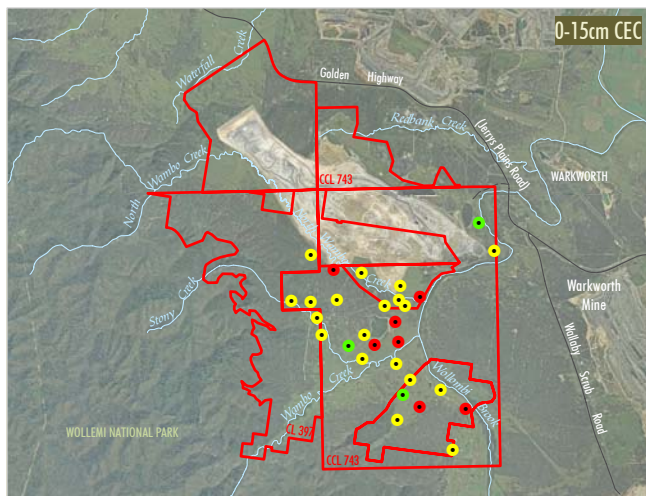
- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <1
 - 1-1.5
 - >1.5



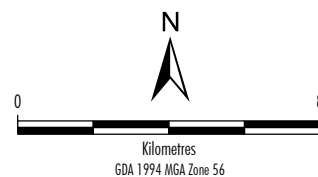
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Peabody
WAMBO COAL MINE
Compaction Severity (SOILpak Score)

WMA-09-15 SWUMW EA_L&S_Soil_2108



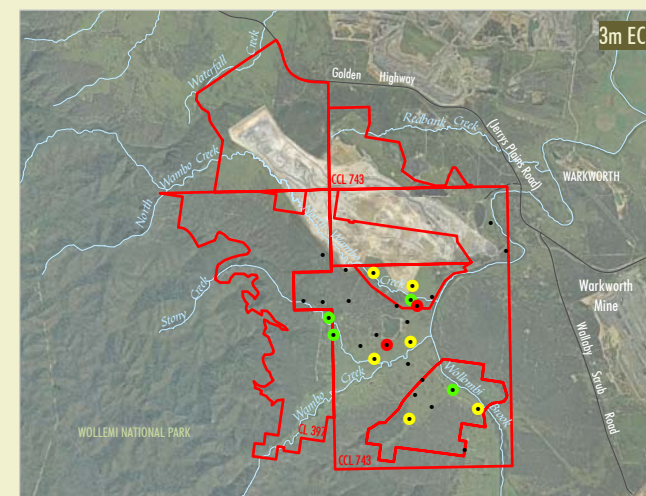
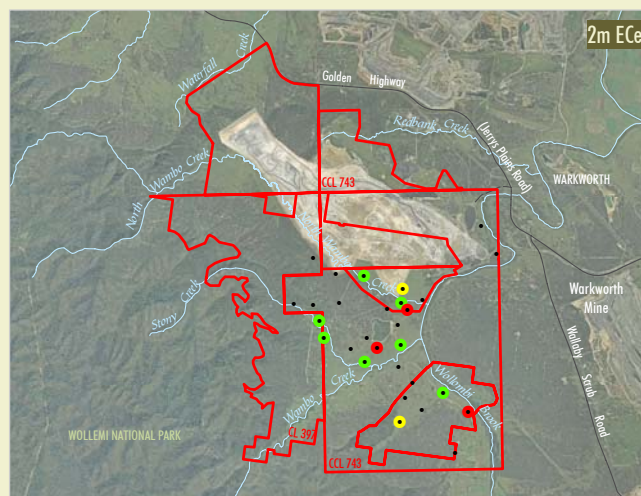
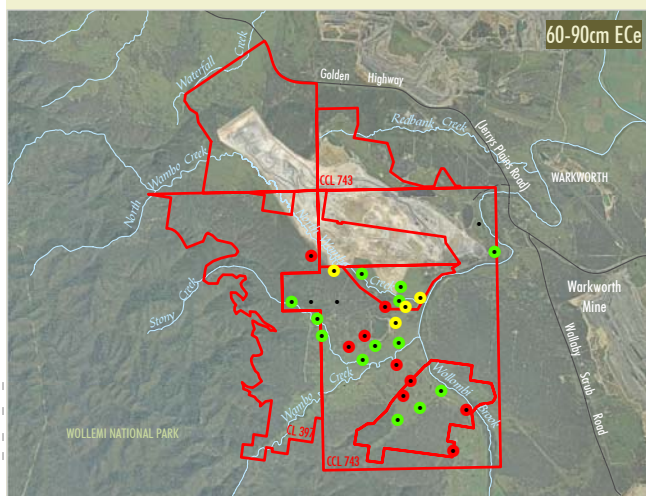
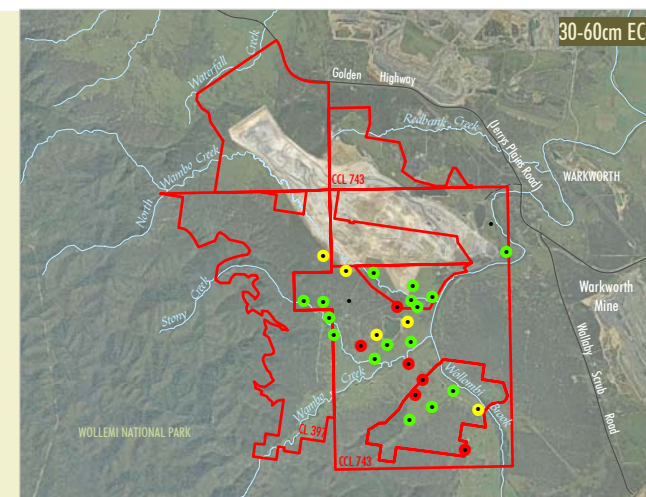
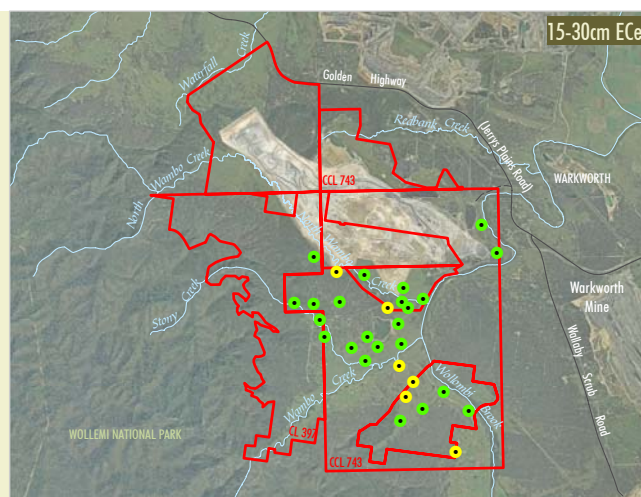
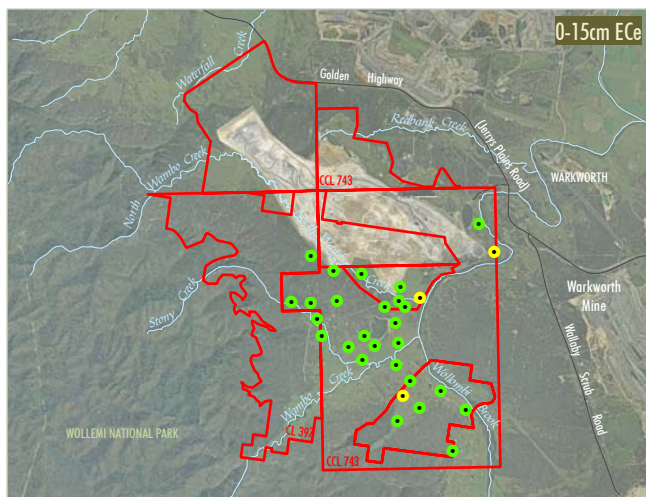
- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <5 (meq/100 g)
 - 5-15 (meq/100 g)
 - >15 (meq/100 g)



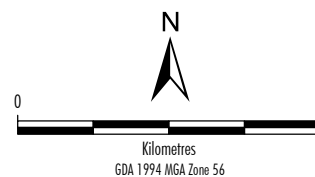
Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Cation Exchange Capacity

WMA-09-15 SWUMW EA_L&S_Soil_2118



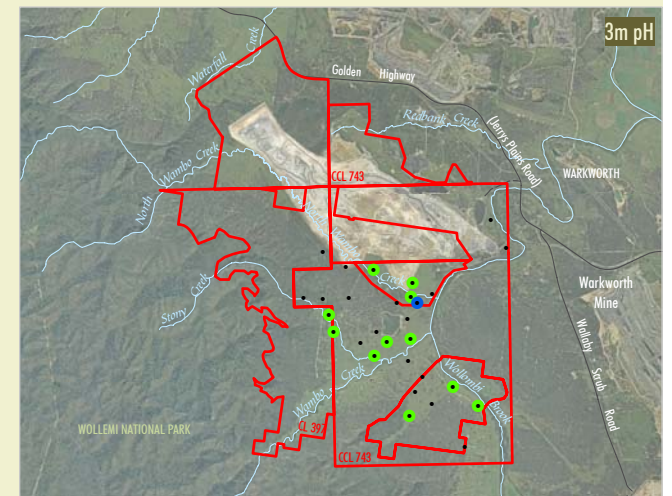
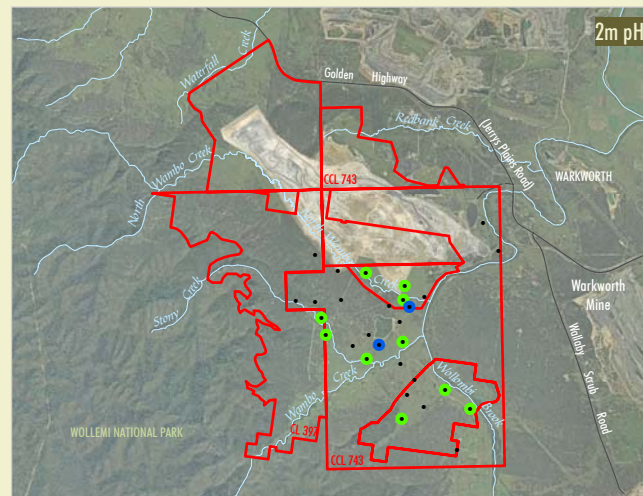
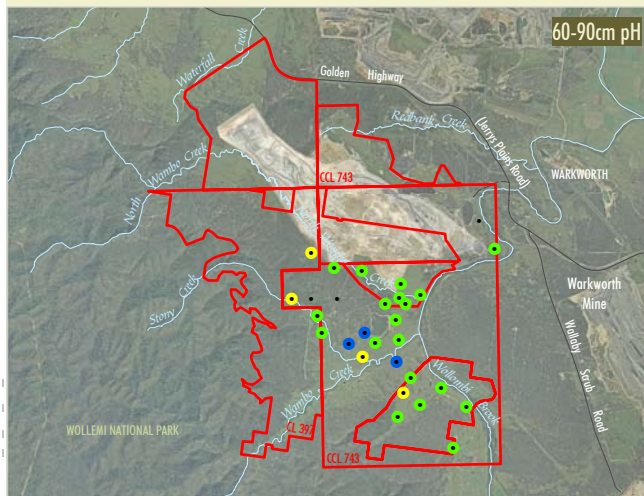
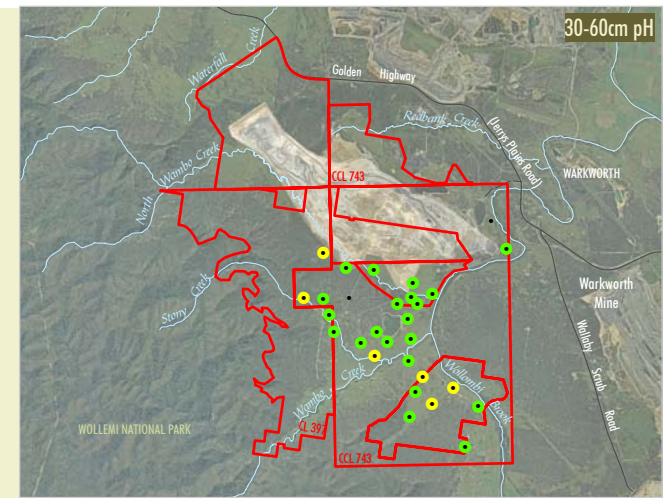
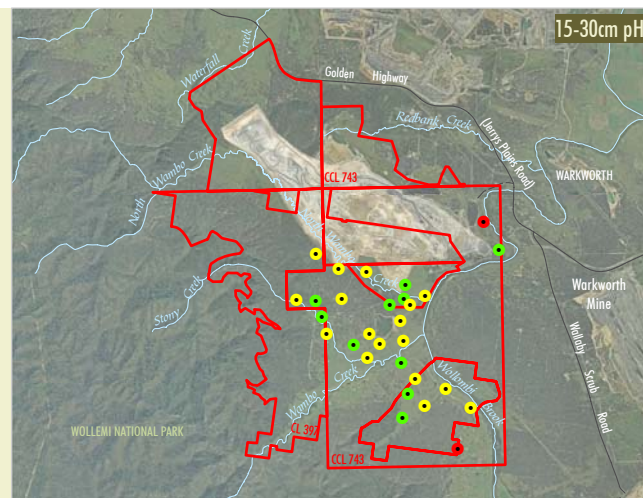
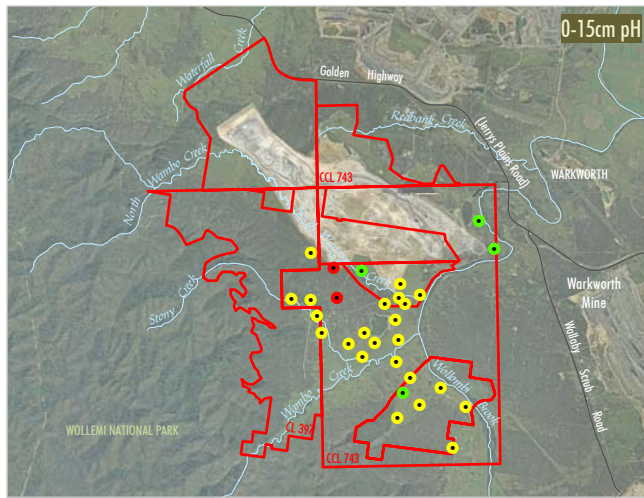
- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pnt
 - > 4 ds/m
 - 1.5-4 ds/m
 - < 1.5 ds/m



Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Salinity (Electrical Conductivity)

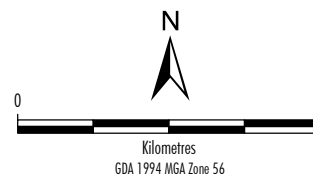
WMAH-09-15 SWMUMW EA_L&S_Soil_2128



- LEGEND**
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - < 4.5
 - 4.5-5.6
 - 5.6-8.2
 - > 8.2

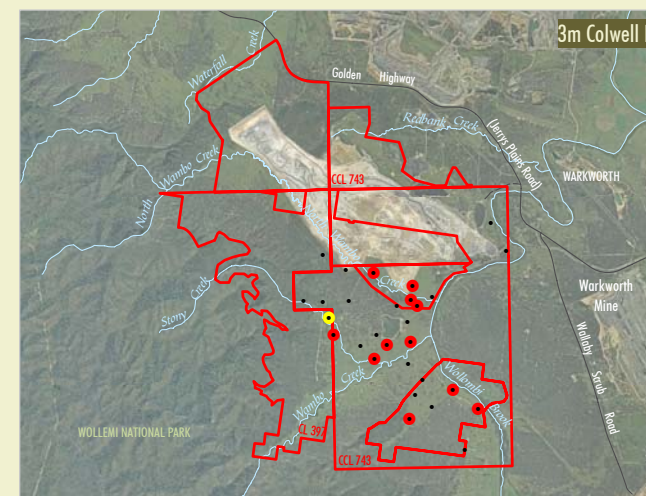
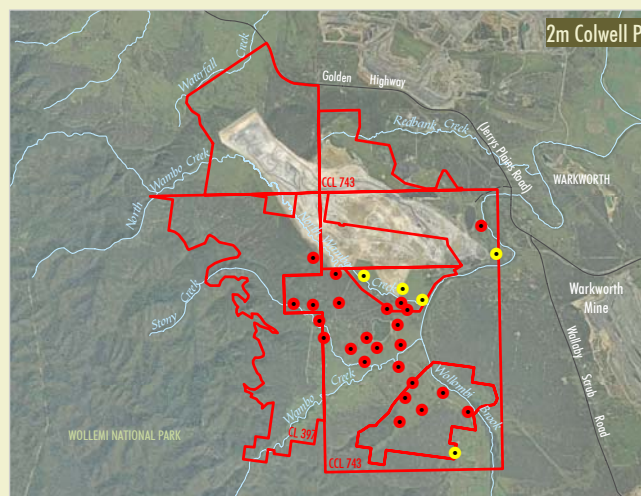
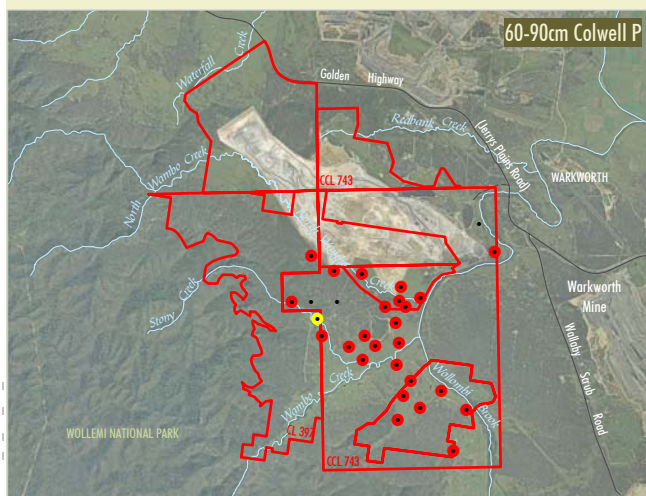
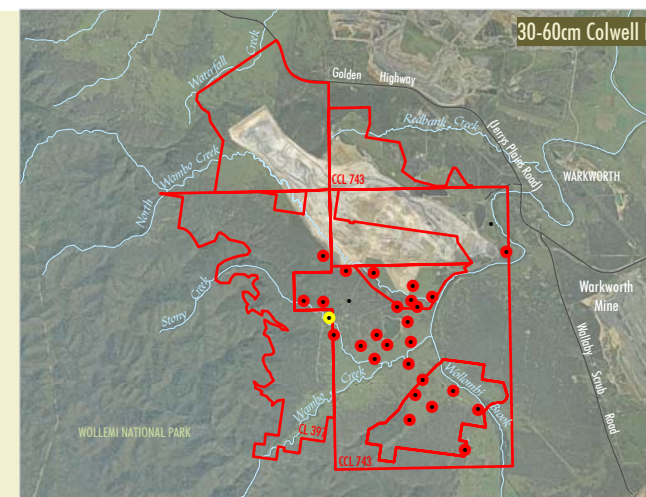
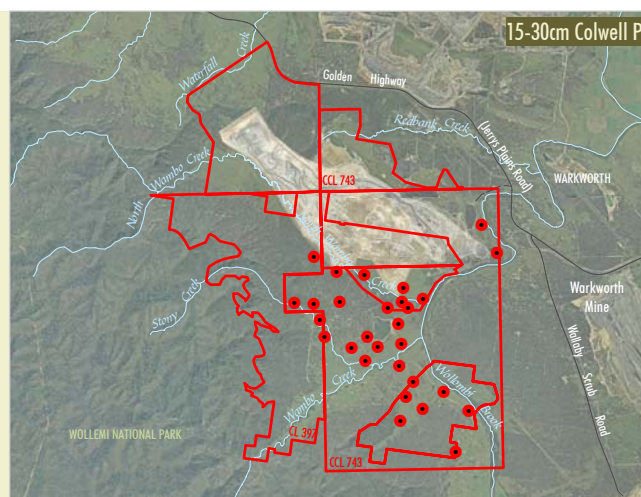
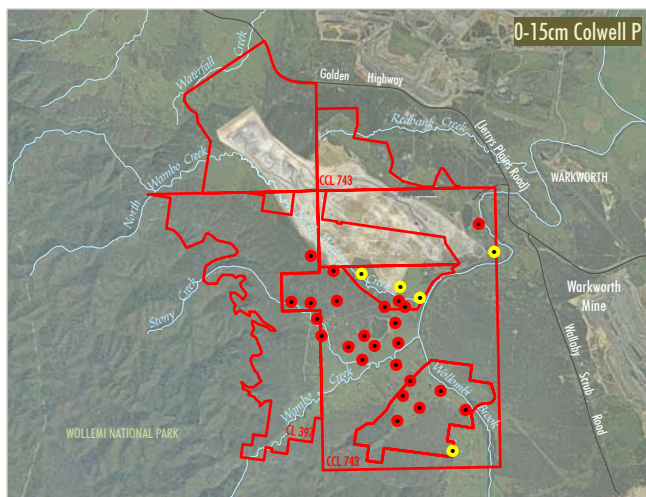


Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

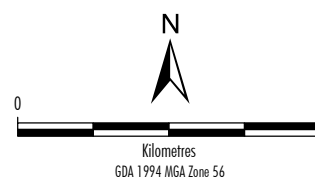


Peabody
WAMBO COAL MINE
pH(CaCl₂)

WMA-09-15 SWUMW EA_L&S_Soil_2138



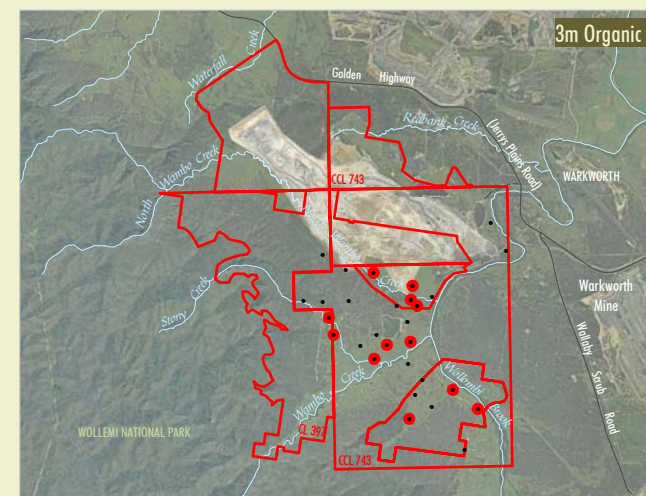
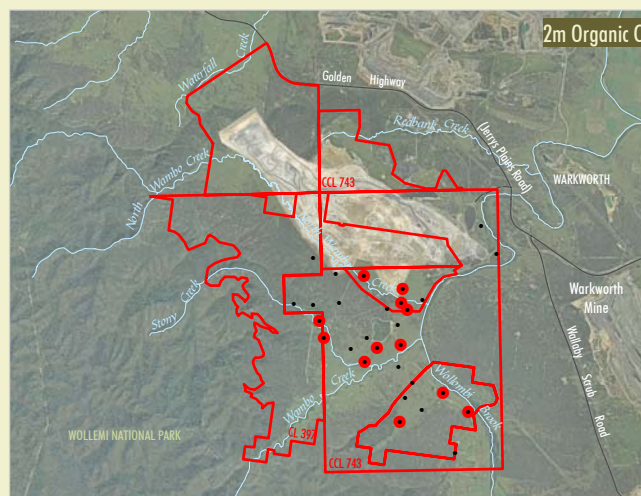
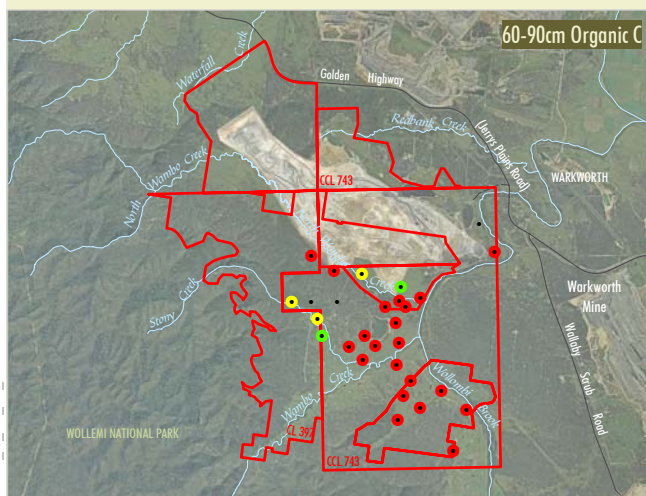
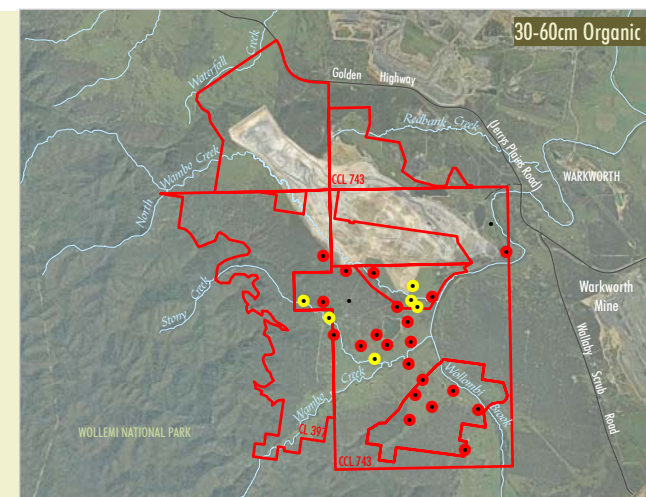
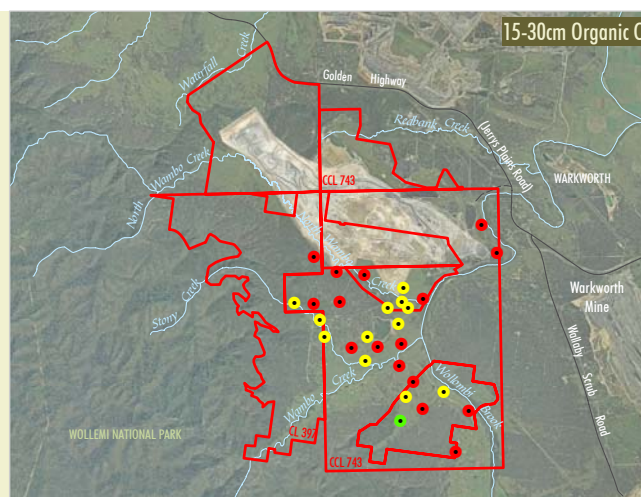
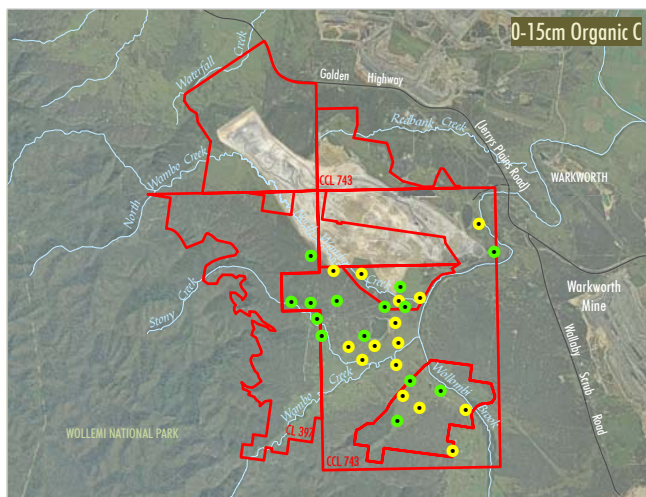
- LEGEND
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <10 mg/kg
 - 10-30 mg/kg



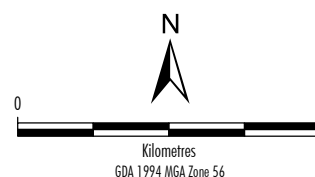
Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Phosphorus (Colwell P)

WMA-09-15 SWUMM EA_L&S_Soil_2148



- LEGEND
- Mining and Coal Lease Boundary
 - Soil Test Pit
 - <0.8 %
 - 0.8-1.6 %
 - >1.6 %



Source: Department of Lands (July 2009); WCPL (2015);
WCPL Orthophoto (Apr-Oct 2013)

Peabody
WAMBO COAL MINE
Organic Carbon

Appendix 1 Overview Data

Soil Test Pit	Photo ID	Easting (m), WGS84	Northing (m), WGS84	Australian Soil Classification		BSAL	Slope (%)	Aspect	Landscape Position	Depth to Rock >90% (cm)	Depth to Mottled >10% later (cm)	Depth to Lime (cm)	TAW (0-100 cm)	Land Use
				Suborder	Order									
1	SW1	309041	6393381	Grey	Sodosol	No	3	NE	Midslope	85	28	-	91	Ironbark-box-casuarina woodland; sparse native pasture
2	SW2	309645	6392980	Yellow	Sodosol	No	4	NE	Midslope	100	40	-	97	Ironbark-casuarina woodland; sparse native pasture
3	SW3	310380	6392907	Stratic	Rudosol	No	2	SW	Creek flats	-	-	-	128	Weedy pasture
4	SW4	311410	6392579	Stratic	Rudosol	No	1	SW	Creek flats	-	-	-	182	Weedy pasture
5	SW11	313483	6394223	Scalpic	Anthroposol	No	5	SW	Upper midslope	40	12	-	46	Weedy pasture
6	SW12	313889	6393487	Brown	Sodosol	No	2	SE	Midslope	-	70	-	80	Ironbark, casuarina, prickly pear, native grasses
7	SW5	308524	6392172	Stratic	Rudosol	No	3	S	Alluvial terrace at head of valley	-	-	-	167	Vigorous native pasture
8	8	309039	6392157	Leptic	Tenosol	No	9	SE	Ridgeline - steep each side	40	-	-	84	Acacia shrubs
9	9	309726	6392185	Leptic	Tenosol	No	6	E	Upper slope	40	80	80	104	Ironbark woodland
10	10 (NW3)	310995	6392031	Grey	Kandosol	No	2	E	Lower slope	-	100	-	154	Moderately vigorous pasture
11	NW1	311370	6392191	Stratic	Rudosol	No	2	NE	Elevated creek terrace	-	-	-	119	Vigorous pasture
12	NW2	311532	6392027	Stratic	Rudosol	No	1	E	Creek flats	-	-	-	186	Moderately vigorous pasture
13	1	311930	6392286	Brown	Sodosol	No	3	E	Knoll / raised terrace	115	25	-	103	Moderately vigorous pasture
14	SW6	309201	6391730	Stratic	Rudosol	No	1	S	Creek flats	-	-	-	143	Native pasture
15	2 (NW4)	311277	6391613	Brown	Sodosol	No	4	SE	Upper midslope	73	20	-	107	Moderately vigorous pasture
16	11	309325	6391277	Stratic	Rudosol	No	1	S	Creek flats	-	-	-	110	Vigorous pasture
17	NW7	310036	6390988	Brown	Kandosol	No	4	SE	Lower slope	-	-	105	162	Poor pasture
18	NW5	310456	6391282	Brown	Kandosol	No	6	E	Near crest of low hill	50	-	-	39	Poor pasture
19	4 (NW6)	310733	6391010	Stratic	Rudosol	No	2	E	Elevated alluvial terrace	-	-	-	88	Moderately vigorous pasture
20	3	311360	6391089	Red	Dermosol	Yes	2	NE	Elevated alluvial terrace	-	-	-	208	Vigorous pasture
21	5 (NW8)	310404	6390642	Stratic	Rudosol	No	1	E	Creek flats	-	-	-	91	Vigorous pasture
22	SW7	311298	6390500	Grey	Sodosol	No	4	NE	Lower slope	-	55	55	92	Native pasture
23	13	311673	6390080	Grey	Sodosol	No	3	N	Midslope	80	-	-	80	Poor pasture
24	SW8	311479	6389691	Grey	Vertosol	No	3	NE	Midslope	140	-	-	90	Poor native pasture
25	6	312477	6389807	Stratic	Rudosol	No	1	NE	Creek flats	-	-	-	147	Vigorous pasture
26	SW10	311328	6389035	Stratic	Rudosol	No	2	SE	Top of broad valley	-	50	-	147	Native pasture
27	SW9	311918	6389364	Yellow-Orthic	Tenosol	No	3	NE	Lower slope	-	-	-	67	Native pasture
28	7	313143	6389307	Brown	Sodosol	No	1	NE	Creek flats	-	60	-	148	Moderately vigorous pasture
29	14	312795	6388232	Grey	Kandosol	No	3	E	Midslope	-	35	-	136	Ironbark dominated woodland

Appendix 2 Photographs of Soil Profiles



1_SW1



2_SW2



3_SW3



4_SW4



5_SW11



6_SW12



7_SW5



8_B8



9_B9



10_B10(NW3)



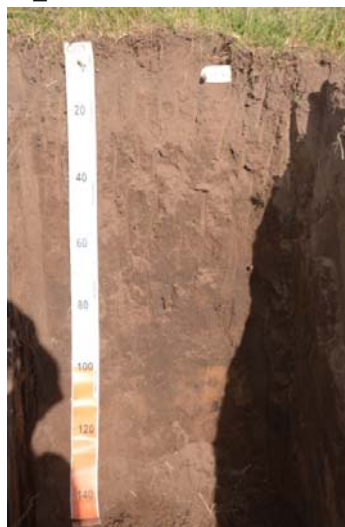
11_NW1



12_NW2



13_B1



14_SW6



15_B2(NW4)



16_B11



17_NW7



18_NW5



19_B4(NW6)



20_B3



21_B5(NW8)



22_SW7



23_B13



24_SW8



25_B6



26_SW10



27_SW9



28_B7



29_B14

Appendix 3 Layer Data

Soil Test Pit	Horizon	Lower Depth (cm)	Texture	pH	Moist Soil Colour (Munsell)	Colour From Munsell Sheet	Mottles	Mn	SOILpak Compaction Score	Coarse Fragments (%)	Dispersion (10 minutes)	Moisture	Root Score	Lime	
														%	Type
1	A1	12	Sandy loam	4.5	10YR4/2	Dark greyish brown	–	–	1.3	–	0	D	2	–	–
	A2	28	Sandy loam	5.0	10YR6/2	Light brownish grey	–	–	1.2	–	2	S	2	–	–
	B2	85	Sandy light clay	5.0	10YR4/2	Dark greyish brown	grey 20%	–	0.4	–	2	S/M	1	–	–
	C	90+	–	–	–	–	–	–	–	100 (conglomerate)	–	–	–	–	–
2	A1	15	Clay loam	4.0	10YR3/2	Very dark greyish brown	–	–	1.4	–	0	D	2	–	–
	B1	40	Sand clay loam	5.0	10YR5/2	Greyish brown	–	–	0.5	–	2	S/M	2	–	–
	B2	100	Light clay	7.0	10YR6/6	Brownish yellow	grey 30%	–	0.2	20	0	S/M	1	–	–
	C	110+	Sandstone	–	–	–	–	–	–	–	–	–	–	–	–
3	A11	10	Sandy loam	5.0	5YR4/2	Dark reddish grey	–	–	0.8	–	0	S	2	–	–
	A12	30	Sandy loam	5.0	5YR4/3	Reddish brown	–	–	0.7	–	0	S	2	–	–
	A3	68	Sandy clay loam	5.5	5YR3/2	Dark reddish brown	–	–	1.7	–	1	M	3	–	–
	2A	78	Loamy sand	5.5	5YR4/3	Reddish brown	–	–	1.8	–	0	M	3	–	–
4	3A	140+	Sandy clay loam	6.0	5YR3/3	Dark reddish brown	–	–	1.7	–	2	M	3	–	–
	A1	18	Clay loam	4.5	7.5YR3/2	Dark brown	–	–	1.6	–	0	S	3	–	–
	B1	60	Light medium clay	5.0	7.5YR3/2	Dark brown	–	–	1.4	–	3	S/M	2	–	–
	2A	72	Clayey sand	7.0	7.5YR4/4	Brown	–	–	1.5	–	2	M	2	–	–
5	3A	140+	Sandy light clay	9.5	7.5YR3/1	Very dark grey	–	–	1.8	–	3	M	2	–	–
	A1	12	Light clay	5.0	7.5YR4/2	Brown	–	–	1	10	0	D	2	–	–
	BC	40	Clayey sand	4.5	10YR8/4	–	red 30%	–	1.5	30	0	S	2	–	–
	C	45+	–	–	–	–	–	–	–	100 (sandstone)	–	–	–	–	–
6	A11	10	Clayey sand	5.5	7.5YR2.5/1	Black	–	–	1.5	–	0	D	4	–	–
	A12	25	Clayey sand	4.5	7.5YR3/4	Dark brown	–	–	1.5	–	0	S	3	–	–
	A2	70	Loamy sand	5.5	7.5YR6/4	Light brown	–	–	1.5	–	0	S/M	2	–	–
	B2	140+	Light medium clay	5.0	10YR5/4	Yellowish brown	grey 20%	–	0.4	–	0	M	1	–	–
7	A1	15	Fine sandy clay loam	5.0	7.5YR3/2	Dark brown	–	–	1.2	5	0	S	2	–	–
	2A	50	Light clay	5.0	7.5YR3/1	Very dark grey	–	–	1.8	20	2	S/M	3	–	–
	3A	100	Light medium clay	5.0	7.5YR3/1	Very dark grey	–	–	1.7	10	2	M	2	–	–
	4A	140+	Sandy light clay	5.0	7.5YR4/2	Brown	–	–	1.6	20	1	M	2	–	–
8	A1	10	Light clay	5.5	7.5YR3/3	Dark brown	–	–	1.2	–	0	S	3	–	–
	B21	30	Light medium clay	6.0	5YR4/4	Reddish brown	–	–	1.1	–	0	S	3	–	–
	B22	40	Light medium clay	6.5	10YR5/4	Yellowish brown	–	–	1.3	–	0	S	3	–	–
	C	100+	–	–	–	–	–	–	–	100 (hard sandstone)	–	–	–	–	–
9	A1	10	Fine sandy loam	5.0	7.5YR4/3	Brown	–	–	1.1	–	2	M	3	–	–
	B2	40	Light medium clay	5.5	5YR4/6	Yellowish red	–	–	1.3	15	0	S	3	–	–
	BC1	80	–	–	–	–	–	–	0.2	98 (sandstone slabs)	–	–	1	–	–
	BC2	140+	Light clay	9.0	2.5Y7/2	Light grey	orange	–	1.2	25 (decomposing rock)	0	M	1 (100)	–	–

Soil Test Pit	Horizon	Lower Depth (cm)	Texture	pH	Moist Soil Colour (Munsell)	Colour From Munsell Sheet	Mottles	Mn	SOILpak Compaction Score	Coarse Fragments (%)	Dispersion (10 minutes)	Moisture	Root Score	Lime	
														%	Type
10	A1	10	Silty clay loam	5.5	7.5YR3/2	Dark brown	–	–	0.5	–	0	W	1	–	–
	B1	65	Light clay	6.0	7.5YR4/2	Brown	–	–	0.7	–	1	M	2	–	–
	B21	100	Medium heavy clay	6.0	7.5YR5/2	Brown	–	–	1.2	–	0	M	1	–	–
	B22	140+	Medium clay	5.0	10YR7/4	Very pale brown	orange	–	0.9	–	0	M	0	–	–
11	A11	20	Sandy loam	5.5	7.5YR3/2	Dark brown	–	–	1.7	–	0	S/M	3	–	–
	A12	80	Sandy loam	6.0	7.5YR3/3	Dark brown	–	–	1.8	–	2	S/M	3	–	–
	2A	140+	Sand	–	–	–	–	–	1.5	15	–	S	2	–	–
12	A1	20	Fine sandy clay loam	5.5	7.5YR2.5/2	Very dark brown	–	–	1.7	–	0	S/M	3	–	–
	2A	40	Silty loam	5.5	7.5YR3/2	Dark brown	–	–	1.3	–	0	S	3	–	–
	3B	65	Light clay	7.0	10YR3/2	Very dark greyish brown	–	–	1.4	–	2	M	1	–	–
	4B	100	Light medium clay	8.0	10YR4/3	Brown	–	–	1.7	–	2	M	1	–	–
	5B	140+	Light clay	8.0	7.5YR4/4	Brown	–	–	1.1	–	0	M	0	–	–
13	A1	25	Sandy loam	5.0	7.5YR3/3	Dark brown	–	–	1.2	–	0	M	3	–	–
	B21	85	Medium clay	7.5	10YR5/6	Yellowish brown	sl. grey	–	0.4	–	3	M	1	–	–
	B22	115	Medium heavy clay	9.0	10YR5/6	Yellowish brown	strong grey	–	0.7	–	0	M	0	–	–
	C	135+	–	–	–	–	–	–	–	100 (hard sandstone)	–	–	–	–	–
14	A1	15	Sandy clay loam	5.5	7.5YR3/2	Dark brown	–	–	1.6	–	0	D	3	–	–
	2A	100	Sandy loam	5.5	5YR3/2	Dark reddish brown	–	–	1.8	–	0	S	3	–	–
	3A	140+	Loamy sand	6.0	7.5YR3/2	Dark brown	–	–	1.5	–	0	M	2	–	–
15	A1	12	Silty clay loam	5.0	7.5YR3/3	Dark brown	–	–	1.2	–	0	M	3	–	–
	A2	20	Silty loam	5.5	7.5YR4/4	Brown	–	–	1.1	–	2	M	3	–	–
	B21	35	Heavy clay	6.0	5YR4/6	Yellowish red	grey	–	0.9	–	2	M	2	–	–
	B22	73	Heavy clay	7.0	10YR5/8	Yellowish brown	–	–	0.7	–	0	M	1	–	–
	C	140+	–	–	–	–	–	–	–	98 (sandstone)	–	–	–	–	–
16	A1	10	Sandy clay loam	5.5	7.5YR3/2	Dark brown	–	–	1.7	2	0	M	3	–	–
	2A	40	Clayey sand	6.0	7.5YR2.5/2	Very dark brown	–	–	1.9	2	0	M	3	–	–
	3A	65	Sand / clayey sand	6.5	–	–	–	–	1.5	10	0	M	3	–	–
	4A	140+	Sandy clay loam	7.0	7.5YR2.5/2	Very dark brown	–	–	1.6	–	1	M	2	–	–
17	A1	10	Light clay	5.5	7.5YR4/3	Brown	–	–	1.2	–	3	S/M	2	–	–
	B21	50	Light medium clay	7.0	7.5YR4/3	Brown	–	–	0.5	–	0	S/M	2	–	–
	B22	105	Light medium clay	7.5	5YR4/4	Reddish brown	–	–	1	–	0	S/M	1	–	–
	B23	140+	Light medium clay	9.0	7.5YR3/2	Dark brown	–	–	1.3	–	0	S/M	0	3	N/P
18	A1	15	Silty light clay	6.0	7.5YR4/2	Brown	–	–	0.7	–	2	S/M	2	–	–
	B2	50	Medium clay	5.5	7.5YR5/4	Brown	–	–	0.9	–	0	S/M	1	–	–
	BC	140+	–	–	–	–	–	–	–	100 (decomp. siltstone)	–	–	0	–	–
19	A1	20	Sandy loam	5.5	7.5YR3/3	Dark brown	–	–	1.5	–	0	M	3	–	–
	2A	80	Clayey sand	5.5	7.5YR4/4	Brown	–	–	1.7	–	2	M	3	–	–
	3A	110	Loamy sand	6.5	10YR5/4	Yellowish brown	–	–	1.4	–	1	M	2	–	–
	4A	140+	Sand	6.0	7.5YR4/4	Brown	–	–	1.5	–	0	M	1	–	–

Soil Test Pit	Horizon	Lower Depth (cm)	Texture	pH	Moist Soil Colour (Munsell)	Colour From Munsell Sheet	Mottles	Mn	SOILpak Compaction Score	Coarse Fragments (%)	Dispersion (10 minutes)	Moisture	Root Score	Lime	
														%	Type
20	A1	15	Silty loam	5.0	7.5YR3/4	Dark brown	–	–	1.2	–	0	M	2	–	–
	2B21	32	Light clay	5.5	5YR4/4	Reddish brown	–	–	1.4	–	0	M	3	–	–
	2B22	65	Light clay	6.0	5YR4/6	Yellowish red	–	–	1.4	–	1	M	2	–	–
	2B23	140+	Medium clay	6.0	2.5YR4/4	Reddish brown	–	–	1.3	–	0	M	1	–	–
21	A1	15	Fine sandy clay loam	5.5	7.5YR3/2	Dark brown	–	–	1.7	–	0	S/M	2	–	–
	2A	95	Clayey sand	5.5	7.5YR2.5/2	Very dark brown	–	–	1.9	–	0	M	3	–	–
	3A	140+	Sandy loam	6.0	7.5YR3/3	Dark brown	–	–	1.6	–	0	M	2	–	–
22	A1	8	Sandy loam	4.5	7.5YR4/2	Brown	–	–	1.3	10	0	S	2	–	–
	B21	55	Light medium clay	7.0	7.5YR5/2	Brown	–	–	0.2	–	2	S/M	1	–	–
	B22	140+	Medium clay	8.5	10YR4/2	Dark greyish brown	yellow 20%	–	0.7	–	1	M	0	1	N
23	A1	10	Silty clay loam	5.5	7.5YR4/2	Brown	–	–	1.2	–	0	S	2	–	–
	A2	12	Silty clay loam	5.5	10YR4/2	Dark greyish brown	–	–	0.7	2	1	S	1	–	–
	B2	80	Medium heavy clay	6.0	10YR4/3	Brown	–	–	0.7	–	1	M	1 (55)	–	–
	C	120+	–	–	–	–	–	–	–	100 (hard sandstone)	–	–	–	–	–
24	A1	10	Light medium clay	5.5	10YR3/2	Very dark greyish brown	–	–	0.2	–	3	D	1	–	–
	B1	50	Medium clay	6.5	10YR4/2	Dark greyish brown	–	–	0.5	–	0	S/M	2	–	–
	B2	140	Medium heavy clay	4.5	10YR4/3	Brown	–	–	0.7	–	0	M	1 (80)	–	–
	C	145+	Patch shale	–	–	–	–	–	–	–	–	–	–	–	–
25	A1	22	Silty light clay	5.5	7.5YR3/2	Dark brown	–	–	1.3	0	0	S/M	4	–	–
	2A	70	Sandy clay loam	5.5	10YR5/3	Brown	–	–	1.4	1	1	M	2	–	–
	3A11	95	Loamy sand	6.0	10YR5/4	Yellowish brown	–	–	1.5	1	2	M	2	–	–
	3A12	140+	Loamy sand	6.0	10YR5/4	Yellowish brown	–	–	1.5	10	2	M	1	–	–
26	A11	18	Clay loam	5.0	7.5YR3/2	Dark brown	–	–	1.3	10	0	S	3	–	–
	A12	32	Light clay	5.0	7.5YR3/1	Very dark grey	–	–	1.7	20	0	S/M	3	–	–
	2A	50	Loamy sand	5.0	7.5YR4/2	Brown	–	–	1.5	50	2	S/M	3	–	–
	3A	65	Sandy loam	5.5	7.5YR5/2	Brown	yellow 5%	–	1.2	–	3	M	2	–	–
	4B	140+	Medium clay	7.0	7.5YR6/2	Pinkish grey	yellow 30%	–	1	–	1	M	1	–	–
27	A11	10	Sandy loam	5.0	7.5YR4/2	Brown	–	–	1.5	–	0	S	3	–	–
	A12	28	Sandy loam	5.0	7.5YR6/4	Light brown	–	–	1.5	–	0	S	3	–	–
	A31	75	Loamy sand	5.5	7.5YR7/3	Pink	–	–	1.5	30	0	S/M	3	–	–
	A32	140+	Sand	5.5	7.5YR5/4	Brown	–	–	1.5	30	0	M	2	–	–
28	A1	20	Fine sandy loam	5.0	10YR5/4	Yellowish brown	–	–	0.8	–	0	S	1	–	–
	2B	60	Medium clay	6.0	10YR5/6	Yellowish brown	–	–	1	–	2	S/M	2	–	–
	3B	140+	Light clay	7.5	10YR5/6	Yellowish brown	red & grey	–	0.4	–	1	S	1	–	–
29	A1	10	Silty clay loam	4.5	10YR3/3	Dark Brown	–	–	0.6	–	3	S	2	–	–
	2B21	35	Light medium clay	5.0	10YR3/2	Very dark greyish brown	–	–	1	–	1	S/M	3	–	–
	2B22	60	Medium clay	7.0	10YR4/2	Dark greyish brown	sl. yellow	–	0.7	–	0	M	1	–	–
	3A	125	Sandy clay loam	8.0	10YR4/6	Dark yellowish brown	sl. grey	–	1.1	20	1	S/M	1	–	–
	4A	140+	Light medium clay	7.5	10YR3/2	Very dark greyish brown	–	–	1	–	0	S/M	1 (80)	–	–

Appendix 4 Soil Structure Details

Soil Test Pit	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak Compaction Score
1	12	M	AB	10	RP	2	1.3
	28	W	PO/LE	8	RP	2	1.2
	85	M	LE/CO	15	RP	5	0.4
	90+	–	–	–	–	–	–
2	15	W	PO	10	RP	2	1.4
	40	M	PO/LE	15	RP	5	0.5
	100	M	LE	25	RP	5	0.2
	110+	–	–	–	–	–	–
3	10	M	LE	15	RP	4	0.8
	30	S	PL	12	RP	4	0.7
	68	M	PO	7	RP	2	1.7
	78	G	–	–	S	1	1.8
	140+	M	PO	7	RP	2	1.7
4	18	M	PO	10	RP	2	1.6
	60	M	PO	8	RP	2	1.4
	72	G	–	–	S	1	1.5
	140+	M	PO	6	RP	1	1.8
5	12	M	PO	15	RP	4	1.0
	40	G	–	–	S	1	1.5
	45+	–	–	–	–	–	–
6	10	G	–	–	S	1	1.5
	25	G	–	–	S	1	1.5
	70	G	–	–	S	1	1.5
	140+	M	LE	20	RP	5	0.4
7	15	M	LE	15	RP	3	1.2
	50	S	PO	7	RP	1	1.8
	100	S	PO	10	RP	1	1.7
	140+	M	PO/LE	10	RP	1	1.6
8	10	M	PO	15	RP	3	1.2
	30	S	PO	12	RP	5	1.1
	40	S	PO	8	RP	4	1.3
	100+	–	–	–	–	–	–
9	10	M	B	10	E	3	1.1
	40	S	PO	7	RP	4	1.3
	80	–	–	–	–	–	0.2
	140+	M	PO	10	RP	3	1.2
10	10	W	LE	15	E	4	0.5
	65	M	LE	10	RP	6	0.7
	100	M	PO	7	RP	3	1.2
	140+	M	LE	12	RP	4	0.9
11	20	M	PO	6	E	2	1.7
	80	M	PO	5	E	1	1.8
	140+	G	–	–	S	1	1.5
12	20	M	PO	7	E	2	1.7
	40	M	PI	12	E	3	1.3
	65	M	PO	10	RP	3	1.4
	100	M	PO	7	RP	2	1.7
	140+	M	LE	12	RP	4	1.1
13	25	M	LE	10	E	2	1.2
	85	W	B	25	RP	6	0.4
	115	W	B	15	RP	4	0.7
	135+	–	–	–	–	–	–
14	15	M	SB	8	RP	1	1.6
	100	M	PO	5	RP	1	1.8
	140+	G	–	–	S	1	1.5
15	12	M	PL	7	E	2	1.2
	20	M	PL	9	E	3	1.1
	35	W	B	12	RP	4	0.9
	73	W	B	20	RP	4	0.7
	140+	–	–	–	–	–	–
16	10	M	PO	5	E	2	1.7
	40	M	SB	4	E	1	1.9
	65	G	–	–	S	1	1.5
	140+	M	PO	7	E	2	1.6

Soil Test Pit	Lower Depth	Grade	Type	Size	Fabric	Consistence	SOILpak Compaction Score
17	10	M	LE	10	RP	3	1.2
	50	S	LE	25	RP	6	0.5
	105	S	LE	12	RP	4	1.0
	140+	S	PO	8	RP	4	1.3
18	15	W	BI	10	E	4	0.7
	50	M	PO	12	RP	4	0.9
	140+	–	–	–	–	–	–
19	20	W	PO	6	E	2	1.5
	80	W	PO	5	E	1	1.7
	110	W	PO	8	E	1	1.4
	140+	G	–	–	S	1	1.5
20	15	M	LE	8	E	2	1.2
	32	M	PO	7	RP	2	1.4
	65	M	PO	7	RP	2	1.4
	140+	M	PO	8	RP	2	1.3
21	15	M	SB	5	E	2	1.7
	95	S	SB	5	E	1	1.9
	140+	M	PO	7	E	2	1.6
22	8	W	PO	12	RP	2	1.3
	55	S	CO	70	RP	5	0.2
	140+	M	LE	15	RP	3	0.7
23	10	W	PO	7	E	4	1.2
	12	W	LE	10	E	6	0.7
	80	W	LE	5	RP	4	0.7
	120+	–	–	–	–	–	–
24	10	S	AB	40	RP	5	0.2
	50	M	AB/PO	15	RP	4	0.5
	140	M	LE	12	RP	3	0.7
	145+	–	–	–	–	–	–
25	22	M	PI	8	RP	2	1.3
	70	M	PO	8	E	2	1.4
	95	G	–	–	S	1	1.5
	140+	G	–	–	S	1	1.5
26	18	M	PO	12	RP	2	1.3
	32	M	PO	7	RP	1	1.7
	50	G	–	–	S	1	1.5
	65	W	AB	15	RP	2	1.2
	140+	M	LE	15	RP	3	1.0
27	10	W	PO	8	RP	1	1.5
	28	W	PO	8	RP	1	1.5
	75	G	–	–	S	1	1.5
	140+	G	–	–	S	1	1.5
28	20	M	PL	12	E	4	0.8
	60	M	PO	10	RP	3	1.0
	140+	W	LE	12	RP	6	0.4
29	10	W	LE/B	15	E	5	0.6
	35	M	LE	10	RP	3	1.0
	60	W	LE	12	RP	5	0.7
	125	W	LE	7	E	2	1.1
	140+	M	LE	10	RP	2	1.0

Appendix 5 Laboratory Data

Soil Test Pit	Depth (cm)	pH (1:5 Water)	pH (CaCl ₂)	EC 1:5 (dS/m)	EC-e (dS/m)	Chloride (mg/kg)	Exchangeable Cations (meq/100g)					CEC	ESP	ESI	Ca/Mg	ASWAT score	NO ₃ -N (mg/kg)	Colwell-P (mg/kg)	SO ₄ -S (mg/kg)	DTPA-Zn (mg/kg)	DTPA-Cu (mg/kg)	Boron (mg/kg)	Org. C (%)
							Ca	Mg	K	Na	Al												
1	0-15	6.4	5.2	0.04	0.55	5	5.5	1.8	0.8	0.1	0.0	8.2	1.5	0.03	3.1	5	1.3	7	3	3.00	0.14	0.48	2.0
	15-30	5.8	4.5	0.04	0.55	19	1.2	1.2	0.6	0.3	0.2	3.4	7.6	0.01	1.0	12	0.2	7	6	0.21	0.04	0.21	0.5
	30-60	6.2	5.1	0.28	2.41	230	0.8	8.1	0.6	3.3	0.0	12.8	25.8	0.01	0.1	16	0.2	5	15	0.11	0.08	0.60	0.3
	60-90	5.9	5.0	0.61	5.25	640	0.4	8.0	0.5	5.4	0.0	14.3	37.7	0.02	0.1	14	0.2	3	42	0.17	0.18	0.52	0.2
2	0-15	5.6	4.2	0.02	0.17	5	1.0	1.1	0.3	0.1	0.6	3.0	3.3	0.01	0.9	6	0.6	7	2	0.51	0.06	0.11	0.8
	15-30	6.3	5.2	0.21	1.81	150	1.7	10.0	0.4	2.0	0.0	14.1	14.2	0.01	0.2	13	0.2	3	13	0.12	0.07	0.51	0.7
	30-60	7.4	6.4	0.33	2.84	310	1.0	11.0	0.3	3.1	0.0	15.4	20.1	0.02	0.1	13	0.2	6	29	0.08	0.05	0.91	0.1
	60-90	7.5	6.6	0.43	3.70	460	0.6	14.0	0.4	4.6	0.0	19.6	23.5	0.02	0.0	13	0.2	3	44	0.15	0.12	0.66	0.1
3	0-15	6.8	5.9	0.04	0.55	5	4.4	1.4	0.6	0.1	0.0	6.5	1.1	0.04	3.1	5	0.7	12	2	2.00	0.28	0.24	1.1
	15-30	7.0	5.5	0.02	0.28	5	3.4	0.9	0.5	0.1	0.0	4.8	1.0	0.02	3.9	7	0.7	7	1	0.33	0.32	0.17	0.5
	30-60	7.5	5.9	0.02	0.17	5	7.5	1.5	0.3	0.2	0.0	9.4	1.7	0.01	5.0	13	0.2	7	1	0.08	0.56	0.37	0.7
	60-90	7.9	6.4	0.02	0.19	5	9.3	2.9	0.1	0.2	0.0	12.6	1.9	0.01	3.2	13	0.2	8	1	0.52	0.45	0.38	1.0
	200	8.9	7.5	0.10	0.95	40	5.2	3.5	0.3	1.3	0.0	10.3	12.6	0.01	1.5	14	0.2	7	15	0.12	0.34	0.62	0.3
	300	9.1	7.8	0.18	1.71	120	6.1	5.5	0.4	2.6	0.0	14.6	17.8	0.01	1.1	15	0.2	6	17	0.18	0.58	0.87	0.3
	300	9.1	7.8	0.18	1.71	120	6.1	5.5	0.4	2.6	0.0	14.6	17.8	0.01	1.1	15	0.2	6	17	0.18	0.58	0.87	0.3
4	0-15	6.4	5.3	0.05	0.43	5	6.7	3.1	0.9	0.1	0.0	10.8	1.3	0.04	2.2	5	2.6	11	3	3.40	0.80	0.66	2.0
	15-30	7.0	5.7	0.03	0.26	5	6.8	3.5	0.5	0.1	0.0	10.9	1.0	0.03	1.9	6	1.1	6	1	0.95	0.83	0.54	1.1
	30-60	7.6	6.2	0.02	0.17	5	7.5	4.4	0.3	0.2	0.0	12.5	1.7	0.01	1.7	11	0.5	6	1	0.37	0.82	0.59	0.9
	60-90	8.9	7.2	0.08	0.69	5	11.0	6.5	0.2	1.9	0.0	19.6	9.7	0.01	1.7	16	0.7	9	4	0.38	0.70	1.10	1.8
	200	8.7	7.6	0.21	2.00	160	3.5	3.4	0.2	1.7	0.0	8.8	19.4	0.01	1.0	15	0.6	9	35	0.17	0.35	0.78	0.1
	300	8.1	7.3	0.21	2.00	240	2.8	2.9	0.2	1.1	0.0	7.0	15.8	0.01	1.0	7	0.5	6	22	0.21	0.29	0.42	0.1
5	0-15	7.3	6.3	0.11	0.95	45	7.2	9.7	0.5	1.0	0.0	18.3	5.3	0.02	0.7	11	0.2	3	20	0.70	0.70	0.53	1.1
	15-30	5.9	4.3	0.04	0.91	5	1.3	3.9	0.2	0.6	0.7	6.6	8.3	0.00	0.3	10	0.2	3	13	0.17	0.11	0.09	0.1
6	0-15	7.2	6.5	0.07	1.59	5	6.1	3.1	0.5	0.0	0.0	9.7	0.3	0.23	2.0	5	1.2	13	5	4.90	0.23	0.63	4.6
	15-30	7.4	6.3	0.02	0.45	5	1.3	0.7	0.2	0.0	0.0	2.2	0.5	0.04	1.9	5	0.2	5	1	0.30	0.07	0.19	0.3
	30-60	7.5	6.3	0.01	0.23	5	0.4	0.6	0.2	0.0	0.0	1.2	0.9	0.01	0.7	6	0.2	3	1	0.03	0.03	0.14	0.1
	60-90	6.6	5.7	0.16	1.38	75	0.4	7.9	0.4	2.0	0.0	10.6	18.8	0.01	0.0	0	0.2	3	45	0.01	0.07	0.58	0.2
7	0-15	6.4	5.0	0.02	0.17	5	7.7	2.4	0.6	0.1	0.0	10.7	0.6	0.04	3.2	5	0.2	6	1	0.77	0.44	0.26	1.6
	15-30	6.5	5.1	0.02	0.17	5	8.7	2.6	0.4	0.1	0.0	11.8	0.7	0.03	3.3	6	0.2	6	1	0.35	0.48	0.22	1.2
	30-60	6.9	5.4	0.02	0.17	5	11.0	2.9	0.5	0.1	0.0	14.5	0.7	0.03	3.8	13	0.2	6	1	0.42	0.51	0.34	1.1
	60-90	7.1	5.5	0.01	0.09	5	11.0	3.0	0.3	0.1	0.0	14.5	0.9	0.01	3.7	13	0.2	8	1	0.45	0.55	0.30	1.0
8	0-15	6.2	5.3	0.07	0.60	5	10.0	3.0	1.1	0.1	0.0	14.2	0.6	0.12	3.3	4	17.0	3	5	4.30	0.91	0.55	2.6
	15-30	6.8	5.7	0.04	0.34	5	11.0	5.8	1.1	0.1	0.0	18.0	0.6	0.07	1.9	4	5.9	3	2	0.04	1.30	0.63	0.7
	30-60	7.3	6.4	0.06	0.52	5	9.3	5.9	1.0	0.1	0.0	16.3	0.8	0.08	1.6	5	2.7	6	9	0.15	1.10	0.76	0.4
9	0-15	5.5	4.4	0.09	1.24	36	2.7	3.5	0.5	0.5	0.3	7.6	6.2	0.01	0.8	7	7.6	3	8	1.50	0.43	0.40	1.7
	15-30	6.5	5.2	0.13	1.12	73	6.1	8.4	0.5	1.6	0.0	16.6	9.6	0.01	0.7	13	0.2	3	14	0.18	0.72	0.58	0.6

Agricultural Resource Assessment: “South Wambo Underground Mine Modification”

Soil Test Pit	Depth (cm)	pH (1:5 Water)	pH (CaCl ₂)	EC 1:5 (dS/m)	EC-e (dS/m)	Chloride (mg/kg)	Exchangeable Cations (meq/100g)					CEC	ESP	ESI	Ca/Mg	ASWAT score	NO ₃ -N (mg/kg)	Colwell-P (mg/kg)	SO ₄ -S (mg/kg)	DTPA-Zn (mg/kg)	DTPA-Cu (mg/kg)	Boron (mg/kg)	Org. C (%)
							Ca	Mg	K	Na	Al												
10	0-15	6.3	5.2	0.09	1.24	43	4.6	5.9	0.7	1.1	0.1	12.4	8.9	0.01	0.8	11	1.3	5	4	0.93	0.30	0.42	1.7
	15-30	7.3	6.5	0.24	2.06	190	7.5	11.0	0.6	3.1	0.0	22.2	14.0	0.02	0.7	14	1.0	5	3	0.21	0.25	0.85	1.1
	30-60	8.0	7.5	0.73	6.28	820	4.8	9.1	0.3	6.1	0.0	20.3	30.1	0.02	0.5	11	0.6	5	18	0.11	0.13	0.59	0.4
	60-90	8.1	7.7	1.13	8.48	1500	3.7	9.1	0.2	8.3	0.0	21.3	39.0	0.03	0.4	10	0.8	5	30	0.12	0.16	0.47	0.2
11	0-15	6.1	4.9	0.03	0.41	10	4.0	1.0	0.6	0.0	0.1	5.7	0.2	0.17	4.0	5	1.6	8	3	1.90	0.46	0.28	1.0
	15-30	6.8	5.6	0.02	0.28	10	6.5	1.1	0.4	0.0	0.0	8.0	0.1	0.16	5.9	6	1.0	5	2	0.27	0.45	0.30	1.0
	30-60	7.3	6.1	0.02	0.28	10	8.0	1.0	0.2	0.1	0.0	9.2	0.5	0.04	8.1	11	0.7	5	2	0.20	0.47	0.30	0.8
	60-90	7.7	6.6	0.02	0.28	10	7.5	1.0	0.1	0.1	0.0	8.7	0.7	0.03	7.6	11	0.8	7	2	0.14	0.33	0.28	0.7
	200	8.1	6.8	0.02	0.28	15	1.6	1.5	0.1	0.1	0.0	3.3	3.0	0.01	1.1	13	0.9	7	3	0.02	0.24	0.23	0.1
	300	8.5	7.0	0.03	0.41	25	1.1	2.9	0.1	0.4	0.1	4.6	8.9	0.00	0.4	15	1.0	6	4	0.02	0.10	0.27	0.1
12	0-15	6.2	5.0	0.03	0.26	10	5.5	2.1	0.3	0.1	0.1	8.1	1.4	0.02	2.6	6	0.7	7	2	2.30	0.81	0.38	1.6
	15-30	6.7	5.3	0.02	0.19	10	5.5	2.6	0.2	0.2	0.1	8.5	2.0	0.01	2.1	7	0.8	5	1	0.47	0.74	0.38	1.1
	30-60	7.8	6.2	0.10	0.86	56	3.9	7.8	0.2	2.6	0.1	14.6	17.8	0.01	0.5	11	0.5	5	3	0.23	1.00	0.97	1.0
	60-90	8.9	7.9	0.28	2.41	250	2.3	8.1	0.2	6.1	0.0	16.7	36.5	0.01	0.3	15	0.7	5	13	0.07	0.55	2.30	0.3
	200	9.5	8.5	0.68	5.84	800	1.2	6.2	0.4	7.4	0.0	15.2	48.7	0.01	0.2	11	0.8	5	29	0.05	0.26	0.48	0.1
	300	9.6	8.5	0.48	4.13	570	1.0	6.0	0.4	5.7	0.0	13.1	43.5	0.01	0.2	12	0.8	8	24	0.10	0.30	0.62	0.1
13	0-15	5.2	4.5	0.16	2.21	10	2.0	1.0	0.8	0.1	0.1	4.0	3.0	0.05	2.0	5	72.0	28	6	2.30	0.33	0.32	1.2
	15-30	6.2	4.9	0.05	0.69	5	2.0	0.9	0.6	0.2	0.0	3.7	5.9	0.01	2.2	5	20.0	8	2	0.70	0.22	0.27	0.6
	30-60	8.1	6.7	0.14	1.05	71	4.3	7.0	1.0	2.2	0.0	14.5	15.2	0.01	0.6	15	3.4	3	7	0.04	0.22	1.70	0.4
	60-90	9.0	7.9	0.36	2.70	340	2.3	7.5	0.8	4.5	0.0	15.1	29.9	0.01	0.3	15	1.0	3	27	0.03	0.10	1.80	0.1
14	0-15	6.7	5.4	0.04	0.38	22	7.4	1.4	1.3	0.0	0.0	10.1	0.3	0.14	5.3	7	2.2	8	2	3.20	0.32	0.40	1.8
	15-30	7.3	6.0	0.03	0.41	5	6.6	1.2	1.0	0.0	0.0	8.8	0.3	0.09	5.5	7	0.8	3	1	0.27	0.36	0.43	1.1
	30-60	7.7	6.3	0.02	0.28	5	6.5	1.9	0.7	0.0	0.0	9.1	0.3	0.06	3.4	7	0.6	11	1	0.13	0.23	0.34	1.0
	60-90	8.0	6.7	0.03	0.41	5	7.6	2.6	0.8	0.0	0.0	11.0	0.4	0.08	2.9	5	0.6	10	2	0.46	0.39	0.49	1.1
	200	8.2	7.2	0.06	0.83	37	4.5	3.9	0.6	0.2	0.0	9.2	2.1	0.03	1.2	11	0.6	19	8	1.30	0.35	0.93	0.5
	300	8.1	7.1	0.06	0.83	30	5.1	3.0	0.6	0.1	0.0	8.8	1.6	0.04	1.7	11	0.9	11	5	1.00	0.36	0.86	0.6
15	0-15	6.1	4.9	0.04	0.55	10	2.1	1.5	0.7	0.1	0.1	4.5	3.1	0.01	1.4	1	1.6	5	2	0.72	0.27	0.24	1.0
	15-30	6.3	5.4	0.12	0.70	56	10.0	6.1	0.4	1.8	0.1	18.4	9.8	0.01	1.6	15	1.0	5	5	0.14	0.37	0.57	0.8
	30-60	7.3	6.8	0.34	1.97	280	12.0	7.6	0.2	3.6	0.0	23.4	15.4	0.02	1.6	11	1.0	5	15	0.09	0.21	1.20	0.6
	60-90	8.2	7.8	0.58	3.36	510	10.0	6.6	0.2	4.1	0.0	20.9	19.6	0.03	1.5	0	1.0	5	24	0.11	0.12	0.89	0.1
16	0-15	6.1	4.9	0.04	0.55	10	2.1	1.5	0.7	0.1	0.1	4.5	3.1	0.01	1.4	1	1.6	5	2	0.72	0.27	0.24	1.0
	15-30	6.3	5.4	0.12	0.70	56	10.0	6.1	0.4	1.8	0.1	18.4	9.8	0.01	1.6	15	1.0	5	5	0.14	0.37	0.57	0.8
	30-60	7.3	6.8	0.34	1.97	280	12.0	7.6	0.2	3.6	0.0	23.4	15.4	0.02	1.6	11	1.0	5	15	0.09	0.21	1.20	0.6
	60-90	8.2	7.8	0.58	3.36	510	10.0	6.6	0.2	4.1	0.0	20.9	19.6	0.03	1.5	0	1.0	5	24	0.11	0.12	0.89	0.1
	200	7.9	6.7	0.03	0.29	14	2.0	1.6	0.3	0.1	0.0	3.9	2.0	0.01	1.3	11	1.0	9	4	0.20	0.19	0.25	0.3
	300	7.8	6.5	0.02	0.45	10	3.8	1.7	0.4	0.1	0.0	5.9	0.8	0.02	2.2	7	1.0	8	1	0.32	0.25	0.32	0.6
17	0-15	6.7	5.5	0.11	0.95	37	4.8	9.9	1.3	1.6	0.0	17.6	9.1	0.01	0.5	13	1.0	5	5	0.34	0.69	0.57	0.9
	15-30	7.1	6.0	0.16	1.38	57	5.5	12.0	1.0	2.3	0.0	20.8	11.1	0.01	0.5	15	1.0	5	5	0.15	0.73	0.68	0.7
	30-60	8.8	7.9	0.50	4.30	490	4.2	12.0	0.4	6.1	0.0	22.7	26.9	0.02	0.4	13	1.0	5	29	0.04	0.28	1.40	0.3
	60-90	9.0	8.3	0.84	7.22	930	4.5	12.0	0.4	8.3	0.0	25.2	32.9	0.03	0.4	2	1.0	5	63	0.12	0.30	1.40	0.2

Agricultural Resource Assessment: “South Wambo Underground Mine Modification”

Soil Test Pit	Depth (cm)	pH (1:5 Water)	pH (CaCl ₂)	EC 1:5 (dS/m)	EC-e (dS/m)	Chloride (mg/kg)	Exchangeable Cations (meq/100g)					CEC	ESP	ESI	Ca/Mg	ASWAT score	NO ₃ -N (mg/kg)	Colwell-P (mg/kg)	SO ₄ -S (mg/kg)	DTPA-Zn (mg/kg)	DTPA-Cu (mg/kg)	Boron (mg/kg)	Org. C (%)
							Ca	Mg	K	Na	Al												
18	0-15	6.3	5.0	0.09	0.77	25	5.0	8.1	0.7	1.0	0.1	14.9	6.7	0.01	0.6	12	1.0	5	6	1.20	1.00	0.48	1.9
	15-30	6.3	5.1	0.15	1.13	67	5.0	12.0	0.7	2.0	0.1	19.8	10.1	0.01	0.4	14	1.0	5	9	0.33	0.91	0.47	1.1
	30-60	6.6	5.8	0.50	3.75	390	5.0	15.0	0.6	4.8	0.0	25.4	18.9	0.03	0.3	11	1.0	5	66	0.12	1.10	0.67	0.5
	60-90	8.8	8.3	1.27	9.53	1100	13.0	16.0	0.7	7.4	0.1	37.2	19.9	0.06	0.8	0	1.0	5	260	0.13	0.43	1.20	0.3
19	0-15	6.1	4.8	0.04	0.55	10	3.0	0.7	0.8	0.0	0.1	4.6	0.7	0.06	4.4	3	7.0	5	2	1.80	0.45	0.33	1.1
	15-30	6.7	5.5	0.03	0.68	10	2.1	0.5	0.6	0.0	0.0	3.2	0.3	0.10	4.2	6	5.4	5	1	0.17	0.25	0.25	0.4
	30-60	7.4	6.3	0.02	0.46	10	1.3	0.4	0.4	0.0	0.0	2.1	0.5	0.04	3.0	12	1.1	5	1	0.08	0.16	0.17	0.1
	60-90	7.8	6.6	0.02	0.46	10	1.7	0.5	0.5	0.0	0.0	2.7	1.1	0.02	3.4	14	1.3	5	1	0.08	0.20	0.22	0.1
	200	8.7	8.2	0.45	10.22	430	4.5	7.2	0.3	4.4	0.0	16.4	26.8	0.02	0.6	11	1.0	5	17	0.13	0.29	1.20	0.1
	300	8.4	7.6	0.21	4.77	220	3.7	6.1	0.3	2.9	0.0	13.0	22.4	0.01	0.6	13	1.0	5	6	0.14	0.31	0.48	0.1
20	0-15	5.9	4.7	0.03	0.29	10	2.9	1.2	0.5	0.0	0.1	4.8	0.6	0.05	2.4	3	1.0	5	2	0.69	0.79	0.54	1.2
	15-30	6.2	5.0	0.02	0.17	10	2.7	1.2	0.3	0.1	0.1	4.4	1.1	0.02	2.3	1	1.0	5	2	0.10	0.63	0.57	0.6
	30-60	6.7	5.6	0.02	0.17	10	1.8	1.4	0.2	0.1	0.0	3.5	2.0	0.01	1.3	11	1.0	5	3	0.02	0.39	0.48	0.2
	60-90	7.1	5.8	0.04	0.34	10	2.1	3.3	0.3	0.3	0.0	5.9	4.5	0.01	0.6	12	1.0	5	11	0.02	0.28	0.61	0.1
	200	7.4	5.9	0.03	0.26	10	1.8	2.4	0.2	0.4	0.0	4.9	9.0	0.00	0.8	14	1.0	5	4	0.03	0.31	0.45	0.1
	300	6.7	6.2	0.22	1.89	10	2.0	2.9	0.3	0.6	0.0	5.8	10.6	0.02	0.7	14	1.0	5	4	0.04	0.40	0.48	0.1
21	0-15	6.5	5.1	0.03	0.29	10	5.0	1.2	0.9	0.0	0.1	7.2	0.1	0.22	4.2	5	1.4	5	2	1.30	0.43	0.44	1.4
	15-30	6.4	5.0	0.02	0.45	10	5.5	1.0	0.8	0.0	0.1	7.4	0.4	0.05	5.6	6	1.2	5	2	0.94	0.42	0.41	1.2
	30-60	6.6	5.0	0.01	0.23	10	4.7	1.1	0.3	0.0	0.1	6.3	0.6	0.02	4.3	12	1.0	5	1	0.35	0.44	0.35	1.1
	60-90	6.9	5.5	0.01	0.23	10	5.5	1.3	0.2	0.1	0.0	7.0	0.9	0.01	4.2	12	1.0	5	2	0.19	0.37	0.35	0.8
	200	7.8	6.7	0.06	0.83	56	1.4	1.3	0.2	0.3	0.0	3.2	8.7	0.01	1.1	11	1.0	5	3	0.07	0.11	0.38	0.1
	300	9.3	8.0	0.14	1.93	57	2.4	5.0	0.5	1.9	0.0	9.8	19.4	0.01	0.5	12	1.0	5	8	0.02	0.08	1.50	0.1
22	0-15	6.8	5.1	0.04	0.55	17	2.5	2.3	0.3	0.4	0.0	5.6	7.9	0.01	1.1	5	0.7	6	2	0.48	0.16	0.29	1.3
	15-30	7.9	6.8	0.23	1.73	140	3.0	7.5	0.1	2.8	0.0	13.4	20.8	0.01	0.4	15	0.2	3	10	0.03	0.13	0.90	0.3
	30-60	9.0	8.1	0.59	4.43	660	2.1	7.8	0.2	5.6	0.0	15.7	35.8	0.02	0.3	14	0.2	3	45	0.02	0.06	1.20	0.1
	60-90	8.9	8.2	0.94	7.05	1100	1.8	8.6	0.2	7.5	0.0	18.1	41.4	0.02	0.2	13	0.2	3	100	0.02	0.07	0.93	0.1
23	0-15	6.3	4.9	0.06	0.52	31	3.0	4.7	0.7	0.6	0.0	9.0	7.1	0.01	0.6	7	4.5	3	5	1.50	0.33	0.38	1.7
	15-30	6.3	5.3	0.30	2.58	240	3.0	9.5	0.2	2.8	0.0	15.5	18.1	0.02	0.3	13	0.2	6	14	0.13	0.26	0.32	0.6
	30-60	5.9	5.2	0.74	6.36	840	2.9	11.0	0.2	5.8	0.0	19.9	29.1	0.03	0.3	13	0.2	6	66	0.23	0.19	0.21	0.6
	60-90	6.3	5.6	0.87	7.48	960	2.0	11.0	0.2	5.8	0.0	19.0	30.5	0.03	0.2	13	0.2	3	110	0.22	0.17	0.09	0.1
24	0-15	6.7	5.7	0.23	1.98	180	4.5	16.0	0.9	2.3	0.0	23.7	9.7	0.02	0.3	11	0.2	3	14	0.41	0.44	0.64	0.9
	15-30	7.5	6.6	0.35	2.63	370	4.6	17.0	0.7	3.5	0.0	25.8	13.6	0.03	0.3	13	0.2	3	17	0.11	0.35	0.87	0.9
	30-60	7.1	6.5	0.93	6.98	1000	2.9	16.0	0.4	6.8	0.0	26.1	26.0	0.04	0.2	12	0.2	3	130	0.12	0.25	0.41	0.4
	60-90	5.7	5.2	1.13	9.72	1300	2.6	16.0	0.4	7.5	0.1	26.6	28.2	0.04	0.2	11	0.2	3	220	0.16	0.35	0.14	0.1
25	0-15	6.2	5.0	0.05	0.43	10	3.9	1.6	0.9	0.1	0.1	6.5	0.8	0.07	2.4	4	1.8	7	4	3.70	0.63	0.55	2.0
	15-30	6.1	4.9	0.03	0.26	10	3.0	1.2	0.6	0.1	0.1	5.0	1.0	0.03	2.5	5	1.0	5	3	0.78	0.49	0.44	1.1
	30-60	6.6	5.3	0.01	0.10	10	1.1	0.7	0.3	0.0	0.1	2.2	1.9	0.01	1.7	14	1.1	5	1	0.09	0.15	0.22	0.1
	60-90	7.0	5.8	0.01	0.23	10	0.8	0.7	0.3	0.1	0.0	1.8	2.8	0.00	1.1	14	1.0	5	2	0.02	0.13	0.18	0.1
	200	7.6	6.2	0.02	0.46	13	2.3	2.5	0.2	0.3	0.0	5.3	6.2	0.00	0.9	15	1.0	5	2	0.07	0.25	0.26	0.1
	300	7.7	6.2	0.03	0.69	10	2.4	3.4	0.2	0.5	0.0	6.4	7.5	0.00	0.7	14	1.0	5	3	0.07	0.29	0.34	0.1

Soil Test Pit	Depth (cm)	pH (1:5 Water)	pH (CaCl ₂)	EC 1:5 (dS/m)	EC-e (dS/m)	Chloride (mg/kg)	Exchangeable Cations (meq/100g)					CEC	ESP	ESI	Ca/Mg	ASWAT score	NO ₃ -N (mg/kg)	Colwell-P (mg/kg)	SO ₄ -S (mg/kg)	DTPA-Zn (mg/kg)	DTPA-Cu (mg/kg)	Boron (mg/kg)	Org. C (%)
							Ca	Mg	K	Na	Al												
26	0-15	6.5	5.4	0.03	0.26	5	7.7	2.2	1.0	0.1	0.0	10.9	0.6	0.05	3.5	5	0.2	6	2	2.60	1.00	0.50	1.6
	15-30	6.8	5.6	0.03	0.26	5	9.8	2.4	0.7	0.1	0.0	13.0	0.6	0.05	4.1	5	0.2	6	2	1.90	0.71	0.49	1.6
	30-60	7.2	5.9	0.01	0.23	5	3.6	1.1	0.3	0.1	0.0	5.1	1.4	0.01	3.3	8	0.6	3	1	0.21	0.28	0.25	0.4
	60-90	7.8	6.5	0.02	0.28	5	4.1	2.0	0.2	0.1	0.0	6.4	1.6	0.01	2.1	12	0.2	3	2	0.06	0.28	0.36	0.1
	200	7.6	6.0	0.02	2.07	5	3.8	2.7	0.3	0.2	0.0	7.0	3.0	0.01	1.4	15	0.2	3	1	0.36	0.50	0.32	0.1
	300	7.6	5.9	0.02	2.07	5	3.1	2.8	0.3	0.2	0.0	6.4	3.3	0.01	1.1	11	0.2	3	1	0.23	0.36	0.23	0.1
27	0-15	6.2	5.0	0.03	0.41	5	2.1	0.8	0.6	0.0	0.0	3.5	1.2	0.03	2.7	6	1.5	8	3	1.40	0.48	0.26	1.0
	15-30	6.5	5.1	0.01	0.14	5	1.6	0.7	0.4	0.0	0.1	2.8	1.1	0.01	2.5	8	1.0	3	1	0.19	0.31	0.19	0.3
	30-60	7.0	5.5	0.01	0.23	5	1.1	0.5	0.3	0.0	0.1	2.1	1.9	0.01	2.1	7	0.6	3	1	0.04	0.19	0.17	0.1
	60-90	7.3	5.9	0.01	0.23	5	1.2	0.6	0.3	0.0	0.0	2.1	1.9	0.01	1.9	6	0.6	3	1	0.04	0.18	0.15	0.1
28	0-15	5.8	4.6	0.05	0.69	11	1.1	1.6	0.3	0.2	0.2	3.5	5.8	0.01	0.7	5	13.0	3	3	0.38	0.19	0.29	0.8
	15-30	6.6	5.4	0.19	1.43	180	1.2	7.9	0.2	3.0	0.0	12.3	24.5	0.01	0.2	14	0.2	3	14	0.06	0.21	1.30	0.5
	30-60	7.4	6.4	0.39	2.93	410	0.8	7.9	0.2	4.6	0.0	13.5	34.0	0.01	0.1	14	0.2	3	33	0.07	0.20	1.90	0.4
	60-90	8.0	7.0	0.53	4.56	600	0.5	6.4	0.3	4.9	0.0	12.1	40.6	0.01	0.1	15	0.2	3	38	0.09	0.19	1.50	0.1
	200	8.5	7.4	0.54	4.64	640	0.2	6.3	0.5	5.8	0.0	12.9	45.1	0.01	0.0	15	0.2	3	16	0.29	0.30	0.56	0.1
29	300	7.9	6.8	0.36	3.10	410	0.4	6.2	0.5	4.8	0.0	11.8	40.7	0.01	0.1	15	0.2	5	14	0.18	0.25	0.74	0.1
	0-15	5.4	4.5	0.16	1.38	63	3.1	3.8	0.6	0.8	0.3	8.5	9.4	0.02	0.8	5	45.0	10	11	2.00	0.44	0.48	1.4
	15-30	5.3	4.4	0.34	2.92	330	5.0	7.8	0.6	3.0	0.6	16.9	17.8	0.02	0.6	13	0.2	5	23	0.32	0.81	0.53	0.6
	30-60	7.3	6.5	0.56	4.20	610	6.5	9.3	0.4	5.6	0.0	21.8	25.7	0.02	0.7	12	1.5	6	38	0.10	0.41	1.10	0.4
	60-90	8.2	7.3	0.60	5.70	720	4.0	6.2	0.3	4.3	0.0	14.8	29.1	0.02	0.6	12	0.2	6	30	0.05	0.32	1.10	0.1