Mt Arthur Coal

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Appendix A –
Agricultural Impact Statement

MT ARTHUR COAL OPEN CUT MODIFICATION

APPENDIX A
AGRICULTURAL IMPACT STATEMENT

PREPARED BY
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1 INTRODUCTION

The Mt Arthur Coal Mine, is located approximately 5 kilometres (km) south-west of Muswellbrook and approximately 130 km north-west of Newcastle, New South Wales (NSW) (Figure 1). The proposed Mt Arthur Coal Open Cut Modification (herein referred to as the Modification) forms an extension to the open cut operation of the Mt Arthur Coal Mine which includes the Northern Open Cut formerly known as Mt Arthur North) and Southern Open Cut (including Bayswater No. 3, and South Pit Extension) mining areas. The approved Mt Arthur Underground Modification, which is currently not producing coal, also forms part of the Mt Arthur Coal Mine. The Mt Arthur Coal Mine is owned and operated by Hunter Valley Energy Coal Pty Ltd (HVEC), a wholly owned subsidiary of BHP Billiton.

Prior to the approval of the Mt Arthur Coal Consolidation Project, HVEC operated under separate approvals for Bayswater No. 3 (including the Bayswater No. 2 mining area), MAN, and South Pit Extension. Open cut mining occurred in Bayswater No 2 from 1966 to 1998, mining at Bayswater No 3 commenced in 1995, while coal production from Mt Arthur North started in 2002. Mt Arthur North has been the focus of HVEC's operations since planning approval for Mount Arthur North was granted in 2001.

The approved mining rate at the Mt Arthur Coal Mine is up to 36 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal, of which a maximum 32 Mtpa may be sourced from open cut mining. The Modification would involve an extension to open cut areas and minor site infrastructure changes at the Mt Arthur Coal Mine.

HVEC is seeking approval for the Modification from the NSW Minister for Planning and Infrastructure in accordance with section 75W of the NSW *Environmental Planning and Assessment Act, 1979.*

The purpose of this Agricultural Impact Statement is to consider the potential impacts of the Modification on agricultural and other land resources and to quantify the potential loss of agricultural land in the region that would arise as a result of the Modification.

This report documents the nature and values of the agricultural and other land resources that may potentially be impacted by the Modification and the potential flow-on effects to associated enterprises, and provides a conclusion regarding the acceptability of the identified potential impacts, management recommendations to mitigate these impacts and strategies to enhance the success of rehabilitation.

1.1 MODIFICATION OVERVIEW

The main activities, relevant to this assessment, associated with the development of the Modification would include (Figure 2):

- a four year continuation of the open cut mine life from 2022 to 2026 at the currently approved maximum rate of 32 Mtpa;
- an increase in open cut disturbance areas;
- use of the conveyor corridor for overburden emplacement;
- duplication of the existing rail loop;
- an increase in the maximum number of train movements per day from 24 to 38;
- the relocation of the load point for the overland conveyor which delivers coal to Macquarie Generation's Bayswater Power Station;
- the relocation and upgrade of the explosives storage, magazine and associated facilities; and
- the construction of additional offices and a control room and a small extension to the ROM coal stockpile footprint.

FIGURE 1

Regional Location

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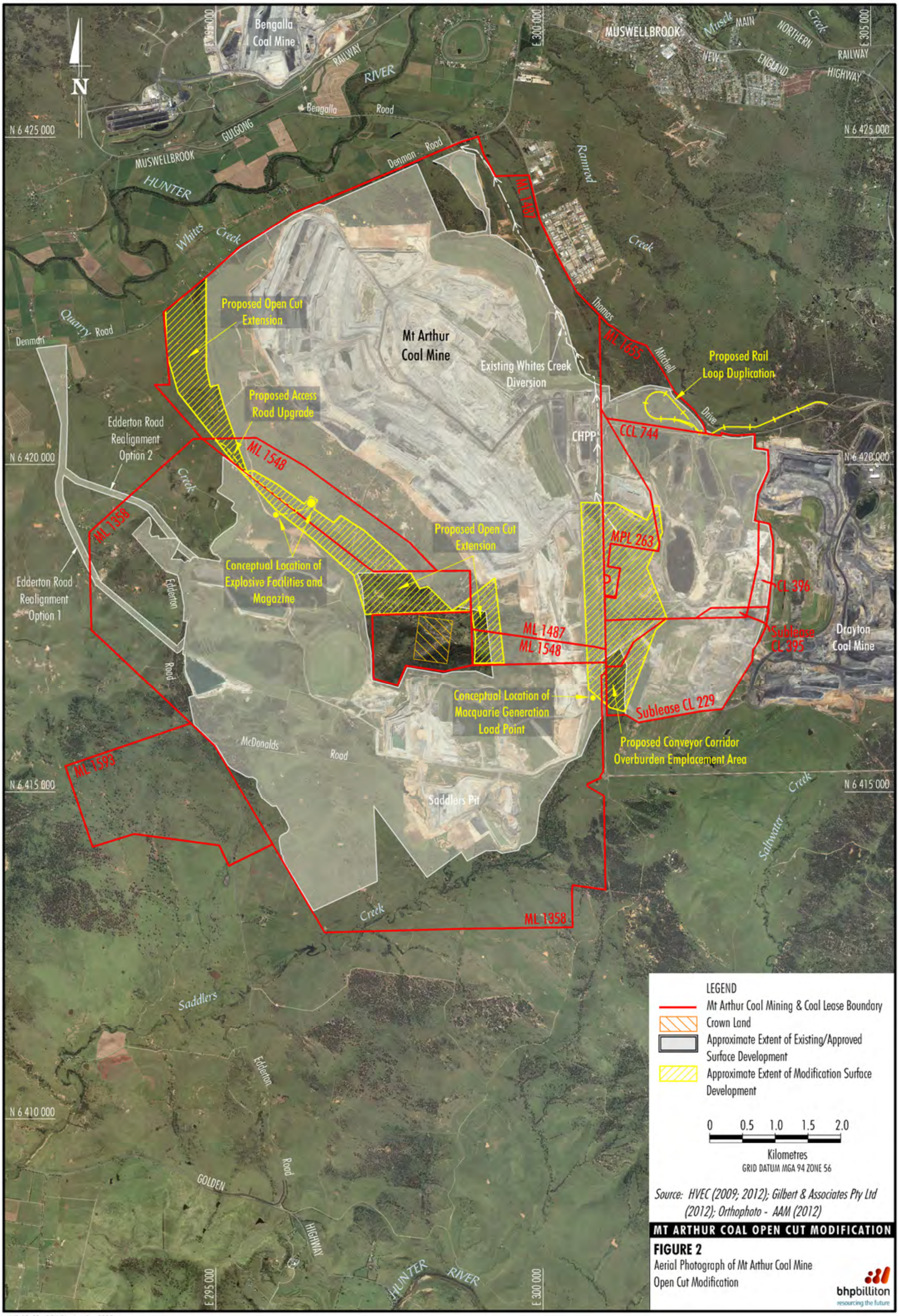

MT ARTHUR COAL OPEN CUT MODIFICATION

FIGURE 2

Aerial Photograph of Mt Arthur Coal Mine Open Cut Modification

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1.2 BACKGROUND

This Agricultural Impact Statement has been prepared to address the following components of the Director-General's Requirements (DGRs) for the Modification:

…

Agricultural and Other Land Resources *- including an Agricultural Impact Statement that includes a specific focused assessment of the impacts of the proposal on strategic agricultural land, having regard to the draft gateway criteria in the draft Upper Hunter Strategic Regional Land Use Plan. The EA must also include a detailed description and assessment of the potential impacts on:*

- *soils and land capability (including salinisation and contamination);*
- *landforms and topography, including steep slopes; and*
- *land use, including agricultural, forestry, conservation and recreational use, with particular attention on the local viticulture and equine industries;*

…

This report has also been prepared in consideration of the NSW Department of Planning and Infrastructure (DP&I) (2012a) *Guideline for Agricultural Impact Statements* and the *Upper Hunter Strategic Regional Land Use Plan* (Upper Hunter SRLUP) (DP&I, 2012b), published in March and September 2012 respectively.

1.3 CONSULTATION

HVEC has ongoing community consultation mechanisms and undertook further consultation in support of the Modification, including consultation with the state and local government agencies and the community through a number of forums. These consultation programmes, raised key issues and ongoing consultation mechanisms are described in Section 1.3 in the Main Report of the Environmental Assessment (EA).

1.4 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 A provides supporting information in the form of a detailed Soil and Land Resource Assessment (SLRA) prepared by GSS Environmental (GSS) (2012). Attachment B provides supporting information in the form of case studies provided by the NSW Minerals Council in relation to HVEC's interactions with the equine and viticulture industries.

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

- Groundwater Impact Assessment (Australasian Groundwater & Environmental Consultants Pty Ltd [AGE], 2013) (Appendix B of the EA);
- Surface Water Assessment (Gilbert & Associates, 2012) (Appendix C of the EA);
- Ecological Assessment (Hunter Eco, 2013) (Appendix D of the EA);
- Aboriginal and Non-Indigenous Cultural Heritage Assessment (RPS Australia East Pty Ltd, 2013) (Appendix E of the EA);
- Air Quality and Greenhouse Gas Assessment (PAE Holmes, 2013) (Appendix F of the EA);
- Noise and Blasting Assessment (Wilkinson Murray, 2013) (Appendix G of the EA);
- Landscape and Visual Impact Assessment (Urbis Pty Ltd, 2013) (Appendix H of the EA);
- Geochemistry Assessment of Overburden and Interburden (Geo-Environmental Management, 2012) (Appendix I of the EA);
- Socio-Economic Assessment (Gillespie Economics, 2012) (Appendix J of the EA); and
- Road Transport Assessment (GTA Consulting, 2012) (Appendix K 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

Climate data for the site is available from the Commonwealth Bureau of Meteorology (BoM) meteorological station located in the township of Jerrys Plains, approximately 15 km to the south-east of the Modification.

Temperature

The Jerrys Plains metrological station records (BoM, 2012) show that temperatures are warmest from November to February and coolest from June to August and that mean daily maximum temperatures are highest in January (31.7 degrees Celsius [ºC]) and mean daily minimum temperatures are lowest in July (3.8ºC).

Rainfall

The annual mean rainfall recorded at the Jerrys Plains metrological station was 644 millimetres (mm) (BoM, 2012).

The months with the highest monthly average rainfalls at the Jerrys Plains meteorological station are December and January (BoM, 2012). This reflects the Modifications rainfall climate which is summer dominated, with relatively drier winter months (GSS, 2012).

Evaporation

The Jerrys Plains meteorological station recorded mean evaporation of approximately 1,583 mm (BoM, 2012) and the monthly-average evaporation exceeded monthly-average rainfall throughout the year.

Further description of the climate of the Modification area, including tabulated climatic data and a characterisation of winds are presented in Section 4.2 in the Main Report of the EA.

2.1.2 Land Use

The Modification is situated within the Upper Hunter region which has a long history of rural land use for a variety of agricultural and industrial activities, predominantly grazing and coal mining. The current dominant land uses within and adjacent to the existing Mining Lease (ML) boundaries include open cut coal mining, power generation and industrial activities, agriculture, rural residential and residential areas.

Agricultural activities conducted in the Modification area include cattle grazing as shown on Figure 3. There is no evidence of crop production for grains (irrigated or unirrigated) or intensive horticulture in the Modification area.

Mining, Power Generation and Industrial

Coal mining is a common land use in the area with Bengalla Coal Mine located approximately 2 km to the north of the Mt Arthur Coal Mine, separated by the Hunter River alluvial floodplain over which no mining tenement is held. Adjacent to the Bengalla Coal Mine is the Mount Pleasant Project Modification, an approved coal mine that has not yet commenced production.

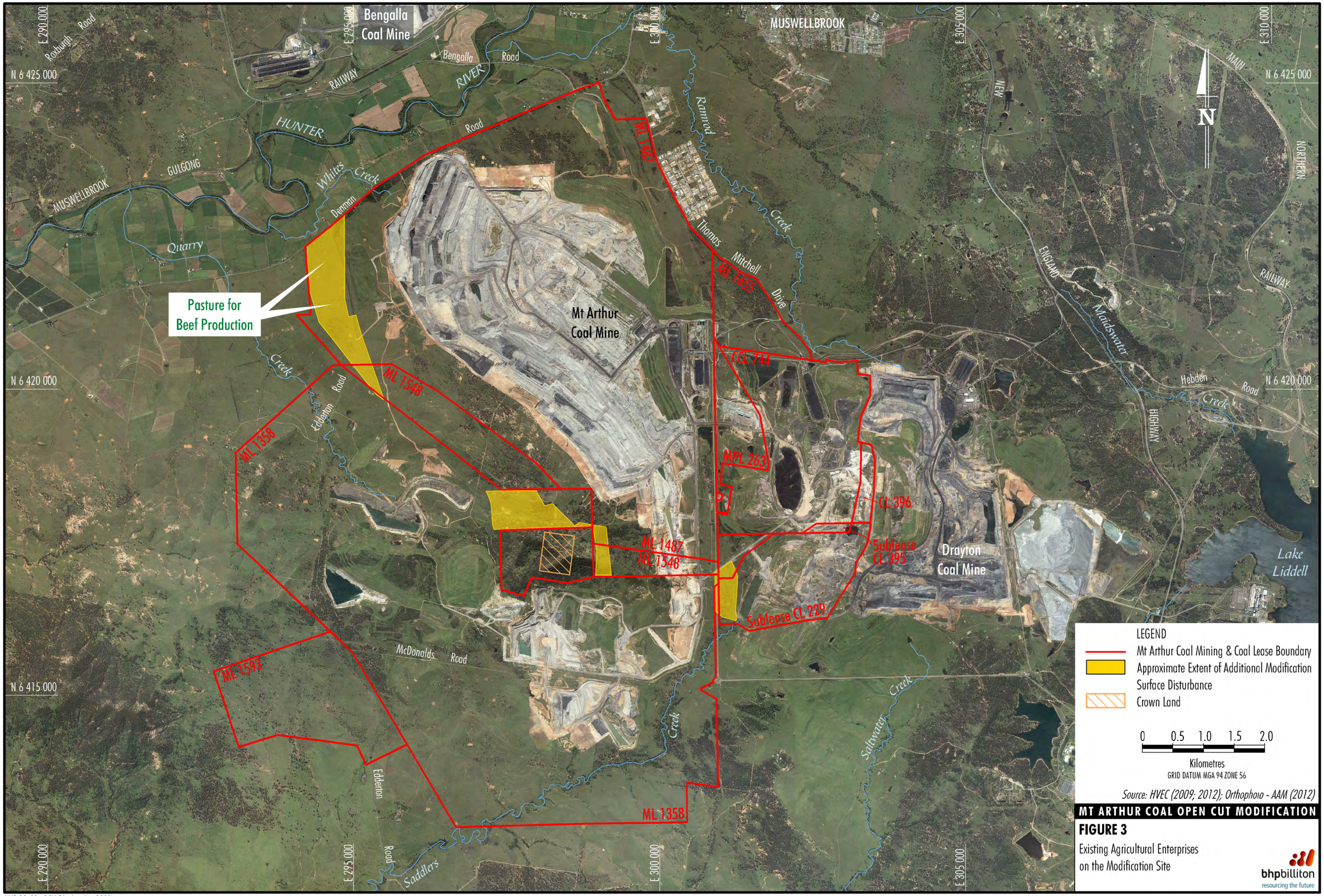

FIGURE 3

Existing Agricultural Enterprises on the Modification Site

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Drayton Coal Mine adjoins to the east, whilst the Drayton South Project exploration leases adjoin the Mt Arthur Coal Mine to the south and the Spur Hill Project exploration lease adjoins the west of the Mt Arthur Underground Modification. Macquarie Generation's Bayswater and Liddell Power Stations are located to the south-east of the Mt Arthur Coal Mine. Macquarie Generation's buffer lands are located to the south-east of the Mt Arthur Coal Mine, between the MLs and power stations. The Muswellbrook Industrial Estate is located on Thomas Mitchell Drive immediately to the east of the Mt Arthur Coal Mine, which houses a variety of businesses predominantly providing supporting services to the mining industry.

Agriculture

The Hunter River is located to the immediate north of the Mt Arthur Coal Mine and plays an important role in the region's agricultural enterprises, meandering south from Glenbawn Dam (east of Scone) to Muswellbrook before heading east towards Newcastle. The Hunter River and its alluvial floodplain support an array of agricultural enterprises including viticulture, grazing, dairying, lucerne hay production, horse studs and olive groves.

The Hunter River alluvium is present in the vicinity of the Mt Arthur Coal Mine and is discussed further in Section 2.1.8. The Modification is located within lands that have been largely disturbed by previous agricultural activities, particularly cultivation and grazing. Agriculture has occurred within the Mt Arthur Coal Mine since the Muswellbrook region was first inhabited by European settlers in 1824, creating largely grassland interspersed with small woodland remnants (HVEC, 2009).

The Modification is located in a rural area characterised by areas of grasslands and open forests-woodland areas where the shrub layer has been heavily cleared. Grasslands are typically a mix of native and introduced pasture grasses between 0.1 and 1 metre (m) in height with some native forbs and exotic weeds present while the more wooded areas are characterised by Ironbark, Box Gum and Kurrajong species at a height of 10 to 15 m (GSS, 2012).

2.1.3 Landforms and Topography

The topography surrounding the Mt Arthur Coal Mine is gently undulating with occasional topographic features, dominated by Mount Arthur (482 m Australian Height Datum [AHD]), located within the mine operational area, and Mount Ogilvie (468 m AHD), located to the west of the Mt Arthur Coal Mine. North of the Mt Arthur Coal Mine, the topography gently slopes up from the alluvial flats of the Hunter River at an elevation of approximately 120 m AHD, rising to approximately 230 m AHD at Macleans Hill and becoming progressively steeper in the vicinity of Mount Arthur and Mount Ogilvie. From Mount Ogilvie, the southern portion of the Mt Arthur Coal Mine slopes down to form part of the Saddlers Creek floodplain (HVEC, 2009).

Generally, rainfall runoff from undisturbed areas flows north-west from Mount Ogilvie and Mount Arthur into Quarry Creek and associated tributaries and then into the Hunter River. Rainfall which falls to the south of Mount Ogilvie and Mount Arthur flows into Saddlers Creek before travelling south-west and entering the Hunter River approximately 17 km downstream of Denman (HVEC, 2009).

2.1.4 Soil Survey

A desktop study and soil survey was conducted by GSS (2012) to characterise and assess the soils in the Modification area as part of the SLRA (Attachment A).

The desktop study consisted of developing an initial soil map by analysing and interpreting aerial photography, topographic maps, previous reports and other reference information (e.g. cadastral data and current resource studies) and determining preferred locations for soil pits through visual assessment of surface soil exposures, topography and vegetation present in the Modification area (Attachment A).

The fieldwork undertaken was an integrated, qualitative 'free survey' at a scale of 1:25,000. Some 15 exposed soil profiles were assessed that covered the main variations in vegetation type, landforms and geology with a focus on the areas to be potentially disturbed by the Modification (i.e. the Study Area). The soil pit locations and field soil description methods are outlined in Attachment A. The soil profiles were assessed according with the *Australian Soil and Land Survey Field Handbook* soil classification procedures (The National Committee on Soil and Terrain, 2009).

Soil Landscapes Units

The soil landscape units that occur within the Study Area are (Attachment A):

- Bayswater Soil Landscape, covering approximately 30 percent (%) of the Study Area;
- Liddell Soil Landscape, covering approximately 55% of the Study Area; and
- Ogilvie Soil Landscape, covering approximately 15% of the Study Area.

More detail on soil landscape units that occur within the Study Area is provided in Attachment A.

GSS identified five soil types in the Modification area as shown in Table 1 and on Figure 3 of the SLRA (Attachment A).

Table 1
Soil Types

Soil Type No.	ASC Name	Study Area	
		Area (ha)	Area (%)
1	Red Chromosol	69.2	29
2	Brown Chromosol	9.7	4
3	Shallow Brown Chromosol	30.9	13
4	Brown Sodosol	104.3	45
5	Red Sodosol	21.0	9
	Total	**235.1**	**100**

Source: Attachment A.
ASC = Australian Soil Classification.
ha = hectares.

Soil Types and Constraints

Soil landscape units containing groupings of the above soil types were identified during the soil survey as identified in Table 2.

Table 2
Soil Types, Constraints and Management

Soil Type	Prevalence	Constraints	Stripping Suitability and Management
Red Chromosols	• Approximately 30% of Modification area. • Generally on plains and lower slopes.	• Significant clay portion and dispersibility in the subsoil.	• Can be stripped up to 75 centimetres (cm) for use as an intermediate layer between overburden and topdressing. • Topsoil presents no specific management risk and can be stripped up to 25 cm for topdressing material to be used in rehabilitation.
Red Sodosol	• Approximately 9% of the Modification area. • Generally found on lower slopes.	• Significant clay portion and sodic characteristics in the subsoil. • Very high erodibility rating.	• Not recommended to be stripped.
Brown Sodosol	• Approximately 42% of the Modification area. • Generally found on lower and midslopes slopes.	• Sodic characteristics and clay content of the subsoil.	• Can be stripped to a depth of 40 cm for material to be used in rehabilitation.
Brown Chromosols	• Approximately 4% of Modification area. • Generally found on mid slopes.	• Extremely dispersive nature.	• Poses significant management risk and as such it should only be stripped if significant soil amelioration and erosion and sediment control measures are implemented. • Not recommended to be stripped for reuse.
Shallow Brown Chromosols:	• Approximately 15% of the Modification area. • Generally found on upper slopes and crests.	• Significant clay portion in the subsoil. • Problematic dispersibility characteristics.	• Poses no specific management risk and can be stripped up to 20 cm.

Source: Attachment A.

Physical and chemical characteristics of each soil type are provided in Section 3.2 of the SLRA (Attachment A).

2.1.5 Rural Land Capability

The Rural Land Capability classification system is used to delineate the various classes of rural land on the basis of the capability of the land to remain stable under particular uses. The essential characteristics and surveyed areas of the eight classes are described in Table 3.

Table 3
Rural Land Capability Classes

Class	Land Use	Management Options	Occurrence (ha)	Occurrence (%)
I	Regular Cultivation	No erosion control requirements.	0	0
II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works.	33.1	14
III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways.	0	0
IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application.	0	0
V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks.	131.0	56
VI	Grazing only	Managed to ensure ground cover is maintained.	62.1	26
VII	Unsuitable for rural production	Green timber maintained to control erosion.	8.9	4
VIII	Unsuitable for rural production	Should not be cleared, logged or grazed.	0	0

Source: Cummingham *et al*., 1988 and Attachment A.

GSS (2012) assessed Rural Land Capability classes across the surveyed Modification area as ranging from Class II to Class VII, with the major factors influencing the classification being land slope, erodibility, subsoil sodicity, fragment presence, and soil texture and depth.

More detail on the Rural Land Capability mapping is provided in Section 4.2 of the SLRA (Attachment A).

2.1.6 Agricultural Suitability

The Agricultural Suitability system is used to classify land in terms of its suitability for general agricultural use. Agricultural land is classified by evaluating biophysical, social and economic factors that may constrain the use of land for agriculture.

The essential characteristics and surveyed areas of the five classes are described in Table 4.

Table 4
Agricultural Suitability Classes

Class	Land Use	Management Options	Occurrence (ha)	Occurrence (%)
1	Highly productive land suited to both row and field crops.	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.	33.1	14
2	Highly productive land suited to both row and field crops.	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation.	0	0
3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation.	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture.	131.0	56
4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage.	62.1	26
5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing.	Land unsuitable for agriculture or at best suited only to light grazing.	8.9	4

Source: Attachment A.

Agricultural Suitability mapping of the Modification area was prepared and based on the results of the soil survey (GSS, 2012).

Land from all Agricultural Suitability classes except Class 2 was identified across the proposed disturbance area of the Modification.

Soil limitations included various combinations of the following factors: high erodibility, subsoil sodicity, fragmentation (i.e. due to roadways), shallowness, steep slopes, and/or constraints due to terrain, physical and chemical characteristics (Attachment A).

More detail on the Agricultural Suitability mapping is provided in Attachment A.

2.1.7 Identification of Strategic Agricultural Lands

In March 2012, the NSW Government through the DP&I released the Upper Hunter draft SRLUP (DP&I, 2012b). The Upper Hunter draft SRLUP includes the Muswellbrook Local Government Area (LGA) and identifies areas of land that have particularly high agricultural values.

The Upper Hunter draft SRLUP identifies biophysical strategic agricultural land (BSAL) at a regional scale. Table 5 shows GSS' (2012) assessment of the Modification disturbance area against the values and criteria used to define BSAL, as presented in the Upper Hunter draft SRLUP.

Table 5
Applied Strategic Agricultural Land Criteria

Component	Criteria	Study Area	Comments
BSAL	• Land that falls under soil fertility classes "high" or "moderate" under the Draft Inherent General Fertility of NSW (NSW Office of Environment and Heritage [OEH], 2012); and	Yes	Moderate to high soil fertility ground truthed at three observation points in the fertility assessment.
	• Land capability classes II or III under the Land and Soil Capability Mapping of NSW (OEH, 2012); and	Yes	Class II land along the Hunter river, running parallel to Denman Road.
	• Reliable water of suitable quality, characterised by: o land having rainfall of greater than 350 mm per annum (9 out of 10 years); or o land within 150 m of the following surface or groundwater resource: - a regulated river; or - unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero); or - 5th order and higher rivers; or - groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5 litres per second and total dissolved solids (TDS) of less than 1,500 milligrams per litre.	Yes	Average annual rainfall recorded at nearby Jerry's Plains is 644.7 mm.
	• Minimum 20 ha in area (based on minimum area required for commercial food production).	No	The portion of land that meets all other BSAL criteria is 2.4 ha.

Table 5 (Continued)
Applied Strategic Agricultural Land Criteria

Component	Criteria	Study Area	Comments
Critical Industry Cluster	Industry clusters that meet the following criteria: • There is a concentration of enterprises that provides clear development and marketing advantages and is based on an agricultural product. • The productive industries are interrelated. • It consists of a unique combination of factors such as location, infrastructure, heritage and natural resources. • It is of state, national and/or international importance. • It contributes to the region's identity. • It is potentially substantially impacted by coal seam gas or mining proposals.	Yes	The Study Area falls within the Equine Critical Industry Cluster according the *Draft Strategic Regional Land Use Plan Map 6*.

Source: GSS (2012) and DP&I (2012b)

GSS concluded, that while the Study Area meets the draft gateway criteria for the Critical Industry Clusters, and several of the BSAL parameters, there is no part of the Study Area that satisfies all criterions and, therefore, no BSAL determined to be present. The 2.4 ha section of land in the north-west of the Study Area that has been classed as Land Capability Class II, and which was determined to have soils that meet the moderate to high fertility criteria, cannot be included as BSAL because it is below the minimum area required for commercial food production (i.e. 20 ha).

GSS also concluded that parts of the Study Area fall within the Equine Critical Industry Cluster as shown in Table 5.

Upper Hunter Strategic Regional Land Use Plan

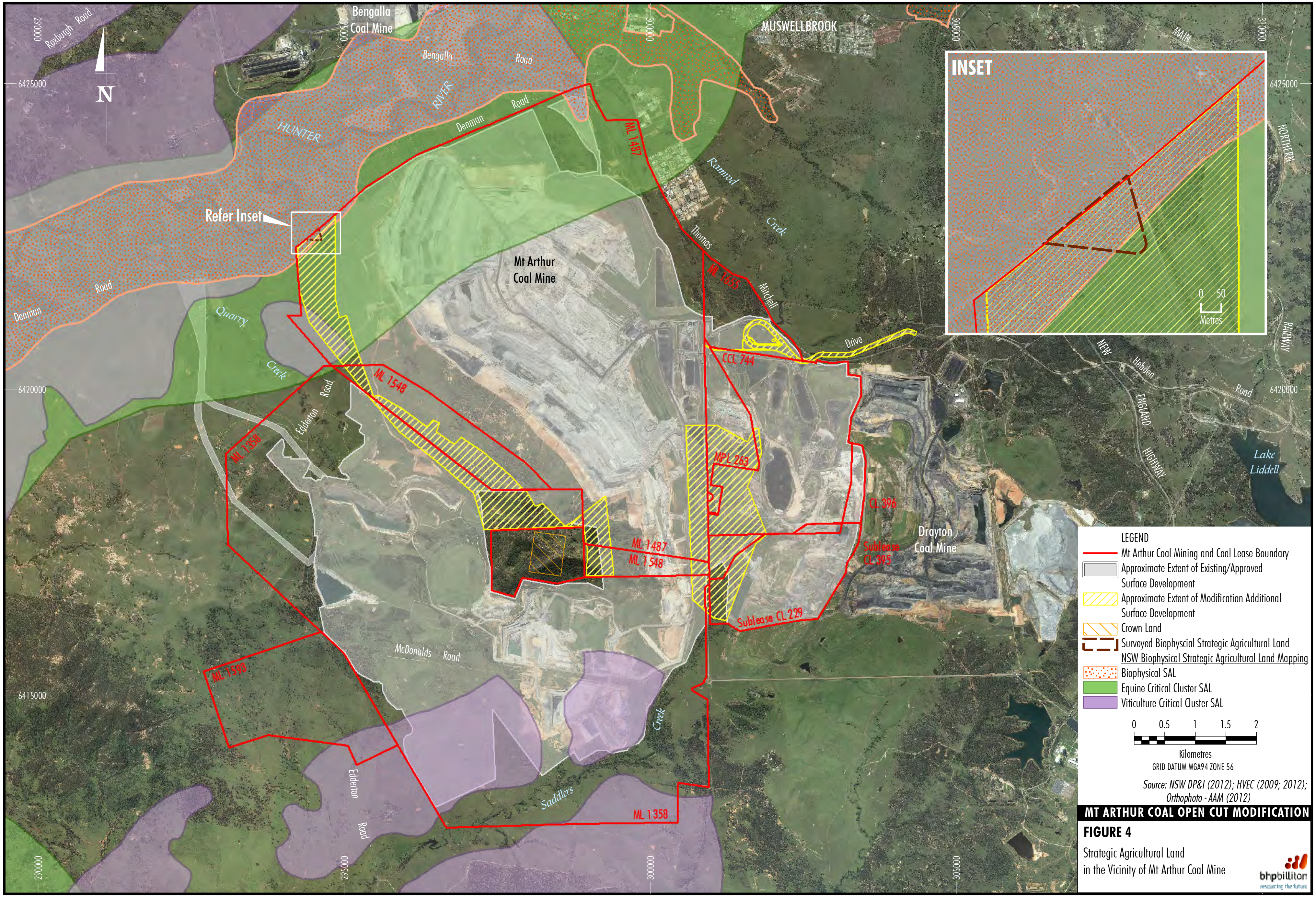
Subsequent to the finalisation of the GSS (2012) report (Attachment 1), on 11 September 2012, the DP&I released the Upper Hunter SRLUP (DP&I, 2012c). The Upper Hunter SRLUP is grossly the same as the Upper Hunter draft SRLUP. However, the criteria for BSAL requiring land to be a minimum of 20 ha (Table 5) (based on minimum area required for commercial food production) was removed. As such the Modification now satisfied the BSAL criteria for an area of 2.4 ha. Figure 4 provides DP&I's regional mapping of BSAL, equine critical industry clusters and viticulture critical industry cluster.

Draft Interim Verification Protocol (Version 7)

In February 2013, the NSW Government released Version 7 of the Draft (February 2013) *Interim Protocol for Site Verification and mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013). This Interim Protocol describes that:

> *BSAL must have a contiguous area equal to or exceeding 20Ha which meets the verification criteria. The minimum area refers to the extent of the biophysical resource not the lot or holding size. Hence if the mining lease area or holding includes less than 20 Ha of BSAL but this BSAL is part of a larger contiguous mass that equals to or exceeds 20 Ha then the land is regarded as BSAL.*

It is noted that the area to the immediate north of the potential BSAL (Figure 4) is associated with Hunter River alluvium. Whilst detailed site verification has not been undertaken on these adjacent areas, it is conservatively assumed that the BSAL is contiguous to the north (i.e. the 2.4 ha of BSAL in the Modification area is part of a larger contiguous mass that equals to or exceeds 20 ha).



MT ARTHUR COAL OPEN CUT MODIFICATION

FIGURE 4

Strategic Agricultural Land in the Vicinity of Mt Arthur Coal Mine

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Accordingly, and consistent with the Upper Hunter SRLUP (DP&I, 2012c), this AIS has conservatively assumed and assessed this 2.4 ha area as BSAL (Figure 4).

2.1.8 Water Resources

Groundwater

A Groundwater Impact Assessment for the Modification was undertaken by AGE and is presented in Appendix B of the EA. The following discussion is based on this assessment and Section 4.4 in the Main Report of the EA.

Existing Groundwater Regime

The hydrogeological regime of the Mt Arthur Coal Mine is considered to consist of three groundwater systems, including:

- alluvium along the Hunter River and Saddlers Creek;
- weathered bedrock (regolith); and
- the coal seams of the Permian Wittingham Coal Measures.

Alluvial Aquifers

Deposits of unconsolidated silts, sand and minor fine gravels of mixed colluvial-alluvial origin occur in the valleys of the creeks and gullies within the Mt Arthur Coal Mine. These deposits are thin and of limited extent, and hence do not have significant groundwater storage capacity (Appendix B of the EA).

Comparatively the alluvial deposits of the Hunter River to the immediate north of the Mt Arthur Coal Mine are a significant source of groundwater. Monitoring data suggests that the Hunter River alluvial groundwater levels have remained relatively constant with no direct correlation to rainfall trends, indicating some buffering of the alluvial groundwater levels by the potentially interconnected Hunter River. Recharge to the Hunter River alluvium is likely to occur from direct infiltration of rainfall and runoff from elevated bedrock sub-crop areas, in addition, recharge from flow in the Hunter River potentially occurs during very dry periods (Appendix B of the EA).

Consistent with the regional hydraulic gradient, groundwater within the alluvium indicates a shallow hydraulic gradient towards the Hunter River. The alluvial water table also has a general downstream hydraulic gradient coinciding with the topographic gradient of the alluvium and flow of the Hunter River (Appendix B of the EA).

Regolith

The regolith or shallow bedrock groundwater systems comprise surficial soils and weathered bedrock. The depth of the profile is variable and depends on factors including the depth of weathering and the extent and frequency of fracturing (Appendix B of the EA).

The regolith acts as a potential temporary water store during sustained wet periods and provides a potential source for recharge to the underlying coal measures, however, it is inferred that this recharge is limited (Appendix B of the EA).

Permian Aquifers

The Permian strata occurs across the whole of the Mt Arthur Coal Mine area and may be categorised into the following hydrogeological units (Appendix B of the EA):

- hydrogeologically "tight" and hence very low yielding to essentially dry sandstone and lesser siltstone that comprise the majority of the Permian interburden/overburden; and
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

Groundwater level data suggests the regional potentiometric surface of the Permian Aquifers is a subdued reflection of the topography, with a groundwater mound beneath the topographically elevated areas of the ridgeline between Mount Arthur and Mount Ogilvie, and a hydraulic gradient towards the Hunter River valley to the north, and Saddlers Creek to the south (Appendix B of the EA).

Historical and ongoing mining within the Mt Arthur Coal Mine area (including surrounding mining operations) has resulted in depressurisation of the Permian coal measures. This depressurisation has resulted in a change to the groundwater gradient beneath the alluvium with discharge from the coal seams to the alluvium reversed to leakage from the alluvium to the pit in the vicinity of the open cut mining (Appendix B of the EA).

Groundwater Quality and Use

Groundwater quality monitoring undertaken on the Hunter River since January 1999 indicated that groundwater quality, as reflected by the Electrical Conductivity (EC), is quite variable, in the range 1,500 microSiemens per centimeter (µS/cm) to 9,370 µS/cm. This probably reflects the dominant recharge source at the time, that is, recharge from the underlying coal measures resulting in poor quality water, or recharge from rainfall or the river itself, resulting in slightly improved quality water. The pH ranges from slightly acid to slightly alkaline (Appendix B of the EA).

As observed during a site visit by AGE in December 2005 (Appendix B of the EA), and confirmed by the monitoring data, the surface water in Saddlers Creek is brackish, indicating a potential discharge source from the underlying Permian coal measures.

Monitoring data indicates that groundwater in the vicinity of the Mt Arthur Coal Mine is beyond the limit of potable use and its environmental value has been classified as "primary industry" with the main use being for irrigation and stock watering.

A search of the NSW Office of Water (NOW) database of registered bores and wells within a radius of 5 km of the mining lease was undertaken. The data indicates that there are 50 registered bores within this radius. This compares to 32 bores found for a similar radius search in the AGE (2009) study. The registered bores include one bore licensed for domestic, two for stock and irrigation supply, thirteen for stock and domestic only, 22 for stock supplies only, six for domestic, irrigation and stock, two for monitoring and four unknown (Appendix B of the EA).

Surface Water

A Surface Water Assessment for the Modification was undertaken by Gilbert & Associates (2012) and is presented in Appendix C of the EA. The following discussion is based on this assessment and Section 4.5 in the Main Report of the EA.

Regional Hydrology

The Mt Arthur Coal Mine is located to the south of the Hunter River (Figure 1), wholly within the Hunter River catchment area. The Hunter River is one of the six major regulated river basins in NSW and has a catchment area of approximately 22,000 square kilometers (km^2). Flow is regulated in the Hunter River by three main water storages, Glenbawn Dam, Glennies Creek Dam and Lostock Dam. Near the Mt Arthur Coal Mine the Hunter River is regulated by Glenbawn Dam which is located approximately 30 km upstream (Appendix C of the EA).

Local Hydrology

Local hydrology comprises a number of drainage lines and creeks flowing north and south-west towards the Hunter River. Quarry Creek, Ramrod Creek, Fairford Creek, Whites Creek and a number of small unnamed creeks drain the western and northern parts of the Modification area and flow northwards into the Hunter River. Southwards flowing drainage lines in the Modification area report to Saddlers Creek which flows generally to the south-west and joins the Hunter River downstream of Denman (Appendix C of the EA).

The catchment areas of Quarry Creek, Fairford Creek, Whites Creek, Ramrod Creek and a small unnamed tributary have been reduced by the development of open cut pits which form part of the Mt Arthur Coal Mine. Quarry Creek has a catchment area of approximately 19 km^2 and drains the westernmost portion of the Modification area. Fairford Creek is a tributary of Whites Creek and has a catchment of approximately 8.6 km^2. Whites Creek had a pre-mining catchment area of approximately 21.5 $km^{2,}$ however this catchment area has been reduced due to diversion of the creek east of the existing Mine Infrastructure Area. Ramrod Creek has a catchment area of approximately 32.4 km^2 downstream of the existing mine rail loop and the neighbouring Drayton Coal Mine. The small unnamed tributaries drain the area north of the Northern Open Cut and have a catchment area of approximately 2 km^2 (Appendix C of the EA).

Catchments to the south of the Modification area are bounded by Mount Arthur and an associated ridgeline. Southward flowing tributary gullies report to Saddlers Creek which has a total catchment area of 91.3 km^2 (Appendix C of the EA).

All creeks within the Mt Arthur Coal Mine mining tenements appear to be ephemeral and are first order streams, with the exception of the headwaters of Saddlers Creek which is first and second order (Appendix C of the EA).

Surface water quality data from the Mt Arthur Coal Mine database has been compared to the Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, which provides a framework for water quality assessment and management. Median pH, EC, total suspended solids, TDS, filtered iron, nitrate and sulphate data from the Mt Arthur Coal Mine database were compared with guideline trigger values for protection of aquatic ecosystems in south-eastern Australian upland rivers and guideline values for Primary Industries water supplies (livestock drinking water quality). These parameters were chosen for assessment due to their potential for impact by mining related activity and by use of Muswellbrook treated effluent as part of the mine's water supply (Appendix C of the EA).

Median pH in local creeks has a tendency to trend towards alkaline levels. Median EC (a measure of salinity) was elevated relative to guideline trigger values at all monitoring locations. A large variability in EC values was observed at most sites. Median turbidity levels were below the upper bound guideline trigger level for protection of aquatic ecosystems at all monitoring locations except for Fairford Creek.

A large variability in turbidity was observed at all sites. Median TDS concentrations displayed the same general trend as EC. The highest concentrations were observed at the upstream reaches of Saddlers Creek and Quarry Creek. Median filtered iron concentrations were highest at the monitoring location on Fairford Creek. Median nitrate levels were well below the recommended guideline level for protection of aquatic ecosystems at all monitoring locations except Fairford Creek. Median sulphate concentrations were highest at the Saddlers Creek and Ramrod Creek monitoring locations and lowest at Fairford and Quarry Creeks. A large variability in recorded values of sulphate was noted at all sites (Appendix C of the EA).

Other Surface Water Users

Agricultural properties located immediately north of the Modification area contain on-stream dams which are used for irrigation and stock watering on Whites Creek, Fairford Creek and the unnamed creeks to the north-east of the Modification area. The majority of these properties are owned by HVEC. Two current private extraction entitlements for less than 16 megalitres of water each for irrigation have been licensed by the NOW on two adjoining properties on Ramrod Creek downstream of the Modification area. Water usage downstream of the Modification area at Saddlers Creek includes stock watering and irrigation from on-stream dams. Agricultural users in the region surrounding the Mt Arthur Coal Mine mining tenements may also rely on groundwater bores to provide water for irrigation, stock watering and domestic usage (Appendix C of the EA).

2.2 AGRICULTURAL PRODUCTION AND ENTERPRISES

Gillespie Economics (2012) has completed an Economic Review of Potential Agricultural Impacts of the Modification, which is presented in the Modification Socio-Economic Assessment (Appendix J to the EA). In Attachment C, Gillespie Economics has analysed the relative contribution of agricultural production to the state of NSW and the local region (Muswellbrook and Singleton LGAs).

The NSW agricultural industry directly provides employment for 76,261 people or 2.7% of total employment in NSW, and agricultural lands cover approximately 81% of NSW (Gillespie Economics, 2012). Trends in agriculture are leading to improved productivity, but reduced economic stimulus in regional areas, as demand for inputs such as labour decline. In general, the prosperity of rural areas that are reliant on agriculture has subsequently been in decline (Gillespie Economics, 2012).

The Muswellbrook LGA is located in the wider Upper Hunter Region. The Upper Hunter draft SRLUP describes the wider regional context of agricultural production over an area that comprises an area of some 2.2 million ha and includes the LGAs of Singleton, Muswellbrook, Dungog, Upper Hunter and Gloucester (DP&I, 2012b).

The Muswellbrook and Singleton region (i.e. the Muswellbrook and Singleton LGAs) has a land area of 831,000 ha, of which approximately 34% is agricultural land and the total value of agricultural production in 2006 was estimated at A$34 million (Gillespie Economics, 2012). Total employment in the agricultural industry in the Upper Hunter in 2006 was 2,288 (Australian Bureau of Statistics, 2011), with the main agricultural employment being in specialised beef cattle farming (Gillespie Economics, 2012).

In comparison, between Muswellbrook and Singleton, there are approximately 150,000 ha of intensive coal mining with a ratio of open cut to underground mining of 3:2 (DP&I, 2012c).

2.2.1 Agricultural History of the Local Area

Archaeology Australia (2009) prepared the *Mt Arthur Coal Consolidation Project Non-Aboriginal Heritage Impact Assessment* for the Consolidated Project. This report indicates that the Modification area originally formed part of the Edinglassie Estate, a station created in 1824.

The report also refers to several historical items and describes them as the remains of a fence line and stock yards. They are described as consisting of numerous extant posts with no rails located and a makeshift loading ramp and, although outside the Modification area, are indications of past agricultural stocking in the immediate area.

2.2.2 Local Agricultural Productivity and Enterprises

As described above, the primary agricultural sector in the Muswellbrook LGA is beef cattle farming.

GSS (2012) has identified that agricultural enterprises known to have been conducted in the Modification area include cattle grazing for beef and dairy products on unimproved pastures, with beef production being the dominant agricultural activity (Attachment 1 of Attachment C).

GSS (2012) estimated the gross margins for beef cattle grazing on land of agricultural suitability Classes 1, 3, 4 and 5 which occur within the Study Area, as ranging from approximately A$311 (Class1) to A$55 (Class 5) per ha, per year on these lands (Attachment 1 of Attachment C).

2.2.3 Support Infrastructure, Suppliers and Services

Local rural suppliers and/or equipment suppliers are located in Muswellbrook, Denman and Singleton. The Modification area and surrounds are well serviced for support infrastructure being located some 4 km south-west of Muswellbrook. In addition, access to regional road transport routes are readily available. The Modification area is also serviced by the Main Northern Railway.

Muswellbrook is also located within a two hour drive from the major regional centre of Newcastle and a short distance from the town of Singleton in the Hunter Valley.

The Modification is also located within approximately 1.5 hours drive of the Tocal College, a NSW Industry & Investment college with associated large commercial farms located in the Hunter Valley.

3 POTENTIAL IMPACTS

This section provides an assessment of the potential impacts of the Modification (including the proposed biodiversity offset areas) on agricultural resources and productivity.

3.1 CONSIDERATION OF RISKS

As a component of the analysis of the 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 Impact 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, blasting, air quality emissions and road transport have been considered in the Air Quality and Greenhouse Gas, Noise and Blasting and Road Transport Assessments (Appendices F, G and K of the EA).

3.2 AGRICULTURAL RESOURCES

3.2.1 Land Resources during the Modification Life

Modification Site

The Modification would disturb approximately 235 ha of additional land including 170 ha of existing agricultural land. This existing agricultural land consists of unimproved pasture, primarily mapped as Classes 4 and 5 Agricultural Suitability (Attachment A).

Adjoining Lands

HVEC owns around 14,000 ha of land that supports a diverse range of users from viticulture, horse breeding, cattle grazing and crop production to mining and habitat re-establishment. This includes Edinglassie, a 500 acre property on the banks of the Hunter River located approximately 500 m from the boundary of the Mt Arthur Coal Mine, separated by Denman Road. Edinglassie is leased and has operated as a thoroughbred stud farm since 1998 and producing Group One horse racing winners Bentley Biscuit, Wonderful World, Gods Own, Nadeem, Tell a Tale, Sharscay, Miss Margaret, Sustain, Emerald Dreams and Lasserfaire (Attachment B).

HVEC owns and operates Ogilvie View, a productive vineyard on a 485 ha property near Muswellbrook with 40 ha of predominantly Chardonnay vines. The remaining land is used for cattle grazing and intensive dry land cropping. Ogilvie View is located 2 km west of Mt Arthur Coal Mine.

Modification Biodiversity Offset Areas

The Modification biodiversity offset areas include approximately 235 ha of cleared land which is potential grazing land, based on existing Rural Land Capability and Agricultural Suitability mapping (Sections 2.1.5 and 2.1.6) and recent aerial photography. Currently, HVEC does not conduct any agricultural practices within the areas proposed for biodiversity offset.

The offset proposal for the Modification involves conserving local areas with existing fauna and flora conservation values and providing active management to maintain and enhance the flora and fauna values. Agricultural activities would therefore not be undertaken on the Modification biodiversity offset areas with the exception of strategic grazing, which may be used as a management tool for conservation purposes in accordance with *A Guide to Managing Box Gum Grassy* Woodlands (Rawlings *et al.* 2010). Reasons for grazing may be to control weeds and biomass or to manipulate species composition or sward structure (Rawlings *et al.* 2010). Conservatively, it is assumed that an additional 235 ha of grazing land outside of the immediate Modification area would be sterilised by the biodiversity offset areas (i.e. the biodiversity offset areas were assumed to be sterilised for agricultural purposes post-mining).

3.2.2 Land Resources Post-Mining

Modification Site

Modification disturbance areas would be progressively rehabilitated in a manner that provides a balance between post-mining agricultural land use and native vegetation regeneration areas.

A review of the physical and chemical properties of the soil resources within the Modification disturbance areas has established that *in situ* soil resources are suitable as a rehabilitation medium for agricultural (grazing) and native vegetation land uses on the Modification site, with the implementation of suitable soil management measures (Attachment A).

GSS (2012) has recommended that topsoil should be spread to a nominal depth of 100 mm on all re-graded land. Topsoil should be spread, treated with fertiliser and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion. Specific topsoil respreading depths for different post mining landform elements would be specified in the Rehabilitation Strategy.

Adjoining Lands

At the completion of the Modification, HVEC may no longer require company-owned lands that adjoin the Modification site. It is therefore expected that these properties would be sold and therefore would continue to be used for agricultural, viticulture and equine purposes in the future.

Modification Biodiversity Offset Areas

The biodiversity offset areas would be permanently conserved and as a result, approximately 235 ha of existing grazing land in these areas would be sterilised in perpetuity.

3.2.3 Availability of Water for Agriculture

As described in the Groundwater and Surface Water Assessments (Appendices B and C of the EA), it is not anticipated that the Modification would require any additional groundwater or surface water licence volumetric entitlements beyond the existing surface water and groundwater volumetric entitlements held by HVEC for the existing Mt Arthur Coal Mine.

Notwithstanding, the Modification would result in some residual catchment excision due to the presence of the final open cut voids and groundwater would continue to report to these voids for an extended period following the cessation of mining and reducing during recovery (Appendices B and C of the EA). On this basis potential impacts of the Modification on the availability of surface water and groundwater for agricultural uses are described in summary form below.

Groundwater

Three HVEC-owned groundwater bores are predicted to experience additional drawdown greater than 2 m as a result of the Modification (Appendix B of the EA). One of these bores is used for groundwater monitoring and the remainder are used for Domestic or Stock purposes (Appendix B of the EA).

For the remaining groundwater bores, there is expected to be negligible impact on groundwater levels or yield for groundwater users with privately-owned bores in any groundwater system attributable to the Modification (Appendix B of the EA).

Notwithstanding the negligible effects due to the Modification noted in surrounding private bores, consistent with the Project Approval for the Mt Arthur Coal Mine – Open Cut Consolidation Project Statement of Commitments:

> *In the event of interruption to water supply resulting from the Project, an alternative water supply will be provided, until such interruption ceases.*

The process for identifying and compensating the interruption to water supply resulting from Mt Arthur Coal operations would be in accordance with the “protocol for adverse affects to nearby users” outlined in the *Surface and Groundwater Response Plan* (BHP Billiton, 2012).

Consideration of the economic flow-on effects of utilising groundwater for the Modification rather than agricultural uses is provided in Appendix J of the EA.

Surface Water

The impacts of local creek catchments post-mining is shown in Table 6. The catchment areas reporting to Whites Creek/the Whites Creek diversion and to the unnamed creeks to the north of the Environmental Dam are actually greater for the Modification at maximum extent than for the calculated maximum extent for the approved operation reported in HVEC (2009). These increases have occurred in recent years as a result of progressive rehabilitation of waste emplacements (Appendix C of the EA). Runoff from these rehabilitated areas has been directed to these catchments. Ongoing rehabilitation of waste emplacements will result in further increases in the catchments reporting to these creeks in the future.

The catchment area of Saddlers Creek at maximum Modification extent may have also been seen to increase compared with the calculated maximum extent reported in HVEC (2009) because of the redesign of waste emplacements. This includes proposed diversion and collection drains on the South West Emplacement Area.

The catchments of the remaining existing natural creeks may be seen to reduce by maximum Modification development compared with the approved operation (HVEC, 2009). Average flow rates would be expected to reduce in proportion. The sum total decrease in catchment area for the Modification at maximum extent (compared with the calculated maximum extent reported in HVEC [2009]) is 0.6 km^2. This represents less than 0.02% reduction in the catchment reporting to the Hunter River nearby. Average flow rates in the Hunter River would be expected to reduce in proportion (Appendix C of the EA).

Table 6
Impact to Local Creek Catchments Post-mining

	Total Catchment Area prior to Mining (km^2)	Catchment Area for Maximum Extents of EA (km^2)	Catchment Area for Maximum Extents of MOD (km^2)	Percentage Change in Catchment Area Resulting from the Modification	Indicative Percentage Change in Flow Resulting from the Modification
Quarry Creek	22.0	18.6	16.5	10% Loss	10% Loss
Fairford Creek	10.8	2.7	1.4	12% Loss	12% Loss
Whites Creek	21.5	2.2	3.6	8% Increase	8% Increase
Unnamed Creeks	4.2	2.8	3.3	12% Increase	12% Increase
Ramrod Creek	33.4	32.2	31.6	2% Loss	2% Loss
Saddlers Creek	99.0	88.1	89.6	2% Increase	2% Increase

Source: After Appendix C of the EA

Agricultural properties located immediately north of the Modification area contain on-stream dams which are used for irrigation and stock watering on Whites Creek, Fairford Creek and the un-named creeks to the north-east of the Mt Arthur Mine area. The majority of these properties are owned by HVEC. Two current private extraction entitlements for less than 16 megalitres per annum of water, each for irrigation, have been licensed by the NOW on two adjoining properties on Ramrod Creek downstream of the Modification area. Water usage downstream of the Mt Arthur Mine area on Saddlers Creek includes stock watering and irrigation from on-stream dams (URS Australia Pty Limited [URS], 2000). Agricultural users in the region surrounding the Mt Arthur Mine area may also rely on groundwater bores to provide water for irrigation, stock watering and domestic usage (Appendix C of the EA).

Consideration of the economic flow-on effects of utilising surface water for the Modification, rather than agricultural uses is provided in Appendix J of the EA.

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 Air Quality and Greenhouse Gas Assessment and Noise and Blasting Assessment (Appendices F and G of the EA). In addition, potential impacts of the Modification on visual amenity, the safety and efficiency of the road network in the vicinity of the Modification have been considered in the Landscape and Visual Impact Assessment and Road Transport Assessment (Appendices H and K 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 temporarily removed by the Modification (a maximum of approximately 170 ha over the life of the mine), and consideration of the area of comparable grazing lands that would be re-instated with the Modification rehabilitation programme, along with sterilisation of existing grazing agricultural lands in the Modification biodiversity offset areas can be considered in the context of the area of land under agricultural production in the state of NSW and in the Muswellbrook/Singleton region (Table 7).

Table 7
Potential Impacts of the Modification on Regional and State Agricultural Land Area

Region	Approximate Area under Agricultural Use (ha)	Modification Maximum Impact*		Residual Impact of Modification Final Landform*	
		(ha)	(%)	(ha)	(%)
NSW	65,000,000	170	0.000003	235	0.000004
Muswellbrook/Singleton	278356		0.0006		0.0008

After: Attachment A.

* Including agricultural lands in Modification biodiversity offset areas.

As shown in Table 7, the potential impact of the Modification on the area of land that is subject to agricultural use in NSW and in the Muswellbrook region would be very small. The existing BSAL that has been identified as being potentially impacted by the Modification is 2.4 ha (Section 2.1.7).

Gillespie Economics (2012) has considered the potential impacts of the Modification sterilisation of agricultural land and the use of some water resources that may otherwise have been available for agriculture on the Muswellbrook region. This analysis indicates that approximately A$0.7M would be in lost agricultural production (in perpetuity) as a result of the Modification (Attachment C).

Regional economic impacts were also evaluated and indicate that the Modification use of agricultural land and water is predicted to reduce direct agricultural employment in the Muswellbrook region by approximately 7 people, and reduce agricultural output by some A$1.0M per annum (Attachment A).

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.

Consideration of the potential impacts of the Modification on the availability of employees in the agricultural sector (i.e. flow-on effects of Modification employment demand in a tight labour market) and potential impacts to population and housing are provided in Appendix J of the EA.

3.4 CONSIDERATION OF POTENTIAL CUMULATIVE IMPACTS

A number of existing and proposed mining projects are located within the general vicinity of the Modification area. The potential impacts of these projects on agricultural land are summarised below.

Bengalla Coal Mine

The Bengalla Coal Mine was approved in October 2011 and allows for the continued operation of the Bengalla Coal Mine to 2017. The *Bengalla Mine Development Consent Modification EA* (2010) (Bengalla Mining Company Pty Limited, 2010a) describes much of the land to be disturbed by this Modification as Class M land, which denotes that the land is currently being used for mining purposes. The remaining land is largely classified as Class VI land which is suitable for grazing only. Some area of Class IV (suitable for grazing with occasional cropping) and Class II land (suitable for a wide range of land uses) were also identified in the southern limits of the survey area, adjacent to the Hunter River Floodplain.

In addition, the *Bengalla 2011 Annual Environmental Management Report* (Bengalla Mining Company Pty Limited, 2010b) describes the current operational areas at Bengalla Coal Mine as being located across predominantly Class IV and Class V grazing and agricultural land which has experienced extensive disturbance in the past. The majority of the leases have been cleared, grazed and were historically invaded by exotic grasses and shrubs.

In February 2012, Bengalla Mining Company Pty Limited lodged a preliminary EA and request for DGRs with the DP&I for the Bengalla Continuation Project which would allow tailings emplacement for continued operations for a further 24 years.

Drayton Mine Extension

The Drayton Mine Extension was approved in June 2012 and allows for the continued operation of the Drayton Coal Mine to 2017. The *Drayton Mine Extension EA* (2007) describes the land within the MLs as small areas of undisturbed land in the North, South and East Pits were classified as suitable for grazing with occasional cultivation in respect to land capability (i.e. Classes IV and V) whilst all remaining areas were identified as unsuitable for rural production (i.e. Classes VII, VIII and M). Undisturbed land in the North, South and East Pits were classified as land suitable for grazing (i.e. Class 4) in respect to Agricultural Land Suitability, whilst all other areas were identified as land unsuitable for agriculture (i.e. Class 5) (*Drayton Mine Extension EA*, 2007).

In March 2011, Anglo Coal lodged a preliminary environmental assessment and request for DGRs with the DP&I for the Drayton South Coal Project which would allow for continuation of mining at the Drayton Coal Mine and would extend operations to 2043.

Mangoola Coal Project

The Mangoola Coal Project was approved in February 2010 and allows for the continued operation of the Mangoola Coal Mine for 21 years. The *Modification to Mangoola Coal Mine Plans and Relocation of 500kV Electricity Transmission Line* describes majority of the land within the Proposed Disturbance Area as Class VI land, which is generally suitable for grazing with intensive management measures. The existing landscape is not suitable for cultivation owing to a combination of limitations of slope, subsoil instability and potential for dispersion and gully erosion. The small area of Class VIII land within the Proposed Disturbance Area is associated with the rocky outcrops around Anvil Hill.

Mount Pleasant Project Modification

The Mount Pleasant Project Modification was approved in September 2011 and allows for the continued operation of the Mount Pleasant Coal Mine to 2020. The *Mount Pleasant Project Modification EA Report* (EMGA Mitchell McLennan, 2010) describes the lands within the proposed action areas as grazing lands having a long history of agricultural use. Land to the west of the site is generally used for grazing with some agricultural activities undertaken.

3.5 CO-EXISTENCE OF AGRICULTURAL ENTERPRISES AND MINING

Agricultural enterprises continue to successfully coexist in close proximity to the Mt Arthur Coal Mine and surrounding resources developments. Some of the agricultural enterprises in the vicinity of the Mt Arthur Coal Mine that coexist with resource developments are described below, with further information provided in Attachment B.

Edderton

Edderton is a large 3,000 acre property located just south of Muswellbrook, owned by HVEC since 1992. Constructed in 1908, the homestead, which boasts regional heritage significance related to its historical association with the expansion of the wool industry in the Upper Hunter, is now a NSW heritage listed property.

The property's 1,450 ha of mostly native grasses provide an ideal pastoral environment for the Petith's herd of 400 Angus cattle and 30 full-blood Wagyu cows that are used to breed Wagyu bulls (Attachment B).

Edinglassie Homestead

Edinglassie is a historic 500 acre property on the banks of the Hunter River. It is an Australian heritage listed property, initially settled by the White family 150 years ago. More recently, Edinglassie was the home of Rosemount Wines, but is currently operated as Edinglassie Thoroughbred Stud (Attachment B).

Since the land was purchased by HVEC in 1998, the stud has continued to produce high quality thoroughbred race horses. Edinglassie's Group One race winners include Bentley Biscuit, Wonderful World, Gods Own, Nadeem, Tell a Tale, Sharscay, Miss Margaret, Suntain, Emerald dream and Lasserfaire. Approximately 50 foals were born at Edinglassie stud in 2011 (Attachment B).

Although the hilly country of the Mt Arthur Coal Mine is only suitable for limited to low intensity agriculture, the bordering alluvial lands of the Hunter River, on which Edinglassie is situated, provide fertile irrigated pastures with undulating hills for young stock and lucerne pastures for mares and foals (Attachment B).

Ogilvie View

Ogilvie View, the former Roxburgh Estate, is a 485 ha property located 12 km south-west of Muswellbrook in the Hunter Valley. HVEC purchased the property from Fosters in 2009. Ogilvie View is located 2 km west of the Mt Arthur Coal Mine , and was purchased by HVEC as a buffer zone for the mine's operation (Attachment B).

Since the property was purchased, decisions about the most productive use of the land have been made in accordance with the demands of the local market. While the breakup of the Rosemount Estate saw many properties change land use, including the incorporation of Giants Creek and Denman vineyards into the Patinack Thoroughbred Farm, Ogilvie View continues to operate as a vineyard with 40 ha under vines. Areas within Ogilvie are also used for cattle grazing (Attachment B).

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 the approved Bengalla Coal Mine, Drayton Coal Mine and Mangoola Coal Mine also indicate that even accounting for these other approved and proposed developments, the potential cumulative impacts on local and regional agriculture would be minor.

Notwithstanding, HVEC 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

Where practicable, the area of agricultural land disturbed by the Modification at any one time would be minimised so that beneficial agricultural uses can continue to be undertaken on available Modification grazing lands. As demonstrated by HVEC at the existing Mt Arthur Coal Mine to date, cattle grazing can be readily undertaken in conjunction with the operation of a mine.

4.2 MANAGEMENT OF SOIL RESOURCES

General soil resource management practices would include the stripping and stockpiling of soil resources prior to any mine-related disturbance for use in rehabilitation, including the use in rehabilitation of agricultural land use areas. Modification soil resource management measures are outlined in detail in Attachment A.

4.3 RE-ESTABLISHMENT OF AGRICULTURAL LANDS

The rehabilitation and mine closure strategy for the Modification would include restoration of agricultural land suitable for grazing. The rehabilitation of this land reduces the area of agricultural land that would be sterilised by the Modification.

This re-establishment of agricultural lands would be undertaken progressively as a component of the Modification rehabilitation programme as described in Section 5 in the Main Report of the EA.

HVEC would continue providing improved pastures and occasional forage crops would be considered on areas of class IV land as per the draft Rehabilitation Strategy (BHP Billiton, 2012).

HVEC would commit to re-establishing the Class II agricultural capability land and Class 1 agricultural suitability land in the north-west of the Mt Arthur Coal Mine as shown of Figures 4 and 6 of the SLRA (Attachment A). The Rehabilitation Strategy would be revised to include further details of this commitment.

4.4 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 4.4.1 and 4.5.3 in the Main Report of the EA.

The existing *Mt Arthur Coal Mine Site Water Management Plan* would be reviewed and revised to describe any additional measures/procedures to be implemented over the life of the Modification. This updated plan would include 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 are adversely affected by the Modification.

4.5 OTHER MEASURES

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

5 JUSTIFICATION OF PROPOSED CHANGES TO AGRICULTURAL LANDS

The results of the site specific soil survey, Rural Land Capability mapping, Agricultural Suitability mapping and review of regional mapping of strategic agricultural land in the Upper Hunter SRLUP indicate that the Modification comprises 2.4 ha of BSAL. However, approximately 33.1 ha of Class I agricultural suitability land is present in the north-west of the Mt Arthur Coal Mine.

In summary:

- The Modification would at maximum disturb some 170 ha of existing grazing agricultural lands that are capable of beef production.
- The Modification would re-instate grazing agricultural land within the Modification disturbance area as a component of the progressive rehabilitation programme.
- The Modification would involve the residual sterilisation of some 235 ha of existing grazing agricultural land (primarily associated with the loss of agricultural land to revegetation of Modification biodiversity offset areas and Modification disturbance areas).
- The Modification residual impacts on agricultural lands would be, at state and regional levels, very minor.
- The Modification potential cumulative impacts on local or regional agriculture support industries would not be material.

The agricultural economic analysis conducted by Gillespie Economics (2012) indicates that the economic benefits of the Modification far outweigh the potential economic costs associated with the reduction in regional agricultural production that would arise due to the sterilisation of some 235 ha of grazing agricultural lands due to the Modification and associated biodiversity offsets.

6 REFERENCES

Anglo Coal (Drayton Management) Pty Limited (2007) *Drayton Mine Extension Environmental Assessment*.

Archaeology Australia (2009) *Mt Arthur Coal Consolidation Project Non-Aboriginal Heritage Impact Assessment*

Australasian Groundwater & Environment Consultants Pty Ltd (2009) *Report on Mt Arthur Coal Consolidation Project – Groundwater Impact Assessment,* Project No. G 1446.

Australasian Groundwater & Environment Consultants Pty Ltd (2013) *Mt Arthur Coal Open Cut Modification Groundwater Impact Assessment.*

Australian and New Zealand Environment and Conservation Council (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Australian Bureau of Statistics (2011) *Census of Population and Housing, Customised Data Report, Place of Usual Residence by Industry, Upper Hunter State Significant Development, Place of Work: Upper Hunter State Significant Development, Place of Usual Residence: Upper Hunter State Significant Development, Outside Upper Hunter State Significant Development, No Usual Address, Industry of Employment: ANZSIC 2006 4 digit (Count of Employed Persons).*

Bengalla Mining Company Pty Limited (2010a) *Bengalla Mine Development Consent Modification Environmental Assessment*.

Bengalla Mining Company Pty Limited (2010b) *Bengalla 2011 Annual Environmental Management Report*.

BHP Billiton (2012) Draft *Rehabilitation Strategy.*

BHP Billiton (2012) *Surface Water and Groundwater Response Plan.*

Bureau of Meteorology (2012) *Monthly Climate Statistics Jerrys Plains Post Office* (Product IDCJCM0037).

Cummingham G.M., Higginson F.R., Riddler A.M.H. and Emery K.A. (1988) *Systems used to classify rural lands in New South Wales.* Soil Conservation Service of New South Wales.

Department of Planning and Infrastructure (2012a) *Guideline for Agricultural Impact Statements*.

Department of Planning and Infrastructure (2012b) *Draft Strategic Regional Land Use Plan – Upper Hunter*.

Department of Planning and Infrastructure (2012c) *Strategic Regional Land Use Plan – Upper Hunter.*

EMGA Mitchell McLennan (2010) *Mount Pleasant Project Modification Environmental Assessment Report.*

Geo-Environmental Management (2012) *Mt Arthur Coal Open Cut Modification Geochemistry Assessment of Overburden and Interburden.*

Gilbert & Associates (2012) *Mt Arthur Coal Open Cut Modification Surface Water Assessment.*

Gillespie Economics (2012) *Mt Arthur Coal Open Cut Modification Socio-Economic Assessment.*

GSS Environmental (2012) *Mt Arthur Coal Open Cut Modification Soil and Land Resource Assessment.*

GTA Consulting (2012) *Mt Arthur Coal Open Cut Modification. Muswellbrook New South Wales Road Transport Assessment.*

Hunter Eco (2013) *Mt Arthur Open Cut Modification Ecological Assessment*.

Hunter Valley Energy Coal (2009) *Mt Arthur Coal Consolidation Project Environmental Assessment Consolidated Project*.

NSW Government (2013) *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land*. Draft.

Office of Environment and Heritage (2012) *Landscapes and Soils – Strategic Regional Land Use Policy. Land and Soils Capability Map, Draft Inherent Soil Fertility Map.*
Website: http://www.environment.nsw.gov.au/soils/index.htm

PAE Holmes (2013) *Air Quality Impact Assessment Mt Arthur Coal Open Cut Modification.*

Rawlings, K., Freudenberger, O., Carr, D. (2010) *A Guide to Managing Box Gum Grassy Woodlands*. Department of the Environment, Water, Heritage and the Arts.

RPS Australia East Pty Ltd (2013) *Aboriginal Cultural Heritage Assessment Mt Arthur Coal Open Cut Modification.*

The National Committee on Soil and Terrain (2009) *Australian Soil and Land Survey Field Handbook 3rd Edition.* Commonwealth Scientific and Industrial Research Organisation Publication, Australia.

Urbis Pty Ltd (2013) *Mt Arthur Coal Open Cut Modification Landscape and Visual Impact Assessment.*

URS Australia Pty Limited (2000) *The Mount Arthur North Coal Project Environmental Impact Statement* – Appendix F Surface Water Hydrology and Water Management.

Wilkinson Murray (2013) *Mt Arthur Coal Open Cut Modification Noise and Blasting Assessment.*

ATTACHMENT A

SOIL AND LAND RESOURCE ASSESSMENT

FINAL

Mt Arthur Coal Open Cut Modification

Soil and Land Resource Assessment

September 2012

MAC01-029

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3	10/09/2012	Soil and Land Assessment Report Final 1	MH	CR

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1.0 INTRODUCTION

1.1 Overview

GSS Environmental (GSSE) was engaged by Hunter Valley Energy Coal Pty Limited, a wholly owned subsidiary of BHP Billiton, to undertake a Soil and Land Resource Assessment for the proposed Mt Arthur Coal Open Cut Modification (the Modification). This will form part of an Environmental Assessment (EA) which will accompany an application to modify the Project Approval to be submitted to the New South Wales (NSW) Department of Planning and Infrastructure (DP&I) under section 75 of the NSW *Environmental Planning and Assessment Act, 1979.*

The Modification includes the following key components:

- a four year continuation of the open cut mine life from 2022 to 2026 at the currently approved maximum rate of 32 million tonnes per annum;
- an increase in open cut disturbance areas;
- use of the conveyor corridor for overburden emplacement;
- duplication of the existing rail loop;
- an increase in the maximum number of train movements per day from 24 to 38;
- the relocation of the load point for the overland conveyor which delivers coal to Macquarie Generation's Bayswater Power Station;
- the relocation and upgrade of the explosives storage, magazine and associated facilities; and
- the construction of additional offices and a control room, and a small extension to the run-of-mine coal stockpile footprint.

This Soil and Land Resource Assessment includes the methodology used in the assessment, a summary of the results, and a description of the management measures proposed to mitigate the potential soil and land resource impacts of the Modification.

A glossary of terms is provided in **Appendix 1**.

1.2 Study Area

The Mt Arthur Coal Mine is located approximately 5 kilometres (km) south-west of the town of Muswellbrook and approximately 130 km north-west of Newcastle, NSW (**Figure 1**). The disturbance areas of the Modification include the following;

- Open cut extension areas – this includes the 355 hectare (ha) extension area, of which approximately 170 ha has been previously soil mapped. Approximately 235 ha of the 355 ha extension area is outside of Mt Arthur Coal Mine's approved consolidated open cut disturbance area.
- Minor site infrastructure changes – some minor disturbance from the relocation or provision of new infrastructure will occur on areas previously soil mapped and, as such, is not considered in this report.

The Study Area mentioned above is comprised of three (3) main study areas (**Figure 2**); the first is located to the west of the existing open cut operations and covers an area of 125.6 ha (referred to in this report as Area 1). The second is located to the south of the existing open cut operations and covers an area of 80.7 ha (Area 2). The third is located to the south east of the current operations and covers an area of 28.8 ha (Area 3).

1.3 Requirements and Objectives

A summary of the Director–General's Requirements (DGRs) for the Modification, are outlined below:

Requirements: Agricultural and Other Land Resources - including an Agricultural Impact Statement that includes a specific focused assessment of the impacts of the proposal on strategic agricultural land (SAL), having regard to the draft gateway criteria in the draft Upper Hunter Strategic Regional Land Use Plan. The EA must also include a detailed description and assessment of the potential impacts on:

- soils and land capability (including salinisation and contamination);
- landforms and topography, including steep slopes; and
- land use, including agricultural, forestry, conservation and recreational use, with particular attention on the local viticulture and equine industries.

As outlined below, the key objectives of the Soil and Land Resource Assessment have been developed to reflect the DGRs focusing on soil and land assessment.

Objective 1 Classify and determine the soil profile types within the Study Area

To satisfy Objective 1 of the Soil and Land Resource Assessment, the soil taxonomic classification system used was the Australian Soil Classification (ASC) system (Isbell, 1996). This system is routinely used as the soil classification system in Australia.

Objective 2 Provide a description of, and figures showing, the land capability within the Study Area

To satisfy Objective 2 of the Soil and Land Resource Assessment, the relevant guideline applied was *Systems used to classify rural lands in New South Wales* (Cunningham *et al*., 1988). This is the guideline approved by the NSW Office of Environment and Heritage (OEH) (formerly the NSW Soil Conservation Service).

Objective 3 Provide a description of, and figures showing, the agricultural land suitability within the Study Area

To satisfy Objective 3 of the Soil and Land Resource Assessment, the relevant guideline applied was the *Agricultural Suitability Maps – uses and limitations* (NSW Agriculture and Fisheries, 1990). This is the guideline approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services.

Objective 4 Provide selective topsoil and subsoil management recommendations

To satisfy Objective 4 of the Soil and Land Resource Assessment, the *Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley* (Elliot and Veness, 1981) was used to determine which soil types in the Study Area are suitable for conservation and re-use in the site rehabilitation programme. The approach described in this guideline remains the benchmark for land resource assessment in the Australian mining industry.

Objective 5 Provide recommendations to mitigate soil erosion and sedimentation associated with the works or soil stockpiles

To satisfy Objective 5 of the Soil and Land Resource Assessment, the *Managing Urban Stormwater: Soils and Construction Vol. 1* (Landcom, 2004) and *Volume 2E, Mines and Quarries* (DECC, 2008) were used as a basis for recommendations related to soil erosion and sedimentation mitigation associated with the proposed works.

2.0 EXISTING ENVIRONMENT

2.1 Climate

Representative climate data for the site has been obtained from the nearest Bureau of Meteorology (BOM) weather station located in the township of Jerrys Plains, approximately 15 km to the south-east of the Study Area (BOM, 2012).

The Study Area has a summer dominated rainfall climate with relatively drier winter months. Average annual rainfall is 645.7 millimetres (mm), and average maximum temperatures range from 17.4 degrees Celsius (^{o}C) in July to 31.7^{o}C in January.

The BOM classifies the Study Area within a temperate climate zone, with no designated wet season. However, the area is susceptible to occasional heavy showers and thunderstorms due to easterly troughs in the region during warmer months.

2.2 Geology

The geology of the Study Area is described with reference to the *Hunter Coal Field Regional Geology Map* (1987). The stratigraphy of the Study Area comprises Middle to Late Permian sedimentary sequences, overlain in part by Quaternary alluvium and Cainozoic alluvial and colluvial deposits. Three (3) Palaeozoic units have been mapped and are described in ascending order (oldest to youngest) below:

- Saltwater Formation – This unit is the lowermost unit of the Late Permian Wittingham Coal Measures. It comprises sandstone and siltstone with minor coaly bands, which outcrop in a narrow north-south trending belt.
- Vane Subgroup – This unit also belongs to the Late Permian Wittingham Coal Measures and comprises coal seams, siltstone, lithic sandstone, shale and conglomerate, which outcrops in a north to north-west trending belt.
- Jerry's Plains Subgroup – This unit is the upper most member of the Late Permian Wittingham Coal Measures. It comprises coal seams, claystone, tuff, siltstone and conglomerate, which outcrop in a north-west trending belt.

Unconformably overlying these Palaeozoic rocks are relatively thin deposits of unconsolidated Cainozoic alluvial/colluvial deposits, which occur as:

- Unnamed Quaternary deposits – This unit comprises Quaternary clay, silt, sand and gravel deposited in point bar, levee and overbank environments. The deposits are of limited extent and occur in places along the north-western boundary of the survey area, on the floodplain of the Hunter River to the north of the survey area. Narrow alluvial tracts have also been mapped along the drainage flats of intermittent streams within the survey area.
- A second Cainozoic unit, not mapped by the regional geological surveys but identifiable within the survey area, comprises Cainozoic slopewash deposits. This unit comprises alluvial and colluvial deposits of gravel, sand, silt and clay, occupying gently inclined outwash slopes and footslopes, typically along lower slopes bordering drainage lines.

2.3 Soil Landscape Units

The soil landscapes within the Study Area have been described with reference to *Soil Landscapes of the Singleton 1:250 000 Sheet* (Kovac and Lawrie, 1991). Soil landscape units are defined as:

> "areas of land that have recognisable and specific topographies and soils that can be presented on maps and described by concise statements" (Kovac and Lawrie, 1991).

The soil landscape units that occur within the Study Area include:

- Bayswater Soil Landscape, covering approximately 30 per cent (%) of the Study Area;
- Liddell Soil Landscape, covering approximately 55% of the Study Area; and
- Ogilvie Soil Landscape, covering approximately 15% of the Study Area.

Bayswater Soil Landscape

The Bayswater Soil Landscape unit occurs on the Singleton Coal Measures and comprises undulating low hills to the south west of Muswellbrook, which range in elevation from 140 – 220 metres (m), with 3 – 10% slopes. Local relief is 40 – 60 m and drainage lines occur at 700 – 1,000 m intervals. Much of the area has been cleared of woodland for grazing on unimproved pastures, with some remnants of Forest Red Gum (*Eucalpytus tereticornis*) and Forest Oak (*Allocasuarina torulosa*). The soils are dominated by yellow loams on slopes with alluvial soils in drainage lines, with some duplex soils on slopes, and depositional material with sandy clay loam, loam and clay loam textures forming infrequently in drainage lines.

Limitations to soils in this unit include moderate sheet and gully erosion, structural degradation and crusting and hardsetting surfaces.

Liddell Soil Landscape

The Liddell Soil Landscape unit occurs on the Singleton Coal Measures and comprises undulating low hills with a few undulating hills, ranging in elevation from 140 – 220 m, with 4 – 7% slopes. Local relief is 60 – 120 m and drainage lines occur at 300 – 1,000 m intervals. Much of the area has been cleared of woodland for grazing on unimproved pastures, with some remnant open woodland of ironbark, box and gum species. The soils are dominated by yellow loams on slopes with, with some duplex sandy textures soils on lower slopes, and sands and skeletal soils forming infrequently throughout.

Limitations to soils in this unit include moderate to high erosion hazard, occasionally high soil salinity, and structural degradation.

Ogilvie Soil Landscape

The Ogilvie Soil Landscape unit occurs in association with the Narrabeen Group sandstone, shales and conglomerates, comprised of steep hills and escarpments with cliffs, which range which from 180 – 260 m, with 15 – 60% slopes. Local relief is 100 – 220 m. The landscape is characterised by remnant woodland consisting of ironbark, box and gum species. The soils are dominated by shallow, skeletal soils on crests and upper slopes, loams forming on lower slopes with sands on flats and drainage lines.

Limitations to soils in this unit include moderate sheet and gully erosion, structural degradation and mass movement and rock outcrop.

2.4 Topography and Hydrology

The topography within the Study Area comprises undulating to rolling low hilly lands associated with Area1, with broadly rounded crestal areas and moderately inclined dissection slopes up to approximately 10% slope gradient. There are isolated areas of flat terrain in both Area 1 and 3. There is one ephemeral waterway within Area 3. Steeper, higher hilly lands occur in Area 2. These hilly lands have mostly narrow rounded ridge crests and moderately steep to steep hill and ridge slopes, mostly in the range of 10 – 20% slope gradient. Locally steeper slopes (>20%) occur on the upper slopes in the vicinity of Mount Arthur.

2.5 Vegetation

The Study Area has historically been used for grazing, resulting in the majority of the area being classified as 'Pastoral Grassland' (URS, 2000). Previous ecology study findings within the Mt Arthur Coal Mine mining lease indicate a mixture of native and introduced pasture grasses between 0.1 – 1 m in height, interspersed with a variety of widespread native forbs and exotic weed species. Grasses recorded in the Study Area include Plains Grass (*Austrostipa aristiglumis*), Wallaby Grasses (*Austrodanthonia* spp. and *Rytidosperma* spp.), Red Grass (*Bothriochloa decipiens*), Queensland Bluegrass *(Dichanthium sericeum*) and Shorthair Plumegrass (*Dichelachne micrantha*), Barley Grass (*Hordeum leporinum*) and Bearded Oats (*Avena barbata*). These grass lands are widespread and exhibit considerable local variation in structure and composition in response to varied grazing pressure, in some places consisting of a stunted grassland and prostrate forb layer of less than 0.1 m in height.

The Study Area also contains areas of Narrow-leaved Ironbark Woodland-Open Forest. Structurally this community consists of an open forest to woodland community characterised by the presence of Narrow-leaved Ironbark (*Eucalyptus crebra*) and/or White Box (*Eucalyptus albens*) hybrids as the dominant canopy species to a height of 10 – 15 m. Additional canopy species which occasionally occur include Grey Box (*Eucalyptus microcarpa*), Slaty Gum (*Eucalyptus dawsonii*) and Kurrajong (*Brachychiton populneus*).

The shrub layer has been heavily cleared and is typically sparse to absent, while the groundcover layer is dominated by a mixture of exotic and native grasses and widespread forb species from 0.3 – 1.0 m in height.

Flora surveys were undertaken by Hunter Eco (2012) for the Modification within the three Study Areas. Hunter Eco concluded the following (Appendix D of the EIS):

- Study Area 1: The dominant vegetation was open grassland with widely scattered trees. The grassland was dominated by native grasses with a large area containing the Commonwealth listed vulnerable species, *Bothriochloa biloba*.
- Study Area 2: A mixture of open grassland and woodland characterised this area. It is reasonable to assume that the surrounding box woodland would have once been continuous across what is now cleared grassland. The majority of the open grassland was therefore determined to form part of the White Box - Yellow Box - Blakely's Redgum grassy woodlands and derived native grasslands. Two communities in this area were dominated by Spotted Gum (*Corymbia maculata*) and by Blakely's Red Gum (*Eucalyptus blakelyi*).
- Study Area 3: A central feature was the drainage line of the upper reaches of Saddler's Creek that was dominated by Broadleaf Cumbungi (*Typha orientalis*) reeds. Remnant vegetation gave some indication of the pattern before clearing. At the edges of the central creekline were patches of *Eucalyptus tereticornis*, *Corymbia maculata* and *Eucalyptus crebra*.

3.0 SOIL SURVEY AND ASSESSMENT

This section outlines the methods used to conduct the soil survey component of the assessment and reporting of results.

3.1 Soil Survey Methodology

A field survey and a desktop study were undertaken for the Study Area. The methodology used is described in the following sections.

3.1.1 Reference Mapping

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

- Aerial photographs and topographic maps:

  Aerial photo and topographic map interpretation was used as a remote sensing technique allowing detailed analysis of the landscape, and mapping of features expected to be related to the distribution of soils within the Study Area. Aerial and topographical maps were provided by HVEC.

- Reference information:

  Source materials were used to obtain correlations between pattern elements and soil properties that may be observable in the field. These materials included cadastral data, prior and current physiographic, geological, vegetation, and water resources studies.

- Previous reports:

  Previous studies were taken into consideration for soils mapping and land assessment. These include the following:

  - *Soil Landscapes of the Singleton 1:250,000 Sheet* (Kovac and Lawrie, 1991) (refer to **Section 2.3**);
  - *Soils Survey and Land Resource Assessment Report – Mt Arthur Coal Part 3A Environmental Assessment* (GSSE, 2009); and
  - Land Capability Spatial Data (NSW Department of Natural Resources, 2005).

3.1.2 Field Survey

3.1.2.1 Scale

The field survey was undertaken at a high intensity scale of 1:25,000. This survey scale enables the production of a detailed map that is suitable for intense land uses such as engineering works (*Guidelines for Surveying Soil and Land Resources* [McKenzie *et al*., 2008]). This survey scale was adopted to offer an adequate dataset of soil types within the Study Area and to assess the potential impact on these soils associated with the Modification.

3.1.2.2 Survey Type

The field survey undertaken was an integrated survey and is a qualitative survey type, meaning that locations were selected at the discretion of field staff based on an understanding of the landscape and previous reference mapping, as opposed to a grid survey approach. An integrated survey assumes that many land characteristics are interdependent and tend to occur in correlated sets (McKenzie *et al*., 2008). Background reference information derived from sources cited in **Section 3.1.1** were used to predict the distribution of soil attributes in the field. The characteristics evaluated to generate the correlated sets include vegetation type, landform and geology.

The specific type of integrated survey undertaken was a ‘free survey’. A free survey is a conventional form of integrated survey and its strength lies in its ability to assess soil and land at medium to detailed-scales. Survey points are irregularly located according to the survey teams’ judgement to enable the delineation of soil boundaries. Soil boundaries can be abrupt or gradual, and catena and toposequences are used to aid the description of this variation.

3.1.2.3 Survey Observations

Survey observations undertaken comply with the 1:25,000 scale survey criteria prescribed in the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al*., 2008).

The recommended observation density for 1:25,000 scale survey is one observation every 6.25 ha. For the Study Area of 230 ha this equates to a total of 37 observations required. A minimum of 10 – 30% (4 – 12 observations) are to be Detailed Profile Descriptions (also referred to as Class I observations), 5% (2 observations) are to be Laboratory Assessed (also referred to as Class II observations), and the remainder are to be made up by Minor Class Observations (also referred to as Class IV observations).

The actual number of observations undertaken for the Study Area was 10 Class I observations, six Class II observations and 28 Class IV observations. This exceeds and therefore satisfies the observation recommendations for a 1:25,000 survey scale. **Figure 3** illustrates the distribution of these survey observations throughout the Study Area, and denotes which sites where selected for laboratory analysis.

Additional observations within the Study Area were undertaken as part of a Fertility Survey, separate to the soils mapping survey detailed in this section. These observations consisted of both Class 1 observations and a series of ‘check’ observations which assessed the top 10 centimetres (cm) of soil. The full methodology and the results of the Fertility Survey can be found in **Section 4.4**.

3.1.2.4 Detailed Soil Profile Observations

Across the Study Area, 10 exposed soil profiles were assessed (**Figure 3**). A number of factors influenced the frequency of soil profile assessment, including access. Soil profiles were assessed for soil type and distribution, with two to five samples taken from the 10 profiles to option for laboratory analysis.

Each soil profile exposure pit was excavated to the required depth and placed upon a presentation tray for the profile to be analysed and photographed. Holes were backfilled post analysis.

Soil profiles within the Study Area were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* soil classification procedures (The National Committee on Soil and Terrain, 2009). Detailed soil profile descriptions recorded information that covered the parameters as specified in **Table 1**. Soil profile logging was undertaken in the field using soil data sheets.

Global Positioning System recordings were taken for all sites where detailed soil descriptions were made. Vegetation type and land use were also recorded. Soil exposures from cores were photographed during field operations as colour photography of profile sites is a useful adjunct to description of land attributes.

Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. A more detailed explanation of the Elliot and Veness procedure is presented in **Section 5** of this report.

Table 1 – Field Assessment Parameters

Descriptor	Application
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion/erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional/dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Structure Ped and Size	Soil structure, root penetration, permeability, aeration
Stones – Amount and Size	Water holding capacity, weathering status, erosional/depositional character
Roots – Amount and Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc.	Biological mixing depth

3.1.3 Soil Laboratory Assessment

Soil samples from six soil profile sites were utilised in the laboratory testing programme. Samples were analysed to:

- classify soil taxonomic classes;
- determine agricultural and land capacity classes; and
- determine suitability of soil as topdressing material.

Soil samples of about 1 – 2 kilograms were collected from each soil layer where appropriate. In total, 21 soil samples were sent to the Scone Research Centre for analysis. Certificate of Analyses for these results are contained in **Appendix 2**. The selected physical and chemical laboratory analysis parameters and their relevant application are listed in **Table 2**.

Table 2 – Laboratory Analysis Parameters

Property	Application
Coarse fragments (>2 mm)	Soil workability, root development, and water holding capacity
Particle-size distribution (<2 mm)	Nutrient retention, exchange properties, erodability, water holding capacity, workability, permeability, sealing, drainage, interpretation of most other physical and chemical properties and soil qualities
Aggregate stability (Emerson Aggregate Test [EAT])	Susceptibility to surface sealing under rainfall or irrigation, effect of raindrop impact and slaking, permeability, infiltration, aeration, seedling emergence, and correlation with other properties
Soil reaction (pH)	Nutrient availability, nutrient fixation, toxicities (especially aluminium and manganese), liming, sodicity, correlation with other physical, chemical and biological properties
Electrical Conductivity (EC)	Appraisal of salinity hazard in soil substrates or groundwater, and total soluble salts
Cation Exchange Capacity (CEC) and exchangeable cations	Nutrient status, calculation of Exchangeable Sodium Percentage (ESP), assessment of other physical and chemical properties, especially dispersivity, shrink – swell, water movement and aeration

The laboratory methods used by Scone Research Centre for each physical and chemical parameter are provided below in **Table 3**.

Table 3 – Laboratory Test Methods

Analyte	Method
Particle Size Analysis (PSA), to determine the percentage of Clay (Cl), Silt (Si), Fine Sand (Fs) and Coarse Sand (Cs)	Sieve and hydrometer
pH	1:5 soil/water extract
EC	1:5 soil/water extract
Emerson Rating	EAT
CEC and exchangeable cations	Silver and thiourea + extraction

3.2 Soil Survey Results

Within the Study Area, five soil types were identified. **Table 4** provides an overview of each soil type and their quantitative distribution within the Study Area. **Figure 3** illustrates their spatial distribution.

Table 4 – Soil Types

Soil Type No.	ASC Name	Study Area	
		Area (ha)	Area (%)
1	Red Chromosol	69.2	29
2	Brown Chromosol	9.7	4
3	Shallow Brown Chromosol	30.9	13
4	Brown Sodosol	104.3	45
5	Red Sodosol	21.0	9
	Total	**235.1**	**100**

The physical and chemical characteristics of the soil types and management recommendations for each are described in the following sections.

3.2.1 Soil Type 1 – Red Chromosol

***Soil Type Overview*:** Soil Type 1 is a Red Chromosol. Chromosols are soils that have significant texture contrast between the A and B horizons. This soil is characterised by an abrupt change between a loam and heavy clay texture with a dominant B2 colour class of red. These soils cover 29% or 69.2 ha of the Study Area and are generally found on plains and lower slopes characterised by gently undulating to flat terrain (**Figure 3**). Site 1 from the field survey is the representative profile for this soil type (Plate 1).

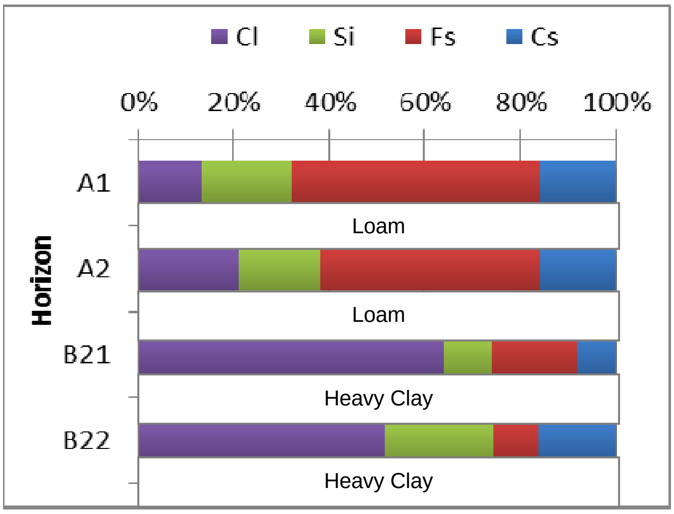
Soil Type 1 consists of a dark brown loam topsoil overlying a subsoil of dark red to red heavy clay (Plate 2). Fine sand is the dominant particle portion in the topsoil, with an abrupt increase in the smaller particles of clay at 25 cm (**Graph 1**). The soil profile has a moderate structure grade in the topsoil of 5 – 10 mm platy peds and a moderate consistence, trending to a moderate structure grade in the subsoil of 5 – 10 mm angular blocky peds to 20 – 30 mm blocky peds with a medium to strong consistence. The lower subsoil contains calcium carbonate segregations at 20% and coarse fragments of 10 mm at 5 – 10% (Plate 2). The profile has good drainage in the topsoil, moderate in the upper subsoil, trending to poor drainage at depth.

Management: This soil is constrained by significant clay portion and dispersability in the subsoil. However, if required, the subsoil could be stripped for use as an intermediate layer between overburden material and topdressing. The topsoil presents no specific management risks and has suitable textural, structural and chemical characteristics for use in topdressing. This soil type can be stripped to 25 cm for topdressing material to be used in rehabilitation, and a further 75 cm retained to be used as an intermediate layer, where deemed necessary.

Physical and Chemical Characteristics:

Plate 2: Red Chromosol

Plate 1: Soil Type 1 Landscape Setting



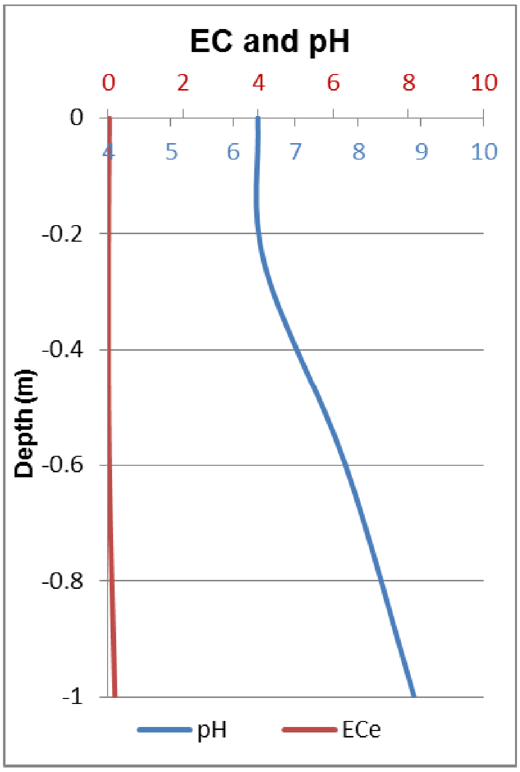
Graph 1: Site 1 PSA

Site 1 was used as a representative profile of Soil Type 1 and was subject to laboratory analysis. A summary of analytical results is provided in **Table 5**. The full data set can be found in **Appendix 2**.

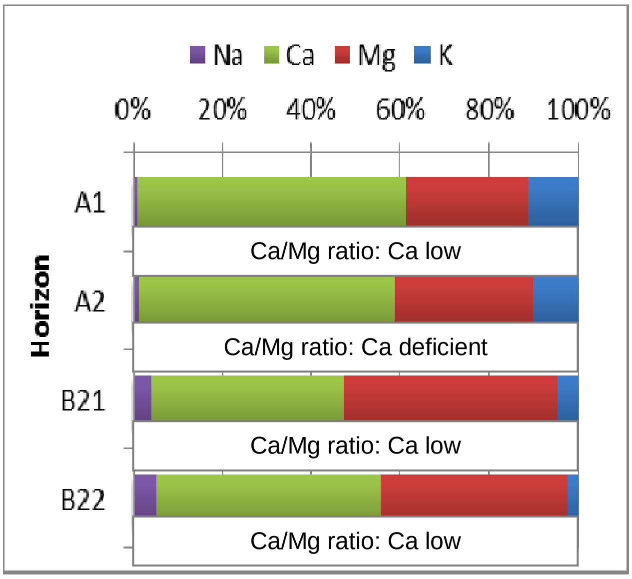
Table 5 – Site 1 Laboratory Analysis

Depth	Colour	pH		EC		CEC		ESP		EAT	
cm	Munsell	#	Rate	%	Rate	#	Rate	%	Rate	#	Rate
0 - 10	Dark brown	6.4	Slightly acidic	0.04	Very Low	11	Low	1	Non sodic	7	Negligible
10 - 25	Dark brown	6.5	Slightly acidic	0.02	Very Low	9.7	Low	1	Non sodic	3(2)	Slight
25 - 60	Dark red	7.8	Mildly alkaline	0.04	Very Low	21	Moderate	4	Non sodic	2(1)	High to Moderate
60 - 100	Red	8.9	Strongly alkaline	0.19	Low	24	Moderate	5	Non sodic	4	Negligible

The pH and EC results are shown in **Graph 2** below, which shows the pH variance, from slightly acidic topsoil trending to strongly alkaline at depth, while the profile is non-saline. **Graph 3** below shows the trend of exchangeable cations throughout the soil profile, and highlights the calcium/magnesium (Ca/Mg) ratio as low to deficient in Ca in the topsoil to being low in Ca in the subsoil. The CEC is a measure of fertility and is low to moderate in the topsoil and subsoil respectively. These soils are non sodic, and have an EAT rating of negligible to slight in the topsoil and moderate to high in the upper subsoil. The potassium (K) factor was rated as moderate to high in the topsoil, and moderate thereafter.



Graph 2: Site 1 pH and EC



Graph 3: Site 1 Exchangeable Cations

Na = sodium

3.2.2 Soil Type 2 – Brown Chromosol

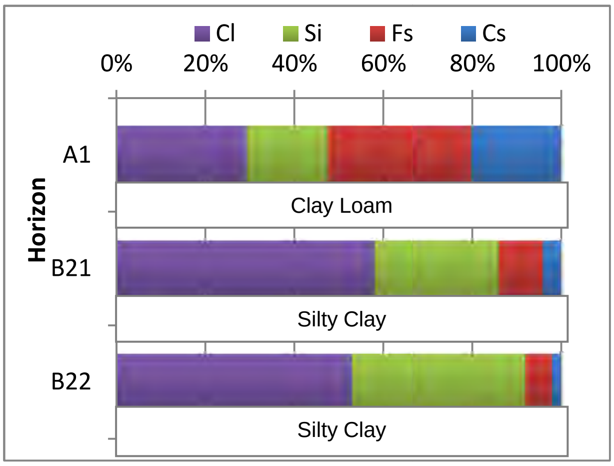
Soil Type Overview: Soil Type 2 is a Brown Chromosol. Chromosols are soils that have significant texture contrast between the A and B horizons. This soil is characterised by an abrupt change between clay loam and silty clay texture with a dominant B2 color class of brown. These soils cover 4% or 9.7 ha of the Study Area and are generally found on mid slopes (**Figure 3**). Site 7 from the field survey is the representative profile for this soil type (Plate 3).

Soil Type 2 consists of a very dark brown clay loam topsoil, overlying a strong brown to reddish brown silty clay subsoil (Plate 4). Fine sand is the dominant particle portion in the topsoil, with clay and silt fractions prevalent in the subsoil (**Graph 4**). The soil profile has a moderate structure grade in the topsoil of 20 – 30 mm sub angular blocky peds and a moderate consistence, trending to a strong structure grade in the subsoil of 30 – 50 mm angular blocky peds and weak consistence. The profile has a coarse fragment presence of 10 – 30 mm at 20% in the topsoil, to 5 – 10 mm at 5% in the subsoil. The profile is well drained in the topsoil, becoming moderately drained with increased clay fraction at depth.

Management: This soil is constrained by its extremely dispersive nature, as indicated by the K factor. Disturbance of this material poses significant management risks and as such it should only be stripped if significant soil amelioration and erosion and sediment control measures are implemented. This soil is not recommended to be stripped for re-use.

Plate 4: Brown Chromosol

Plate 3: Soil Type 2 Landscape Setting



Graph 4: Site 7 PSA

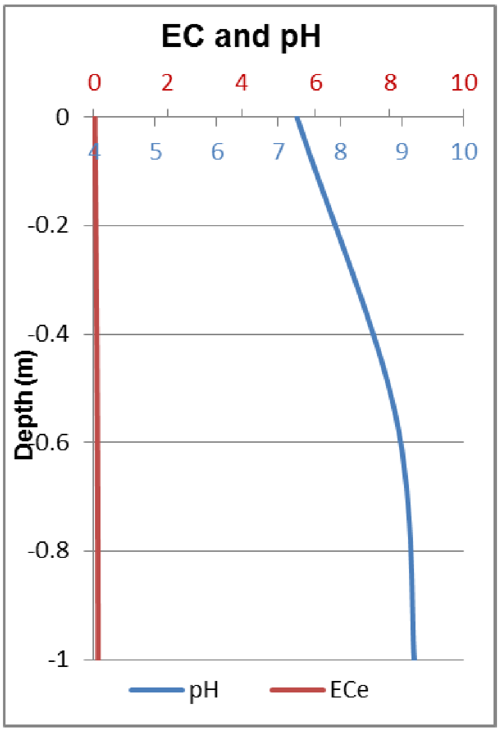
Physical and Chemical Characteristics:

Site 7 was used as a representative profile of Soil Type 2 and was subject to laboratory analysis. A summary of analytical results is provided in **Table 6**. The full data set can be found in **Appendix 2**.

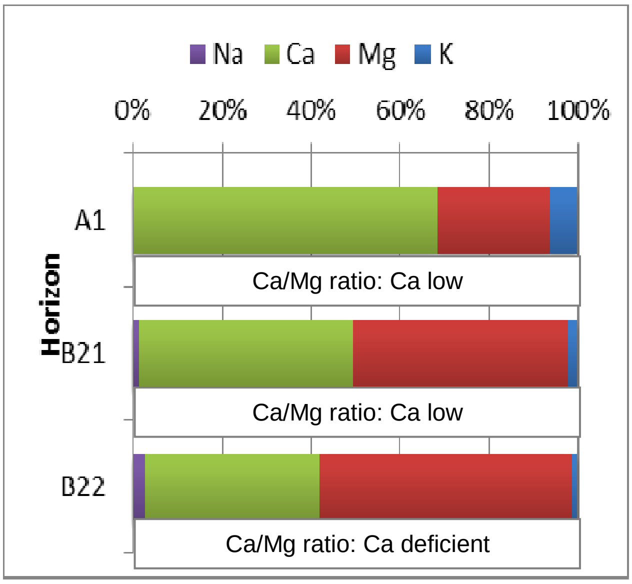
Table 6 – Site 7 Laboratory Analysis

Depth	Colour	Ph		EC		CEC		ESP		EAT	
cm	Munsell	#	Rate	%	Rate	#	Rate	%	Rate	#	Rate
0-20	Very dark brown	7.3	Neutral	0.04	Very Low	19	Moderate	0.37	Non sodic	7	Negligible
20-55	Strong brown	8.9	Strongly alkaline	0.11	Very Low	28	High	1.21	Non sodic	4	Negligible
55 -100	Reddish brown	9.2	Very strongly alkaline	0.13	Low	28	High	3.00	Non sodic	4	Negligible

The pH and EC results are shown in **Graph 5** below. The topsoil has a neutral pH, which becomes strongly alkaline to very strongly alkaline with depth, while the profile is non-saline. **Graph 6** below shows the trend of exchangeable cations throughout the soil profile, and highlights the Ca/Mg ratio as low to deficient. The CEC is moderate in the topsoil to high in the subsoil. These soils are non sodic and have an EAT rating of negligible. The K factor was rated very high in the topsoil, and high in the subsoil.



Graph 5: Site 7 pH and EC



Graph 6: Site 7 Exchangeable Cations

3.2.3 Soil Type 3 – Shallow Brown Chromosol

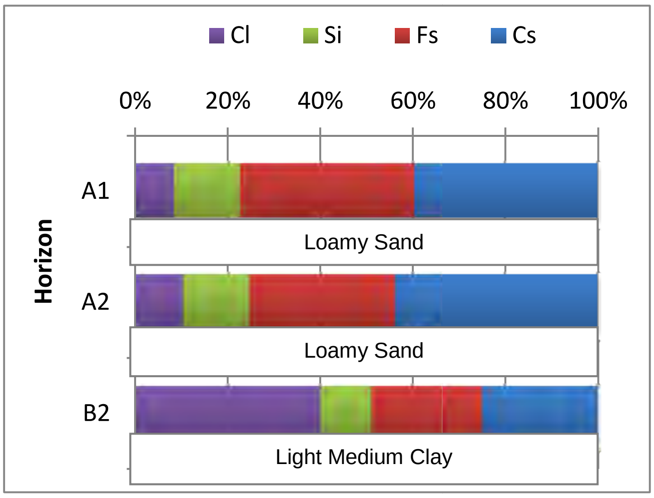
Soil Type Overview: Soil Type 3 is a Shallow Brown Chromosol. Chromosols are soils that have significant texture contrast between the A and B horizons. This soil is characterised by an abrupt change between loamy sand and a light medium clay texture with a dominant B2 colour class of brown. These are shallow soils with decomposing parent material evident at 60 cm. These soils cover 13% or 30.9 ha of the Study Area and are generally found on upper slopes and crests (**Figure 3**). Site 8 from the field survey is the representative profile for this soil type (Plate 5).

Soil Type 3 consists of a dark reddish brown to dark brown loamy sand topsoil overlying a subsoil of strong brown light medium clay (Plate 6). Fine and coarse sand are the dominant particle portions in the topsoil, with an abrupt increase in the smaller particles of clay at 30 cm (**Graph 7**). The soil profile has a moderate structure grade in the topsoil of 5 – 10 mm platy peds and a moderate consistence, trending to a moderate structure grade of 5 – 10 mm angular blocky peds in the topsoil, and moderate structure grade of 20 – 30 mm blocky peds with a medium to strong consistence in the subsoil. The lower subsoil contains calcium carbonate segregations at 20% and coarse fragments of 10mm at 5 – 10%. The profile has good drainage in the topsoil, moderate in the upper subsoil, trending to poorly drained at depth.

Management: This soil is constrained by significant clay portion in the subsoil, and problematic dispersability characteristics in the A2 and the B horizons. The A1 poses no specific management risk and has appropriate structural and chemical characteristics for re-use. This soil type can be stripped to 20 cm.

Plate 6: Shallow Brown Chromosol

Plate 5: Soil Type 3 Landscape Setting



Graph 7: Site 8 PSA

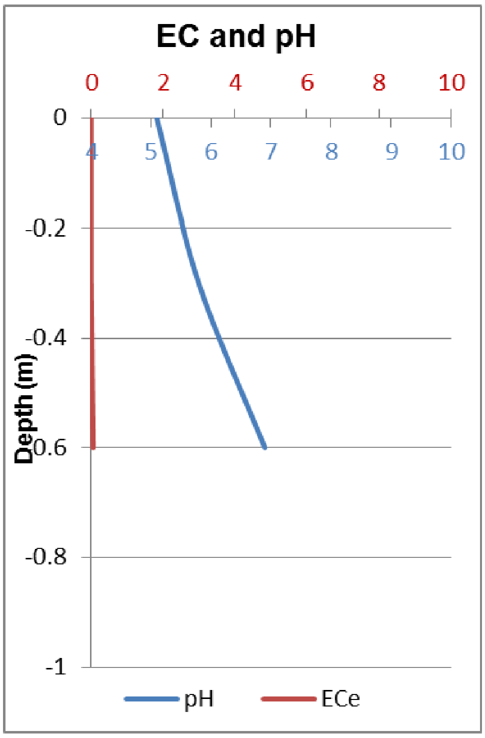
Physical and Chemical Characteristics:

Site 8 was used as a representative profile of Soil Type 3 and was subject to laboratory analysis. A summary of analytical results is provided in **Table 7**. The full data set can be found in **Appendix 2**.

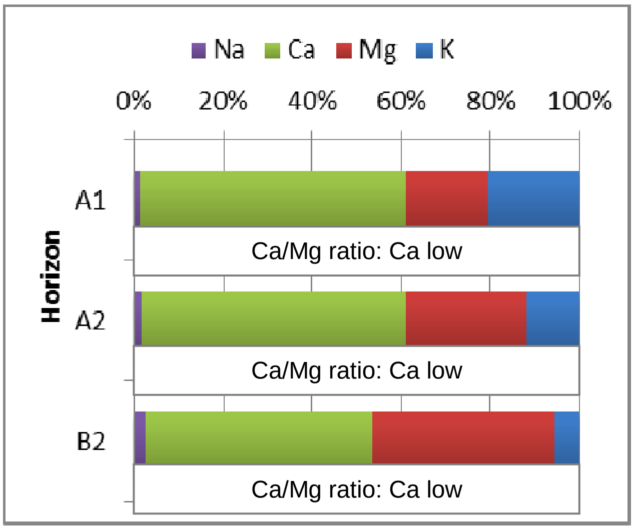
Table 7 – Site 8 Laboratory Analysis

Depth	Colour	pH		EC		CEC		ESP		EAT	
Cm	Munsell	#	Rate	%	Rate	#	Rate	%	Rate	#	Rate
0-20	Dark reddish brown	5.1	Strongly acidic	0.01	Very Low	3.7	Very Low	1.08	Non sodic	5	Slight
20-30	Dark brown	5.8	Moderately acidic	0.01	Very Low	3.8	Very Low	1.58	Non sodic	2(1)	High to Moderate
30-60	Strong brown	6.9	Neutral	0.06	Very Low	14	Moderate	2.71	Non sodic	2(1)	High to Moderate

The pH and EC results are shown in **Graph 8** below, which shows the pH variance of strongly acidic in the topsoil to neutral at depth, while the profile is non-saline. **Graph 9** below shows the trend of exchangeable cations throughout the soil profile, and highlights the Ca/Mg ratio as low in Ca throughout the profile. The CEC is very low in the topsoil and moderate at depth. These soils are non sodic, and have an EAT rating of slight in the A1, which becomes high to moderate in the A2 and B2. The K factor was rated as moderate throughout.



Graph 8: Site 8 pH and EC



Graph 9: Site 8 Exchangeable Cations

3.2.4 Soil Type 4 – Brown Sodosol

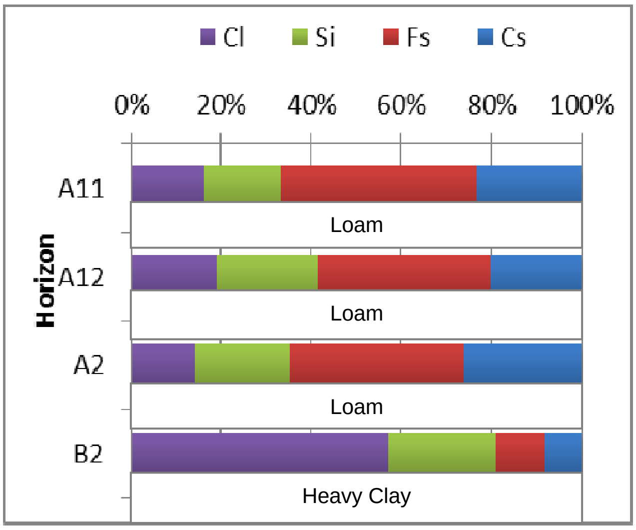
Soil Type Overview: Soil Type 4 is a Brown Sodosol. Sodosols are soils that have a significant texture contrast between the A and the sodic B horizons. These soils are characterised by a marginally sodic to sodic subsoil and a dominant color class of brown. These soils cover 45% or 104.3 ha of the Study Area and are generally found on lower and midslopes slopes characterised by gently undulating terrain (**Figure 3**). Site 3 from the field survey is the representative profile for this soil type (Plate 7).

Soil Type 4 consists of brown loam A11 and A12 horizons, with a bleached (field color) A2 overlying a subsoil of strong brown heavy clay (Plate 8). Fine sand is the dominant particle portion, although there is an abrupt increase in the smaller particles of silt and clay at 65 cm (**Graph 10**). The soil profile has a strong structure grade in the topsoil of 10 – 20 mm sub angular blocky peds and a moderate consistence, trending to a moderate structure grade of 5 – 10 mm blocky peds and weak consistence, to a weak structure grade of 2 – 5 mm blocky peds with weak consistence, becoming strongly graded with >20 mm blocky peds of moderate consistence. The profile has a consistent coarse fragment presence of 2 mm at 5% to the lower subsoil, where coarse fragments increase in size to 2 – 10 mm, at the presence of 5 – 10%. The profile is well drained in the upper three horizons, but becomes poorly drained with increased clay fraction at depth.

Management: This soil is constrained by the sodic characteristics and clay content of the subsoil, which has compromised the structure of the A2 horizon. Nonetheless, the A1 horizons show no specific management risks and can be stripped to a depth of 40 cm for material to be used in rehabilitation.

Plate 8: Brown Sodosol

Plate 7: Soil Type 4 Landscape Setting



Graph 10: Site 3 PSA

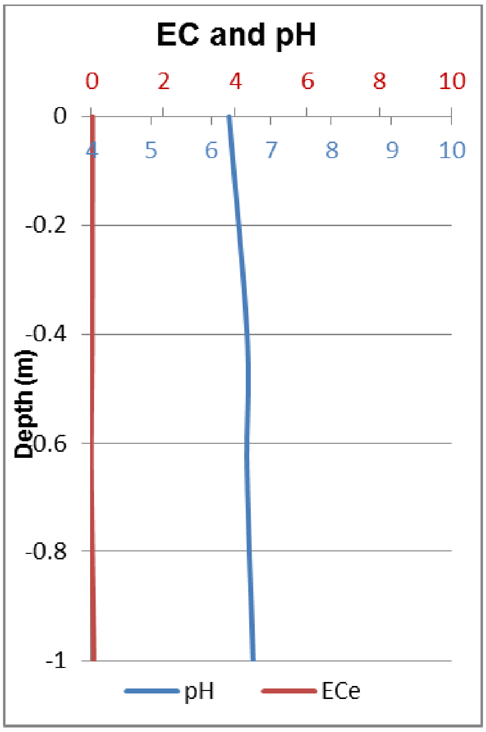
Physical and Chemical Characteristics:

Site 3 was used as a representative profile of Soil Type 4 and was subject to laboratory analysis. A summary of analytical results is provided in **Table 8**. The full data set can be found in **Appendix 2**.

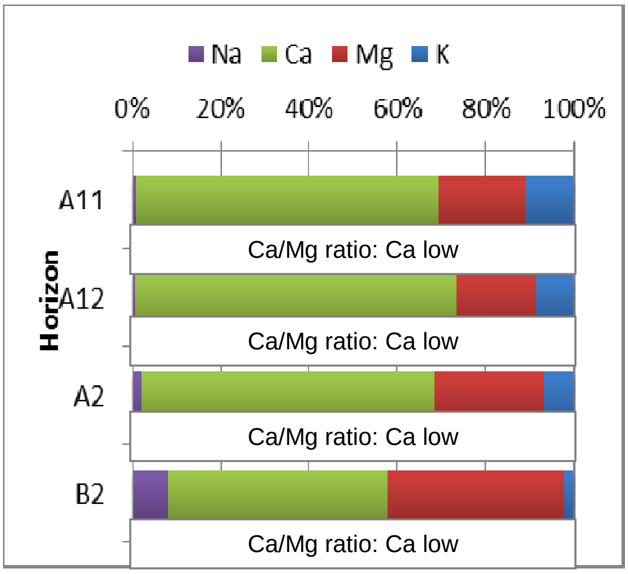
Table 8 – Site 3 Laboratory Analysis

Depth	Colour	pH		EC		CEC		ESP		EAT	
cm	Munsell	#	Rate	%	Rate	#	Rate	%	Rate	#	Rate
0 - 15	Brown	6.3	Slightly acidic	0.04	Very Low	12	Low	0.83	Non sodic	3(1)	Slight
15 - 40	Brown	6.6	Neutral	0.03	Very Low	10	Low	0.8	Non sodic	3(1)	Slight
40 - 65	Bleached	6.6	Neutral	0.01	Very Low	6.7	Low	2.09	Non sodic	2(1)	High to Moderate
65 - 100	Strong brown	6.7	Neutral	0.08	Very Low	18	Moderate	8.33	Marginally Sodic to sodic	1	Very High

The pH and EC results are shown in **Graph 11** below, which shows the minor pH variance of slightly acidic in the topsoil to neutral thereafter, while the profile is non-saline. **Graph 12** below shows the trend of exchangeable cations throughout the soil profile, and highlights the Ca/Mg ratio as low in Ca. CEC is a measure of fertility and is low in the topsoil to moderate in the subsoil. These soils are non sodic in the A horizons, becoming marginally sodic to sodic in the B horizon, and have an EAT rating of slight to high in the topsoil and very high in the subsoil. The K factor analysis was rated as moderate to high in the topsoil, and moderate in the subsoil.



Graph 11: Site 3 pH and EC



Graph 12: Site 3 Exchangeable Cations

3.2.5 Soil Type 5 – Red Sodosol

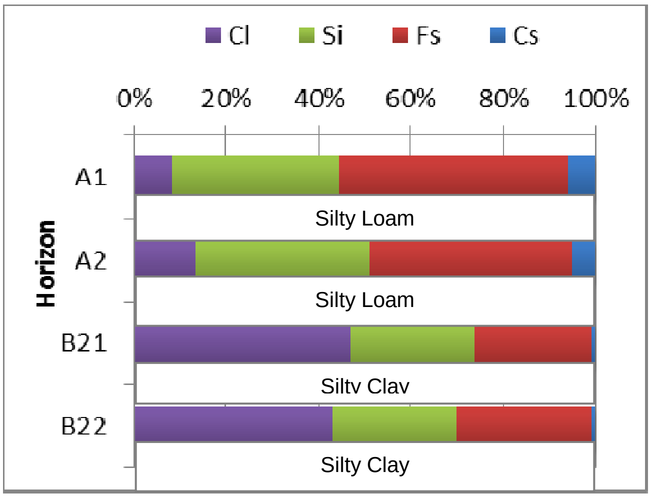
Soil Type Overview: Soil Type 5 is a Red Sodosol. Sodosols are soils that have a significant texture contrast between the A and the sodic B horizons. These soils are characterised by a marginally sodic to sodic subsoil and a dominant colour class in the upper B horizon of red. These soils cover 9% or 21 ha of the Study Area and are generally found on lower slopes and are characterised by gently undulating to flat terrain (**Figure 3**). Site 10 from the field survey is the representative profile for this soil type (Plate 9).

Soil Type 5 consists of a dark brown to brown silty loam topsoil overlying a subsoil of yellowish red to strong brown silty clay (Plate 10). Fine sand and silt are the dominant particle portions in the topsoil, with an abrupt increase in the smaller particles of clay at 30 cm (**Graph 13**). The soil profile has a moderate structure grade in the topsoil of 5 – 10 mm sub angular blocky peds and a weak consistence, to a weak structure grade in A2 of 5 – 10 mm sub angular blocky peds and weak consistence, trending to a strong structure grade in the subsoil of 10 – 20 mm blocky peds and strong consistence. The subsoil has a calcium carbonate segregation presence of 5 – 10%. The profile is moderately drained in the topsoil, becoming poorly drained thereafter. Within the mapping of this soil type there are depositional sediments associated with the creek flow, however, due to limited size and poor texture and structural characteristics, these alluvial are not commonly associated with good agricultural land.

Management: This soil is constrained by a significant clay portion and sodic characteristics in the subsoil, and the topsoil shows a specific management risks with a very high erodibility rating, based on K factor. This soil is not recommended to be stripped.

Plate 10: Red Sodosol

Plate 9: Soil Type 5 Landscape Setting



Graph 13: Site 10 PSA

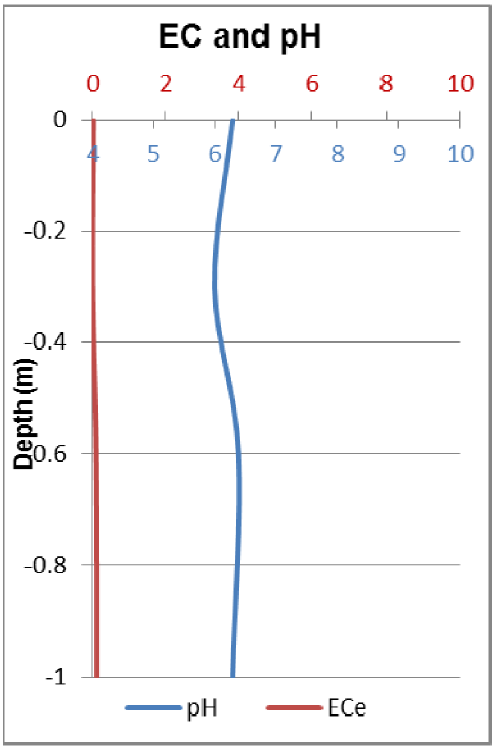
Physical and Chemical Characteristics:

Site 10 was used as a representative profile of Soil Type 5 and was subject to laboratory analysis. A summary of analytical results is provided in **Table 9**. The full data set can be found in **Appendix 2**.

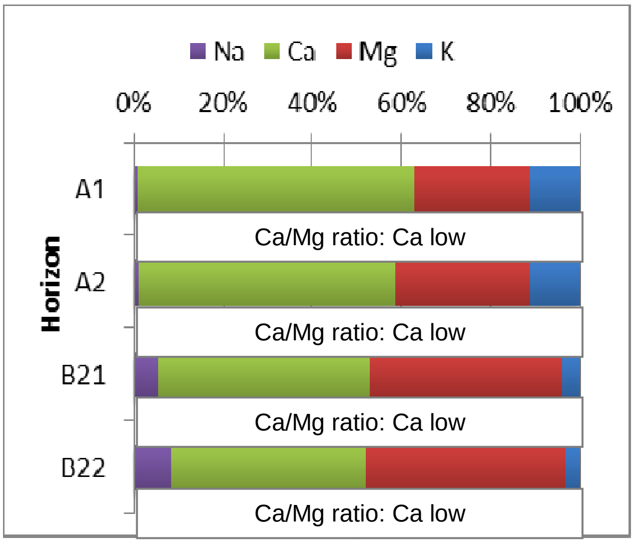
Table 9 – Site 10 Laboratory Analysis

Depth	Colour	pH		EC		CEC		ESP		EAT	
cm	Munsell	#	Rate	%	Rate	#	Rate	%	Rate	#	Rate
0-15	Dark brown	6.3	Slightly acidic	0.03	Very Low	6.2	Low	0.97	Non sodic	6.2	Low
15-30	Brown	6	Moderately acidic	0.01	Very Low	5.2	Very Low	1.35	Non sodic	5.2	Very Low
30-60	Yellowish red	6.4	Slightly acidic	0.11	Very Low	15	Moderate	5.93	Non sodic	15	Moderate
30-100	Strong brown	6.3	Slightly acidic	0.13	Low	15	Moderate	8.67	Marginally Sodic to sodic	15	Moderate

The pH and EC results are shown in **Graph 14** below, which shows the pH variance of slightly acidic to moderately acidic in the topsoil to slightly acidic thereafter, while the profile is non-saline. **Graph 15** below shows the trend of exchangeable cations throughout the soil profile, and highlights the Ca/Mg ratio as low throughout the profile. CEC is a measure of fertility and is low to very low in the topsoil and moderate in the subsoil. These soils are non sodic in the topsoil becoming marginally sodic to sodic in the subsoil, and have an EAT rating of low to very low in the topsoil and moderate in the subsoil. The K factor analysis was rated as very high in the topsoil and high thereafter.



Graph 14: Site 10 pH and EC



Graph 15: Site 10 Exchangeable Cations

4.0 LAND ASSESSMENT

The Study Area has been classified for both rural land capability and agricultural suitability, and has been assessed in the context of the Draft *Strategic Regional Land Use Policy* (the Policy). The methods and results for these assessments are presented in this section fulfilling report Objectives 2 and 3.

4.1 Land Capability and Agricultural Suitability Relationship

In NSW, rural lands are currently being mapped according to two different land classification systems. The first of these was developed by the former Soil Conservation Service of NSW and classifies land into eight classes (I-VIII) known as land capability classes. The second system used by the former NSW Department of Agriculture classifies land into five classes (1-5) known as agricultural suitability classes. A brief overview of their relationship to each other is discussed here with further details provided in **Sections 4.2** and **4.3**.

The aim of the land capability classification system is to delineate the various classes of rural lands on the basis of their capability to remain stable under particular land uses. This system classifies the land in terms of its inherent physical characteristics or physical constraints and denotes measures needed to protect the land from soil erosion and other forms of land degradation. It therefore considers the optimum use of land rather than the maximum use.

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

4.2 Land Capability

4.2.1 Land Capability Methodology

The land capability system applied to the Study Area is in accordance with the OEH (formerly the NSW Soil Conservation Service) requirements. The relevant guideline is called S*ystems used to classify rural lands in New South Wales* (Cunningham *et al*., 1988).

This system classifies the land on its potential for sustainable agricultural use if developed, rather than its current land use, and includes three types of land uses:

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

The system consists of eight classes, which classify the land based on the severity of long-term limitations. Limitations are the result of the interaction between physical resources and a specific land use. A range of factors are used to assess this interaction. These factors include climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses.

The principal limitation recognised by these capability classifications is the stability of the soil mantle and classes are ranked on their increasing soil erosion hazard and decreasing versatility of use. A description of the eight land capability classes is provided in **Table 10**.

Table 10 – Rural Land Capability Classes

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

Source: Cunningham *et al*., 1988

4.2.2 Pre – Disturbance Land Capability Results

The Study Area has been assessed and classified into the land capability classes described below. The relevant land capability classes for the Study Area are displayed in **Table 11** and shown on **Figure 4**.

Class II Land

Class II land consists of a portion of Soil Types 1 and 4 in the north of Area 1 (**Figures 3** and **4**). This classification indicates the land is capable of a wide range of land uses and land management practices (i.e. suitable for intensive cropping with cultivation, grazing, forestry, or nature conservation). This land can be subject to sheet, rill and gully erosion as well as wind erosion and soil structure decline. However, these limitations can be controlled by land management practices that are readily available and easily implemented. This land is currently being used for grazing.

This low-lying land is derived from colluvial and alluvial material. The primary constraints are minor slope (1 – 3%), a moderate to high erodibility in the topsoil, and a marginally sodic to sodic subsoils. Disturbance of topsoil for cultivation could pose a management risk.

Class V Land

Class V land is characterised by soils on the lower to mid and upper mid slopes of the Areas 1, 2 and 3, consisting of Soil Types 1, 4 and 5 (**Figures 3** and **4**). This classification indicates that the land is capable of a range of land uses, such as cropping with minimal or no cultivation and grazing. However, for land uses such as cropping and intensive grazing, soil management practices need to be able to mitigate moderate to severe limitations. This land is generally used for grazing, and is suitable for pasture improvement.

This land is derived largely from duplex soils on slopes of 10 – 25%. The primary constraints include sodic to strongly sodic subsoils (specifically associated with Soil Type 4 in the south east of the Study Area), very high erodibility, surface texture and coarse fragment presence.

Class VI Land

Class VI land is characterised by soils on mid to upper slopes of Area 2, consisting of Soil Types 2 and 3 (**Figures 3** and **4**). This classification indicates that the land is capable of a limited range of land uses, and specialised practices are necessary to overcome very severe limitations. The land should not be cultivated for cropping or for establishing pasture grasses, however, the land can be used for grazing if careful management and stocking practices are implemented.

The primary constraints to this land class are a slope of 25 – 33%, sandy textured topsoils with rapid drainage characteristics, high topsoil erodibility, occasionally high coarse fragment presence and occasionally shallow soils.

Class VII Land

Class VII land is characterised by sandy soils on steep upper slopes and crests of Area 2, associated with Soil Type 3 (**Figures 3** and **4**). This classification indicates that most land uses are restricted by extremely severe limitations that cannot be overcome. The land is not suitable for cropping or grazing due to severe limitations and is land best protected by green timber.

The primary constraints of this land class are slopes of 33 – 50%, sandy texture, shallow soils and rocky outcrops.

Table 11 – Pre-Disturbance Land Capability Summary

Land Capability Class	Study Area	
	ha	%
II	33.1	14
V	131.0	56
VI	62.1	26
VII	8.9	4
Total	**235.1**	**100**

4.2.3 Post – Disturbance Land Capability Results

The post-disturbance land capability of the Study Area landforms is described in this section. The relevant post-disturbance land capability classes for the Study Area, as well as the net change of land capability classes from pre-disturbance are displayed in **Table 12** and shown on **Figure 5**.

Class I Land

No Class I land exists with the Study Area and therefore will not be impacted by the Modification.

Class II Land

In accordance with the Rehabilitation Strategy for the Study Area, following mining activity the Class II land will be returned to its original condition, given that a soil profile is re-established as per **Section 5.1.5**. The Modification will have no permanent impact on Class II land, which will remain at 33.1 ha.

Class III Land

No Class III land exists with the Study Area and therefore will not be impacted by the Modification.

Class V Land

Class V land will be reduced by approximately 31 ha. This will occur in the south west Study Area where the slopes of the final landform will render it Class VI land.

Class VI Land

Class VI land will have a net reduction of approximately 9 ha. As described above, there will be an increase in Class VI land in the south west Study Area, however, a greater portion of this class will become Class VIII land due to the extreme slopes of the landform associated with the final void.

Class VII Land

Class VII land will not be altered by the Modification.

Class VIII Land

Class VIII land will be created by the Modification in the south western Study Area, where an area of approximately 40 ha of previously Class VI land will be made Class VIII land by the extreme slopes of the final landform.

Table 12 – Post-Disturbance Land Capability Summary

Land Capability Class	Pre-Disturbance		Post-Disturbance		Change	
	ha	%	ha	%	ha	%
II	33.1	14	33.1	14	0	0
V	131.0	56	100.3	43	-30.7	-13
VI	62.1	26	53.0	22	-9.1	-4
VII	8.9	4	8.9	4	0	0
VIII	0.0	0.0	39.8	17	39.8	17
Total	**235.1**	**100**	**235.1**	**100**	**0**	**0**

4.3 Agricultural Suitability

4.3.1 Agricultural Suitability Methodology

The agricultural suitability system applied to the Study Area is in accordance with Industry and Investment NSW (formerly the NSW Agriculture and Fisheries) requirements. The relevant guideline is the *Agricultural Suitability Maps – uses and limitations* (NSW Agriculture and Fisheries, 1990).

The system consists of five classes, providing a ranking of rural lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. Class 1 ranks the land as most suitable for agricultural activities and Class 5 the least suitable. Classes 1 to 3 are generally considered suitable for a wide variety of agricultural production, whereas, Classes 4 and 5 are unsuitable for cropping however are suitable for some grazing activities.

The main soil properties and other landform characteristics considered significant for the land suitability assessment are topsoil texture, topsoil pH, solum depth, external and internal drainage, topsoil stoniness and slope as well as bio-physical factors such as elevation, rainfall and temperature.

The overall suitability classification for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. A description of each agricultural suitability class is provided in **Table 13**.

Table 13 – Agricultural Suitability Classes

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

Source: NSW Agriculture and Fisheries (1990)

4.3.2 Pre – Disturbance Agricultural Suitability Results

The pre-disturbance Agricultural Suitability of the Study Area is described in this section. The relevant classes for the Study Area are displayed in **Table 14** and shown on **Figure 6**.

Table 14 – Pre-Disturbance Agricultural Suitability Class Summary

Agricultural Suitability Class	Study Area	
	ha	%
1	33.1	14
3	131.0	56
4	62.1	26
5	8.9	4
Total	**235.1**	**100**

Class 1 Land

Class 1 land consists of a portion of low-lying colluvial and alluvial derived soils from Soil Types 1 and 4 in the north west of the Study Area. This land is suitable for regular cultivation for crops, and is suited to continuous cultivation. It has a high suitability for agriculture but soils factors such as high erodibility and subsoil sodicity limit the productivity. There are no industry constraints due to the proximity to larger areas of Class 1 and 2 land, however, infrastructure constraints such as being fragmented by roadways, may limit the commercial potential of this land. Sections of the land mapped as Suitability Class 1 were previously part of the South Pit Extension Ecological Offset Strategy. However, this land is currently being used for grazing.

Class 3 Land

Class 3 land is characterised by soils on the lower to mid and upper mid slopes of the Study Area, consisting of Soil Types 1, 2 and 5. This classification indicates the land is suited to grazing and pasture improvement. There is potential for this land to be cropped, however, this must be done in rotation with sown pasture. The overall production level is moderate due to soil factors such as sodicity and high erodibility. For grazing purposes, there are no industry or infrastructure constraints, and grazing is the current land use in these areas.

Class 4 Land

Class 4 land is characterised by soils on mid to upper slopes, consisting of Soil Types 2 and 3. This classification indicates the land is suitable for grazing but not cultivation. Agriculture activity must be based on native or improved pastures established using minimum tillage techniques. The production level is low as a result of constraints such as high erodibility associated with slope, and shallow soils. Currently, the Class 4 land is partially cleared for grazing on mid slopes, and protected by green timber of upper slopes. However, no grazing is currently undertaken on the cleared area.

Class 5 Land

Class 5 land is characterised by sandy soils on steep upper slopes and crests, associated with Soil Type 3. This class of land is best managed by the presence of light green timber due to its highly erodible soils and steep slopes. Partial clearing for grazing can occur, however, significant stands of trees are required to maintain soil cover. This soil type is severely constrained by its terrain, physical and chemical characteristics. Currently, this land is comprised of remnant vegetation with partial clearing for infrastructure.

4.3.3 Post – Disturbance Agricultural Suitability Results

The post-disturbance agricultural suitability of the Study Area landforms is described in this section. The relevant post-disturbance agricultural suitability classes for the Study Area, as well as the net change of agricultural suitability classes from pre-disturbance are displayed in **Table 15** and shown on **Figure 7**.

Table 15 – Agricultural Suitability Class Disturbance Summary

Agricultural Suitability Class	Pre-Disturbance		Post-Disturbance		Change	
	Ha	%	ha	%	ha	%
1	33.1	14	33.1	14	0	0
3	131.0	56	100.3	43	-30.7	-13
4	62.1	26	53.0	22	-9.1	-4
5	8.9	4	48.7	21	39.8	17
Total	**235.1**	**100**	**235.1**	**100**	**0**	**0**

Class 1 Land

In accordance with the Rehabilitation Strategy for the Study Area, following mining activity the Class 1 land will be returned to its original condition, given that a soil profile is re-established as per **Section 5.1.5**. Therefore, the Modification will have no permanent impact on Class 1 land.

Class 2 Land

No Class 2 land exists with the Study Area and therefore will not be impacted by the Modification.

Class 3 Land

Class 3 land will be reduced by approximately 31 ha. This will occur in the southwest Study Area where the slopes of the final landform will render it Class 4 land.

Class 4 Land

Class 4 land will have a net reduction of approximately 9 ha. This will become Class 5 land due to the slopes of the landform associated with the final void.

Class 5 Land

Class 5 land will be created by the Modification in the south western Study Area, where an area of approximately 40 ha previously Classes 3 and 4 will be made unsuitable for agricultural activity by slopes of the final landform.

4.4 Strategic Regional Land Use Assessment

4.4.1 Introduction

The NSW Government recently released the Policy to assist development of a long-term strategy for continued development of the mining industry that also ensures local community sustainability and on-going viability of existing industries. This strategy will consist of an overarching Coal and Gas Policy and the development of Strategic Regional Land Use Plans (SRLUPs). SRLUPs will particularly focus on NSW regions that have land use conflicts between coal and coal seam gas industries and agriculture.

Transitional arrangements to facilitate the staged implementation of the Policy were released in May 2011, and include a requirement for all new coal, coal seam gas and petroleum extraction applications to be accompanied by an Agricultural Impact Statement/Assessment (DP&I, 2012a). This assessment is required until the SRLUPs have been approved.

The purpose of the Agricultural Impact Statement is to ensure a focussed assessment of the potential impacts of mining and petroleum (including coal seam gas) projects on agricultural resources or industries. The term ‘agricultural resource’ is used to describe the land on which agriculture is dependent and the associated water resources (quality and quantity) that are linked to that land. The Agricultural Impact Assessment guidelines indicate that the assessments require social, agricultural and economic effects in both a local and regional context to be identified.

SAL includes both land with unique natural resource characteristics, known as Biophysical Strategic Agricultural Land (BSAL), and clusters of significant agricultural industries that are potentially impacted by coal seam gas or mining development, known as Critical Industry Clusters.

With regards to the agricultural component of the assessment, the Policy defines SAL as “highly productive land that has both unique natural resource characteristics (such as soil and water resources) as well as socio-economic value (such as high productivity, infrastructure and access to markets)”. GSSE understands from this definition and recent communications with government agencies that the rural land capability classification scheme may be employed to identify SAL.

In order to provide an overview from a soils perspective, GSSE have focused on the whether the Study Area can be verified in the context of the Policy and determining the potential biophysical impacts of the Modification on SAL.

4.4.2 Methodology

GSSE has consulted the current the Policy area maps, which specify both soil fertility and land capability classes, which are used to assess gateway criteria for BSAL, as well as the Critical Industry Cluster mapping. GSSE have compared the Study Area's rural land capability classes (**Section 4.2**), agricultural suitability classes (**Section 4.3**), current land use activities and proposed disturbance activities to assess if the Modification may contain 'best agricultural land'.

In addition to the review of information outlined above, GSSE has undertaken a fertility assessment of the Study Area in order to confirm the presence and extent of BSAL, targeting land that has been mapped as having moderate to high fertility that coexists with Class II Land Capability (the threshold for SAL criteria). A total of 15 observation points were recorded in a 'free survey' that covered a section of the north western Study Area, as shown in **Figure 8**. Observation points consisted of a combination of surface assessment (0 – 10 cm sampling), denoted with an F on **Figure 8**, and full profile assessment, such as that detailed in **Section 3.1.2.4**, denoted with a C. A total of 18 samples were sent for laboratory analysis and subject to the Fertility Suite, which consists of the following:

- EC;
- pH;
- exchangeable cations and total CEC;
- phosphorus (P), sulphur (S), nitrogen (N);
- organic carbon; and
- trace elements.

While there are no specific guidelines on how fertility can be classed as low/moderate/high in the context of the SAL criteria, GSSE have developed a rigorous assessment framework that accounts for each of the analytes of the Fertility Suite and distinguish soils that have fertility characteristics suited to a cultivation-based agricultural use.

4.4.3 Results

4.4.3.1 Strategic Agricultural Land Criteria

The Study Area was assessed for its suitability as BSAL and its relative location to Critical Industry Clusters. **Table 16** outlines the criterion and stipulates the applicability of the Study Area. Each criterion must be met for the land to be considered SAL.

Table 16 – Applied Strategic Agricultural Land Criteria

Component	Criteria	Study Area	Comments
BSAL	• Land that falls under soil fertility classes "high" or "moderate" under the Draft Inherent General Fertility of NSW (OEH, 2012); and	Yes	Moderate to high soil fertility ground truthed at three observation points in the fertility assessment (**Section 4.4.3.3**).
	• Land capability classes II or III under the Land and Soil Capability Mapping of NSW (OEH 2012); and	Yes	Class II land along the Hunter river, running parallel to Denman Road
	• Reliable water of suitable quality, characterised by: o land having rainfall of greater than 350 mm per annum (9 out of 10 years); or o land within 150 m of the following surface or groundwater resource: - a regulated river; or - unregulated rivers where there are flows for at least 95% of the time (i.e. the 95th percentile flow of each month of the year is greater than zero); or - 5th order and higher rivers; or - groundwater aquifers (excluding miscellaneous alluvial aquifers, also known as small storage aquifers) which have a yield rate greater than 5 - litres per second and total dissolved solids of less than 1,500 milligrams per litre.	Yes	Average annual rainfall recorded at nearby Jerry's Plains is 644.7 mm.
	• Minimum 20 ha in area (based on minimum area required for commercial food production).	No	The portion of land that meets all other SAL criteria is 2.4 ha.
Critical Industry Cluster	Industry clusters that meet the following criteria: • There is a concentration of enterprises that provides clear development and marketing advantages and is based on an agricultural product. • The productive industries are interrelated. • It consists of a unique combination of factors such as location, infrastructure, heritage and natural resources. • It is of state, national and/or international importance. • It contributes to the region's identity. • It is potentially substantially impacted by coal seam gas or mining proposals.	Yes	The Study Area falls within the Equine Critical Industry Cluster according the *Draft Strategic Regional Land Use Plan Map 6* (DP&I, 2012b).

Source: DP&I (2012)

4.4.3.2 Review of Information

The Study Area meets the criteria for 'reliable water of suitable quality', with average annual rainfall of 644.7 mm meeting the criteria of greater than 350 mm per annum in 9 out of 10 years (BOM, 2012).

Critical industries recognised for Upper Hunter region include the equine industry around Scone, Denman and Bylong and the viticulture industry around Broke and Pokolbin (DPI, 2012). The draft mapping indicates that the Study Area lies within an equine critical industry cluster.

Digital mapping provided by the OEH (2012) shows that a section of the Study Area has been classified as 'Moderately High Soil Fertility', and 'Land and Soil Capability Class II' in the north west of the Study Area, within the boundary of Land Capability Class II that has been mapped during this study (**Figure 8**). The GSSE Land Capability Assessment, presented in **Section 4.2**, confirms the presence of the Class II Land. GSSE have further undertaken a fertility assessment to ground truth the 'Moderately High Soil Fertility', with findings discussed in the following section.

4.4.3.3 Fertility Assessment

The fertility assessment shows that moderate to high soil fertility characteristics are present within the Study Area, however, this is at a reduced extent to that shown on digital mapping provided by OEH (2012). **Figure 8** shows a comparison between the reference mapping and the ground truthed fertility boundary.

Of the 15 observation points recorded, three were considered to have moderate to high fertility characteristics. These sites are located within close proximity of each other in the context of the scope of the fertility assessment. Results are as follows:

- Observation points F2 and F12 have a moderate CEC rating, while C13 has a high CEC rating.
- Consistently appropriate pH levels with an acid trend.
- None are inhibited by EC characteristics.
- Consistently strong Ca levels.
- Consistently optimal organic carbon levels.
- Consistently neutral P characteristics, with low S and N.

The cation exchange characteristics are an indication that the soils could support cropping activity with only minor soil management, and therefore have been determined to meet the BSAL criteria for fertility. This covers an area of 2.4 ha.

The remaining observation points, including those that were located within the boundary of the OEH 'Moderately High Soil Fertility' mapped land (7.5 ha), have low fertility characteristics and are not considered to meet the fertility criteria of BSAL. The full fertility assessment results can be found in **Appendix 2**.

4.4.3.4 SAL Classification

While the Study Area meets the draft gateway criteria for the Critical Industry Clusters, and several of the BSAL parameters, there is no part of the Study Area that satisfies all criterions and, therefore, no BSAL determined to be present. The 2.4 ha section of land in the north west of the Study Area that has been classed as Land Capability Class II, and which was determined to have soils that meet the moderate to high fertility criteria, cannot be included as BSAL because it is below the minimum area required for commercial food production.

Table 17 details the considerations outlined by the draft gateway criteria with the expected impacts of the Modification, and shows that there are no expected impacts on BSAL.

Table 17 – Modification Impacts on Strategic Agricultural Land

Criteria	Comment
1. Impacts on the land through surface area disturbance and subsidence.	There will be no impacts on SAL from the Modification.
2. Impacts on: - soil fertility; - rooting depth; or - soil profile materials or thickness.	There will be no impacts on SAL from the Modification.
3. Increases in land surface micro relief or soil salinity, or significant changes to soil pH	There will be no impacts on SAL from the Modification.

5.0 DISTURBANCE MANAGEMENT

Soil to be disturbed due to the Modification has been specifically assessed to determine its suitability for stripping and re-use for topdressing on rehabilitation sites. This assessment is an integral process for successful rehabilitation as per the site's rehabilitation objectives. This section provides information on the following key areas related to the management of the topsoil resources in the Study Area:

- topsoil stripping assessment which provides a topsoil stripping strategy indicating recommended stripping depths for topsoil salvage and re-use as topdressing in rehabilitation; and
- topsoil management for soil that is stripped, stored and used as a topdressing material for rehabilitation.

5.1 Topsoil Stripping Assessment

5.1.1 Topsoil Stripping Methodology

Determination of suitable soil to conserve for later use in rehabilitation has been conducted in accordance with Elliott and Veness (1981). The approach remains the benchmark for land resource assessment in the Australian mining industry. This procedure involves assessing soils based on a range of physical and chemical parameters. **Table 18** lists the key parameters and corresponding desirable selection criteria.

Table 18 – Topsoil Stripping Suitability Criteria

Parameter	Desirable criteria
Structure Grade	>30% peds
Coherence	Coherent (wet and dry)
Mottling	Absent
Macrostructure	>10 cm
Force to Disrupt Peds	3 force
Texture	Finer than a Fine Sandy Loam
Gravel and Sand Content	<60%
pH	4.5 to 8.4
Salt Content	<1.5 deciSiemens per metre

Gravel and sand content, pH and salinity were determined for all samples using the laboratory test results. Texture was determined in the field and cross referenced with laboratory results, specifically PSA. All other physical parameters outlined in **Table 18** were determined during the field assessment.

Structural grade is significant in terms of the soil's capability to facilitate water relations and aeration. Good permeability and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade and depends on the proportion of coarse peds in the soil surface. Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils, without pores, are considered less suitable as topdressing materials.

The shearing test is used as a measure of the soil's ability to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the excavation, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soils with low permeability however some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

5.1.2 Topsoil Stripping Depths

Soil Types 1, 3 and 4 are recommended to be stripped to the depths stipulated in **Table 19** below. The constraints of all the Soil Types, including 2 and 5, which are not recommended for re-use, are outlined in **Section 3.0**. Although some chemical and physical characteristics of Soil Types 1, 3 and 4 are not ideally suited to revegetation activities, these soils are generally suitable to facilitate germination and appropriate management of this soil and amelioration (such as treatment with lime) will provide an acceptable and stable media for revegetation.

While there is minor variation in the soil profiles throughout each soil type, such as depth, structure and minor chemical characteristics, the soils that are recommended to be stripped as stipulated in **Table 19** are generally appropriate for use as topdressing. Soil Type 1 subsoil may be stripped for re-use, however, should only be used as an intermediate layer between overburden and topdressing. This intermediate layer is created to mimic a developed soil profile and has a greater water holding capacity than the topdressing material and will assist in meeting the land class objectives of the Rehabilitation Plan. **Table 19** summarises the recommended stripping depths by soil type.

Table 19 – Stripping Depth for each Soil Type

Soil Type	ASC Name	Recommended Soil Stripping Depth (cm)	
		Topsoil	Subsoil
1	Red Chromosol	25	75*
2	Brown Chromosol	Nil	Nil
3	Shallow Brown Chromosol	20	Nil
4	Brown Sodosol	40	Nil
5	Red Sodosol	Nil	Nil

* Where deemed necessary subsoil is to be stripped in order to create an intermediate soil horizon.

5.1.3 Topdressing Suitability Volume

The topsoil volumes discussed in this section have been generated from the recommended stripping depths of each soil type by disturbance element. The estimated total volume of material available for re-use across the Study Area is 1,053,900 cubic metres (m^3) (**Table 20**). (Note: The surface disturbance area accounts for areas that have previously been cleared for the development of roads and tracks. This is an accepted oversight of the topsoil stripping strategy as there is an excess of material available to respread to the depths recommended in **Section 5.1.5**).

Table 20 – Soil Volumes

Soil Type #	Topsoil Stripping Depth (m)	Subsoil Stripping Depth (m)	Surface Disturbance Area (m^2)	Topsoil Volume (m^3)	Subsoil Volume (m^3)
1	0.25	0.75	692,000	173,000	519,000
3	0.20	Nil	309,000	61,800	Nil
4	0.40	Nil	1,043,000	417,200	Nil
			Volume	**652,000**	**519,000**
			Total Volume	**1,171,000**	
			Total Volume with 10% handling loss	**1,053,900**	

5.1.4 Topdressing Management

Where soil stripping and transportation is required, the following handling techniques are recommended to prevent excessive soil deterioration:

- Strip material to the depths stated in **Table 19**, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Where practicable, material should not be stripped in either an excessively dry or wet condition.
- Grading or pushing soil into windrows with graders or dozers for later collection for loading into rear dump trucks by front-end loaders, are examples of preferential less aggressive soil handling systems. This minimises compression effects of the heavy equipment (i.e. scrapers) that is often necessary for economical transport of soil material.
- Where possible, direct placement is a preferred option to stockpiling, but where this is not practical stockpiling measures should be observed.
- The surface of soil stockpiles should be left in as coarsely structured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 3 m.
- If long-term stockpiling is likely (i.e. greater than 3 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward will provide sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.
- Prior to re-spreading stockpiled topsoil, an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and/or “scalping” of weed species prior to topsoil spreading.
- An inventory of available soil should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.

5.1.5 Soil Re-Spreading and Seedbed Preparation

Soil should be re-spread directly onto reshaped areas where practical. Where topsoil resources allow, topsoil should be spread to a nominal depth of 100 mm on all re-graded land. Topsoil should be spread, treated with fertiliser and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion. Soil respreading on steep slopes at depths exceeding 0.1 m can be deleterious because of the "sponge" effect which can cause slippage of the topsoil from the slope. Flat areas should be topsoiled at a nominal depth of 0.2 m.

In areas where a soil profile is required to be established in order for the Land Capability Class II and Agricultural Suitability Class 1 to be achieved, topdressing should be at a depth of 200 mm, overlying an intermediate subsoil depth of 300 – 400 mm. Other specific topsoil respreading depths for different post-mining landform elements will be specified in the Mining Operations Plan or relevant site management plan.

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be lightly contour ripped (after topsoil spreading) to create a "key" between the soil and the spoil. Ripping should be undertaken on the contour. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to, or during seeding, to reduce runoff and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

6.0 CONCLUSION

This Soil and Land Resource Assessment has been conducted based on the findings of a field investigation and a desktop review of reference information.

Objectives 1 and 2 - Soils types within the Study Area

Soil types identified within the Study Area include Red Chromosol (29%), Brown Chromosol (4%), Shallow Brown Chromosol (13%), Brown Sodosol (45%) and Red Sodosol (9%).

Objectives 3 and 4 - Land Resource Assessment of the Study Area

Net change in Land Capability Class V and VI, reduced 13% and 4% respectively, with an increase in Class VIII land of 17%. Class II land will not be impacted as there is no mining disturbance in this area. Net change in Agricultural Suitability Classes of 3 and 4, reduced by 13% and 4% respectively, with an increase in Class 5 land of 17 %. Land Capability II and Agricultural Suitability 1 lands will not be permanently impacted by the Modification. There is no BSAL within the Study Area and therefore no BSAL will be impacted by the Modification.

Objective 5 - Disturbance Management

Soil Stripping Assessment within surface disturbance area stipulated that the following soils are generally suitable for stripping; Red Chromosol (topsoil 0 – 25 cm, subsoil 25 – 75 cm), Brown Sodosol (topsoil 0 – 40 cm) and Brown Chromosol (topsoil 0 – 20 cm).

Further management recommendations based on the findings of Objectives 1 to 4 are presented in this assessment, and are a guide to mitigating the impacts of the proposed developments and enhance the success of rehabilitation.

7.0 REFERENCES

Bureau of Meteorology (2012) *Jerrys Plains Post Office, BOM Station 061086, Monthly Climate Statistics*. Product IDCJCM0028. ccessed 28.05.2012.
Website: http://www.bom.gov.au/climate/averages/tables/cw_061086.shtml

Cummingham G.M., Higginson F.R, Riddler A.M.H and Emery K.A. (1988) *Systems used to classify rural lands in New South Wales*. Soil Conservation Service of NSW.

Department of Environment and Climate Change (2008) *Managing Urban Stormwater: Soils and Construction*. Vol. 2E Mines and Quarries.

Department of Natural Resources (2005) *Land Capability Spatial Data*. Resource Information Unit, Hunter Region.

Department of Planning and Infrastructure (2012a) *Strategic Regional Land Use Policy: Guideline for agricultural impact statements*.

Department of Planning and Infrastructure (2012b) *Draft Strategic Regional Land Use Plan*. Map 6.

Department of Primary Industries (2012) *Strategic Regional Land Use Policy Delivery, Frequently Asked Questions*.

Elliot, G.L. and Veness, R.A. (1981) The Guide for Selection of Topdressing Material for Rehabilitation of Disturbed Areas in the Hunter Valley*. Soil Cons. NSW* 37 37-40.

GSS Environmental (2009) *Soils Survey and Land Resource Assessment Report – Mt Arthur Coal Part 3A Environmental Assessment*.

Hunter Coal Field Regional Geology Map (1987) *Geological Series-Sheet 9033*.

Hunter Eco (2012) *Mt Arthur Coal Open Cut Modification Flor and Fauna Assessment*.

Isbell, R.F. (1996) *The Australian Soil Classification*. CSIRO Publication, Australia.

Kovac, M., Lawrie, J.M. (1991) *Soil Landscapes of the Singleton 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.

Landcom (2004) *Managing Urban Stormwater: Soils and Construction Vol. 1*.

McKenzie, N.J, Grundy, M.J., Webster, R. and Ringrose-Vogse, A.J. (2008) *Guidelines for Surveying Soil and Land Resources.*

NSW Agriculture and Fisheries (1990) *Agricultural Suitability Maps – uses and limitations*. Agfact AC.9.

Office of Environment and Heritage (2012) *Landscapes and Soils - Strategic Regional Land Ise Policy. Land and Soils Capability Map, Draft Inherent Soil Fertility Map*.
Website: http://www.environment.nsw.gov.au/soils/index.htm

The National Committee on Soil and Terrain (2009) *Australian Soil and Land Survey Field Handbook*. 3rd edition. CSIRO Publication, Australia.

URS (2000) *Mt Arthur North, Environmental Impact Statement*.

FIGURES

FIGURE 1

Locality Plan

Project:	Mt Arthur Coal Open Cut Modification
Client:	Hunter Valley Energy Coal Pty Ltd
File:	Fg1_MAC01-029_LocalityPlan_120907
Projection:	GDA94 MGA Zone 56

Version	Date:	Author:	Checked:	Approved:
1	22/05/2012	ZJ	MH	CR
2	13/06/2012	ZJ	MH	CR
3	7/09/2012	LF/ZJ	MH	CR

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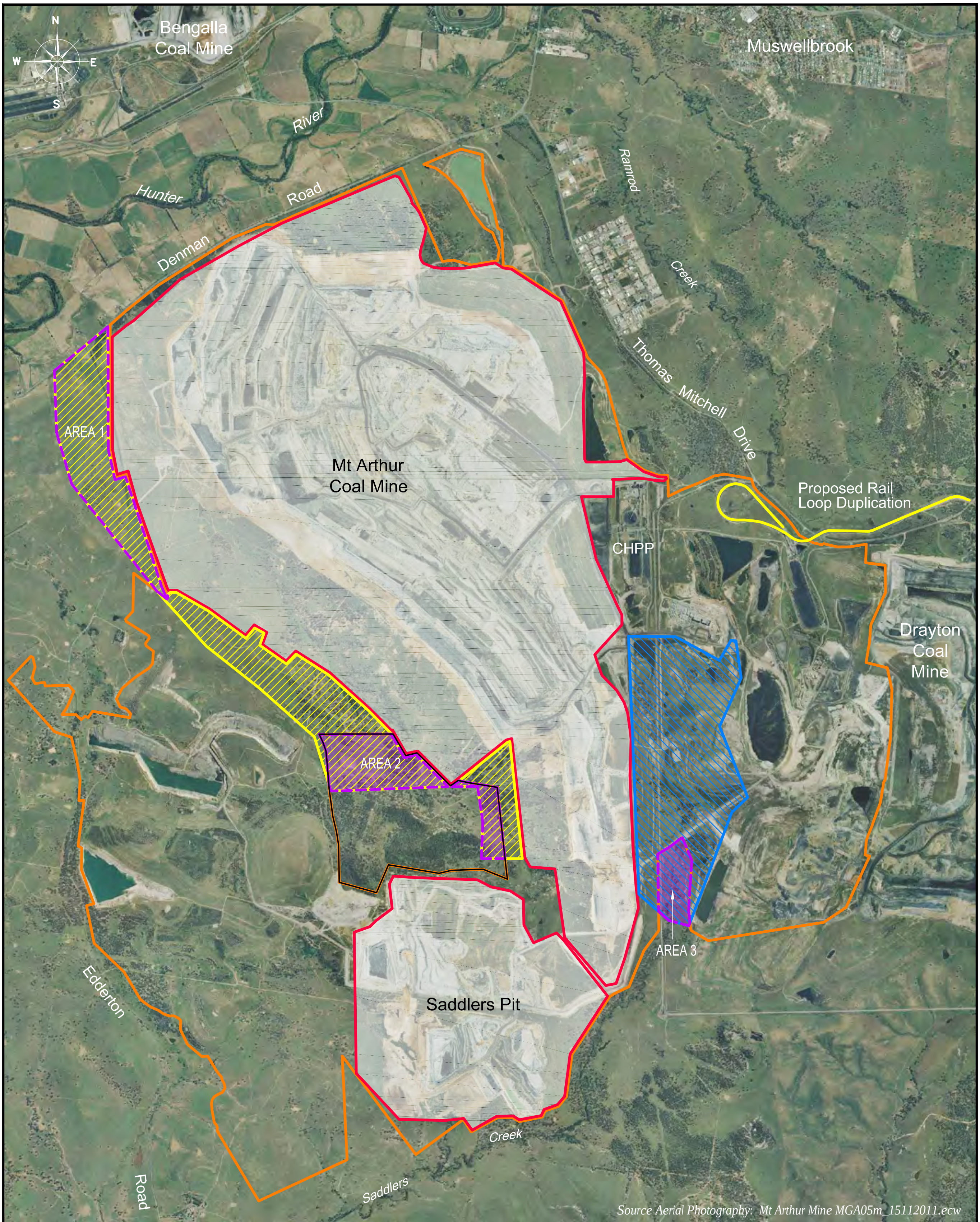

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area

0 1.25 2.5km

Scale 1:60000

Version	Date:	Author:	Checked:	Approved:
1	22/05/2012	ZJ	MH	CR
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3	7/09/2012	ZJ/LF	MH	CR
4	21/09/2012	KC	MH	CR
5	12/12/2012	LF	MF	CR

FIGURE 2

Site Plan

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Project:
Mt Arthur Coal Open Cut Modification

Client:
Hunter Valley Energy Coal Pty Ltd

File:
Fg2_MAC01-029_SitePlan_121212

Projection:
GDA94 MGA Zone 56

To be printed A4

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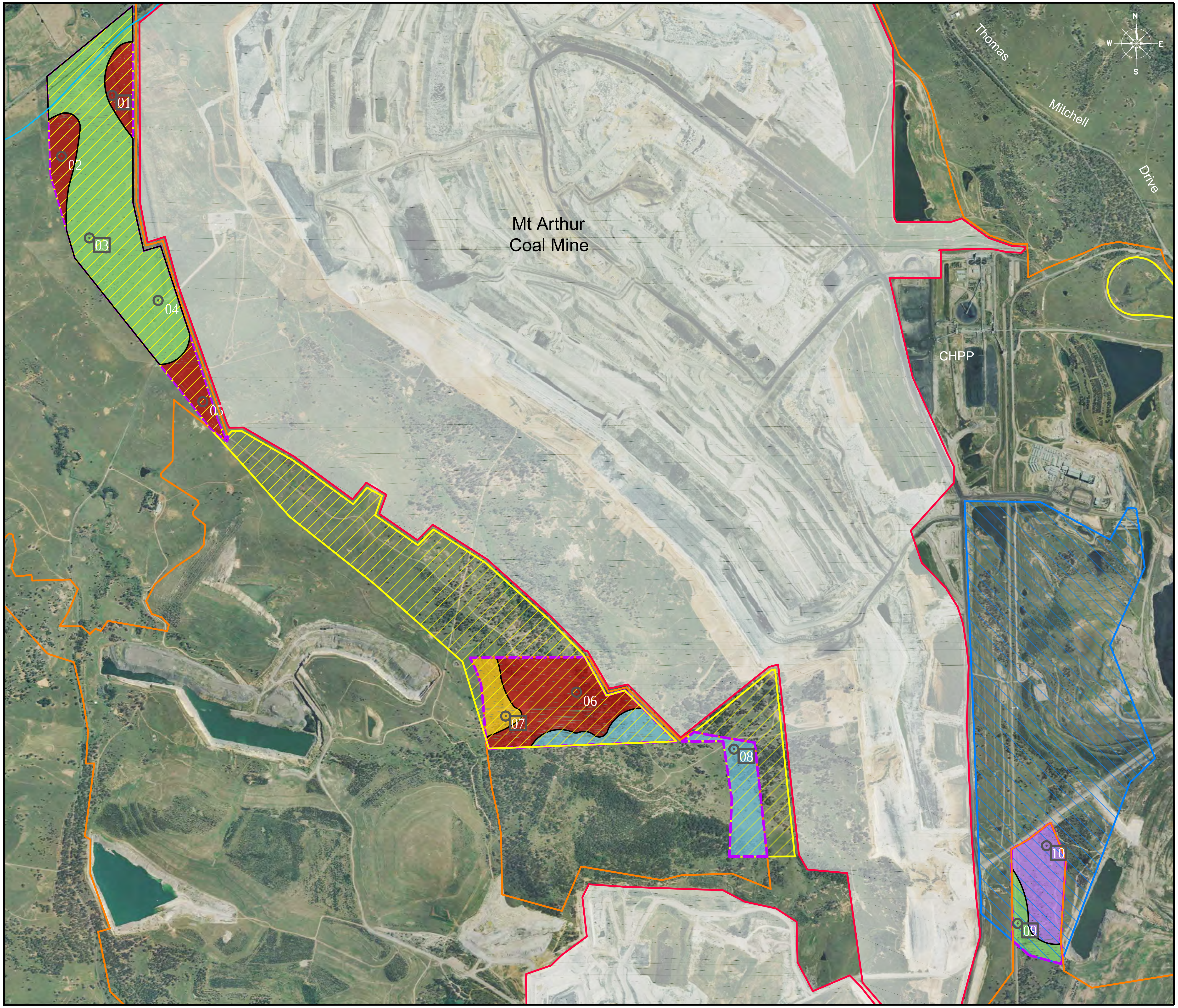

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area
- 05 Soil Sampling Points
- 05 Soil Sampling Points (Lab Analysed)

SOIL TYPES

1. Red Chromosol
2. Brown Chromosol
3. Shallow Brown Chromosol
4. Brown Sodosol
5. Red Sodosol

0 500 1km

Scale 1:25000

Source Aerial Photography: Mt Arthur Mine MGA05m_15112011.ecw

FIGURE 3

Soil Types

Project:
Mt Arthur Coal Open Cut Modification

Client:
Hunter Valley Energy Coal Pty Ltd

File:
Fg3_MAC01-029_SoilTypes_121212

Projection:
GDA94 MGA Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	22/05/2012	ZJ	MH	CR
2	08/06/2012	ZJ	MH	CR
3	13/06/2012	ZJ	MH	CR
4	25/06/2012	ZJ	MH	CR
5	10/09/2012	LH	MH	CR
6	21/09/2012	KC	MH	CR
7	12/12/2012	LF	MF	CR

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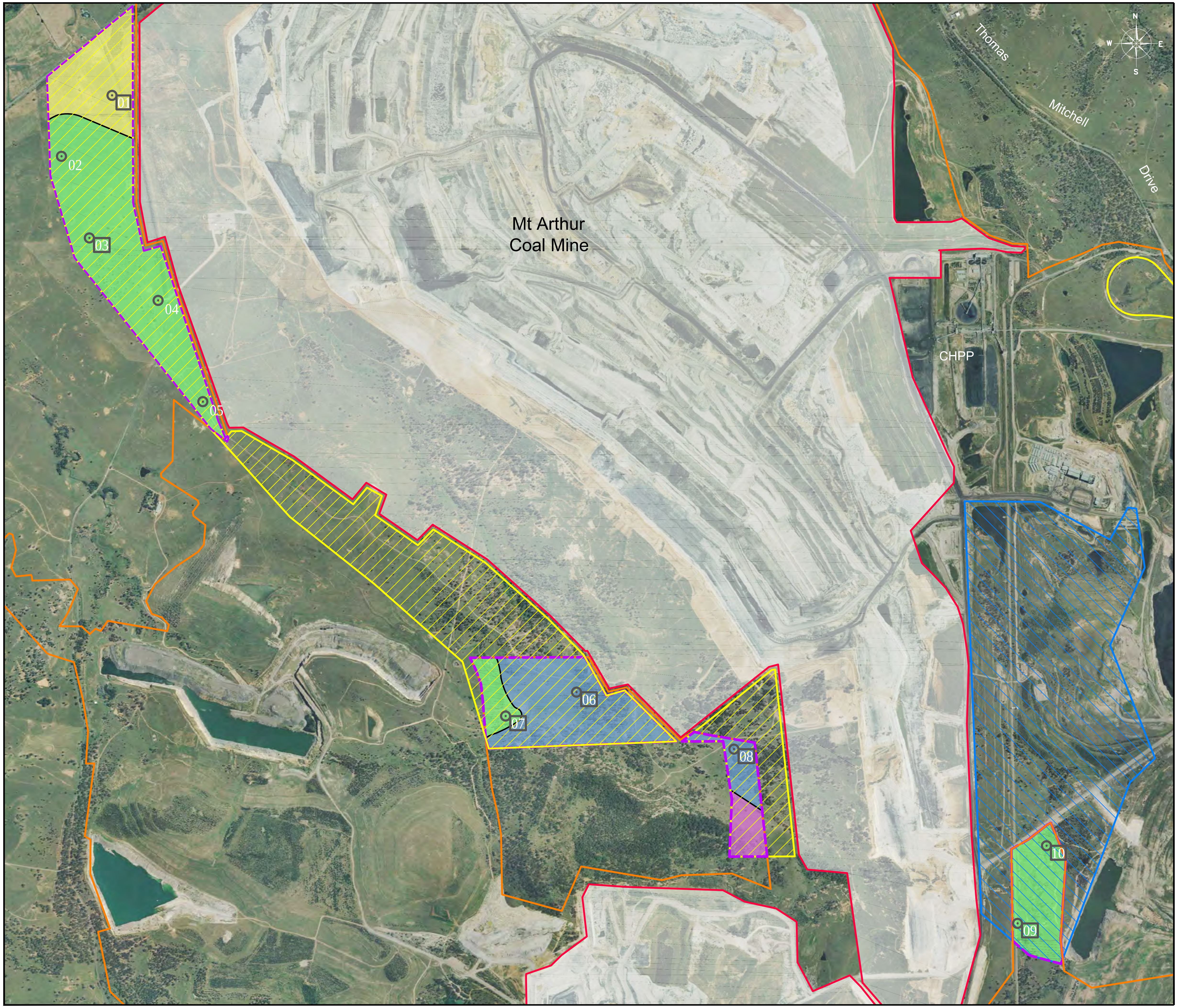

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area
- Soil Sampling Points
- Soil Sampling Points (Lab Analysis)

LAND CAPABILITY

- Class II
- Class V
- Class VI
- Class VII

0 500 1km

Scale 1:25000

Source Aerial Photography: Mt Arthur Mine MGA05m_15112011.ecw

FIGURE 4

Pre-disturbance Land Capability

Project: Mt Arthur Coal Open Cut Modification

Client: Hunter Valley Energy Coal Pty Ltd

File: Fg4_MAC01-029_PreLandCap_121212

Projection: GDA94 MGA Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	08/06/2012	ZJ	MH	CR
2	13/06/2012	ZJ	MH	CR
3	10/09/2012	LH	MH	CR
4	21/09/2012	KC	MH	CR
4	12/12/2012	LF	MF	CR

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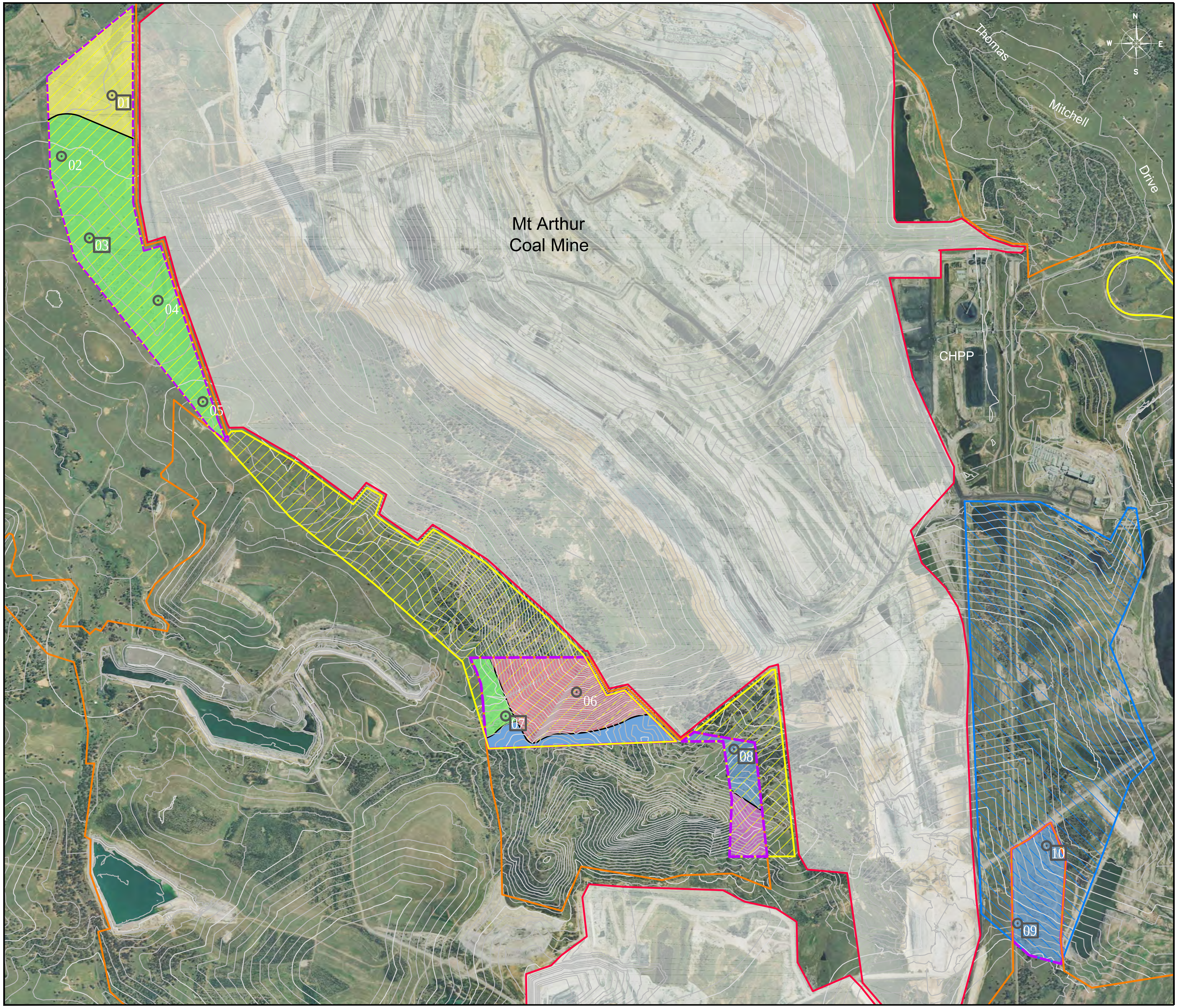

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area
- Soil Sampling Points
- Soil Sampling Points (Lab Analysed)

LAND CAPABILITY

- Class II
- Class V
- Class VI
- Class VII
- Class VIII

0 500 1km

Scale 1:25000

Source Aerial Photography: Mt Arthur Mine MGA05m_15112011.ecw

FIGURE 5

Post-disturbance Land Capability

Project: Mt Arthur Coal Open Cut Modification

Client: Hunter Valley Energy Coal Pty Ltd

File: Fg5_MAC01-029_PostLandCap_121212

Projection: GDA94 MGA Zone 56

Version:	Date:	Author:	Checked:	Approved:
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3	06/08/2012	ZJ	MH	CR
4	10/09/2012	LH	MH	CR
5	21/09/2012	KC	MH	CR
6	12/12/2012	LF	MF	CR

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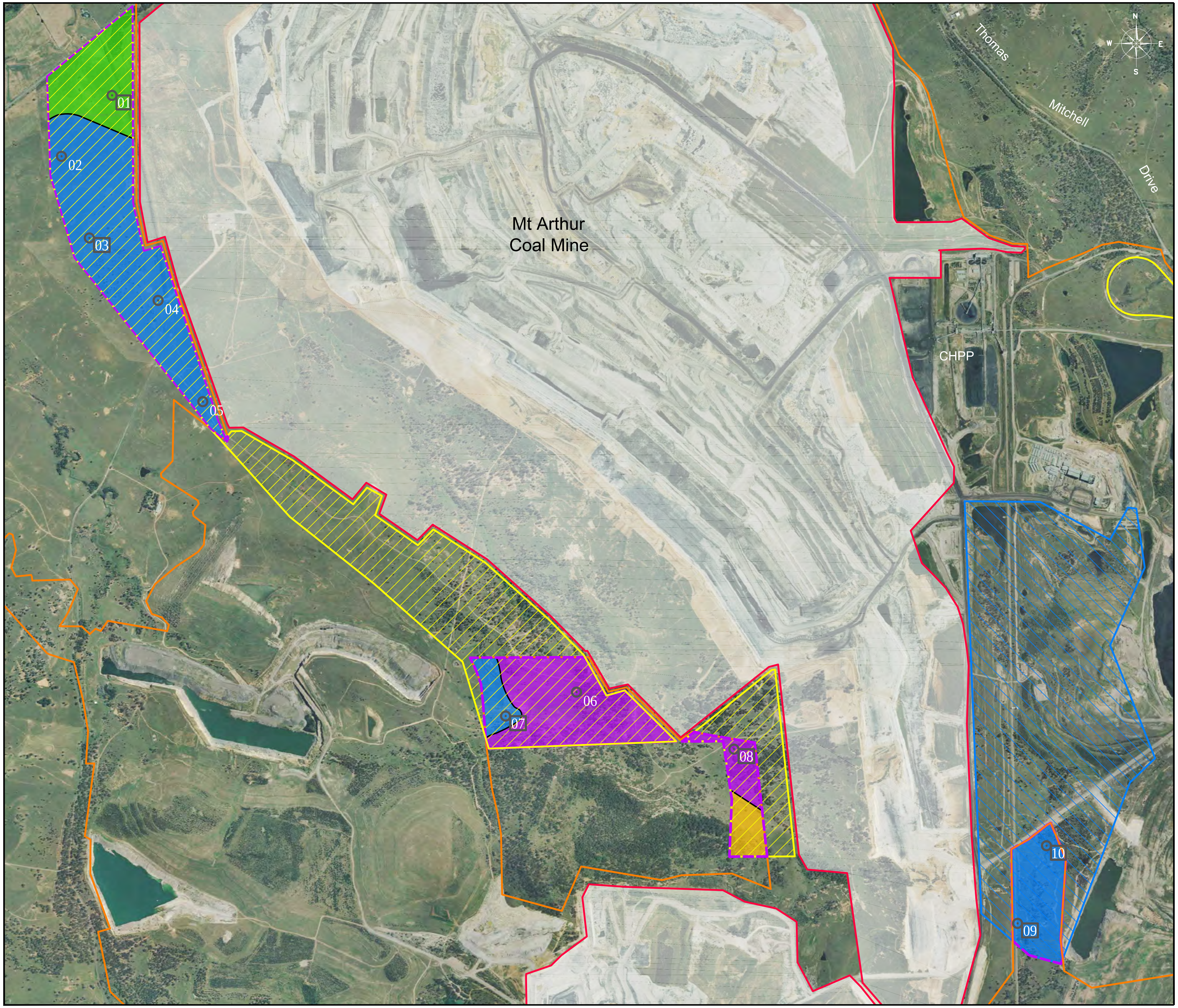

LEGEND
- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area
- 05 Soil Sampling Points
- 05 Soil Sampling Points (Lab Analysed)

AGRICULTURAL SUITABILITY
- Class 1
- Class 3
- Class 4
- Class 5

0 500 1km
Scale 1:25000
Source Aerial Photography: Mt Arthur Mine MGA05m_15112011.ecw

FIGURE 6

Pre-disturbance Agricultural Suitability

Project: Mt Arthur Coal Open Cut Modification

Client: Hunter Valley Energy Coal Pty Ltd

File: Fg6_MAC01-029_PreAgSuit_121212

Projection: GDA94 MGA Zone 56

Version:	Date:	Author:	Checked:	Approved:
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3	10/09/2012	LH	MH	CR
4	21/09/2012	KC	MH	CR
5	12/12/2012	KC	MF	CR

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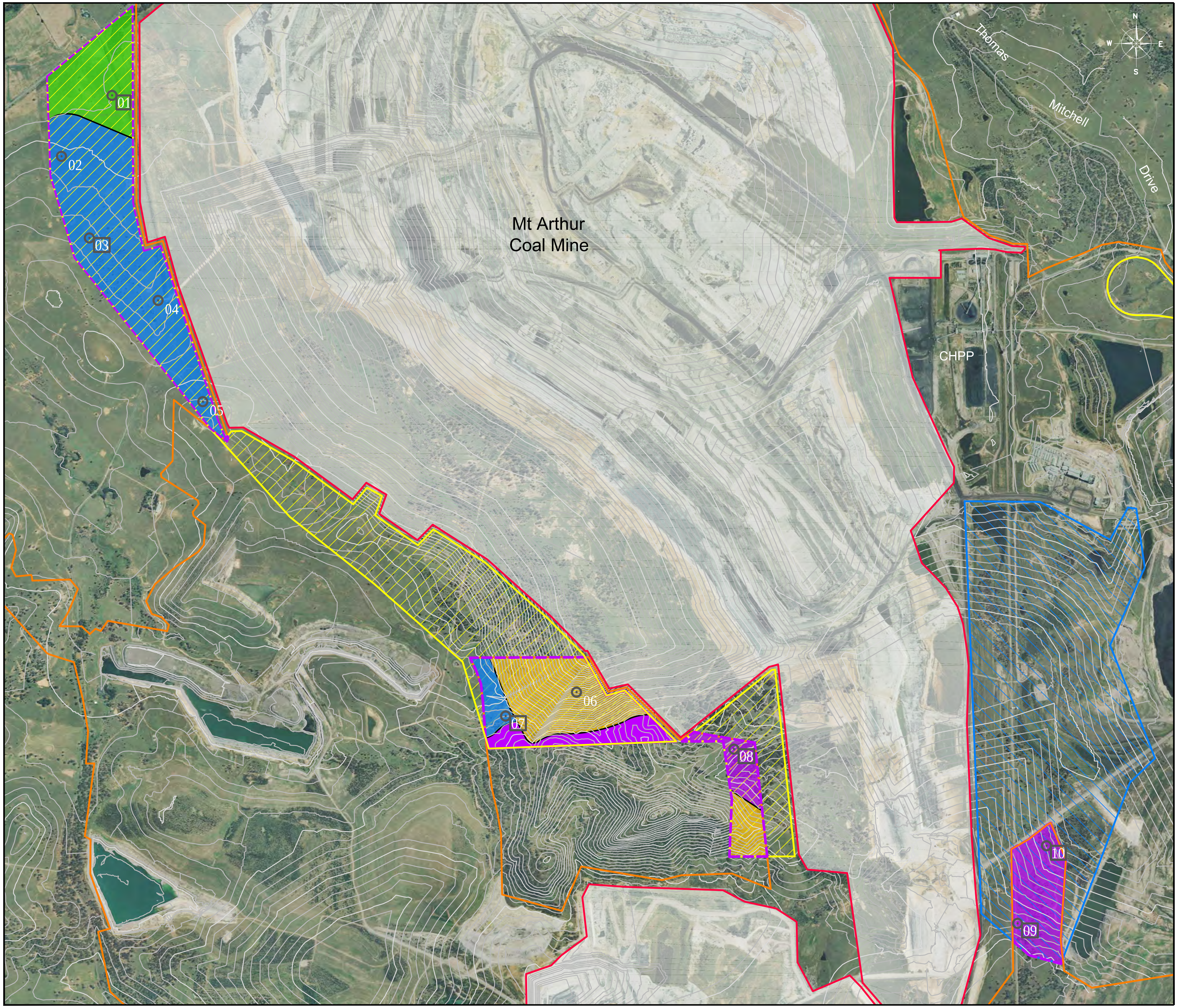

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Proposed Overburden Emplacement Area
- Study Area
- 05 Soil Sampling Points
- 05 Soil Sampling Points (Lab Analysed)

AGRICULTURAL SUITABILITY

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

0 500 1km

Scale 1:25000

Source Aerial Photography: Mt Arthur Mine MGA05m_15112011.ecw

FIGURE 7

Post-disturbance Agricultural Suitability

Project: Mt Arthur Coal Open Cut Modification

Client: Hunter Valley Energy Coal Pty Ltd

File: Fg7_MAC01-029_PostAgSuit_121212

Projection: GDA94 MGA Zone 56

Version:	Date:	Author:	Checked:	Approved:
1	08/06/2012	ZJ	MH	CR
2	13/06/2012	ZJ	MH	CR
3	10/09/2012	LH	MH	CR
4	21/09/2012	KC	MH	CR
5	12/12/2012	KC	MF	CR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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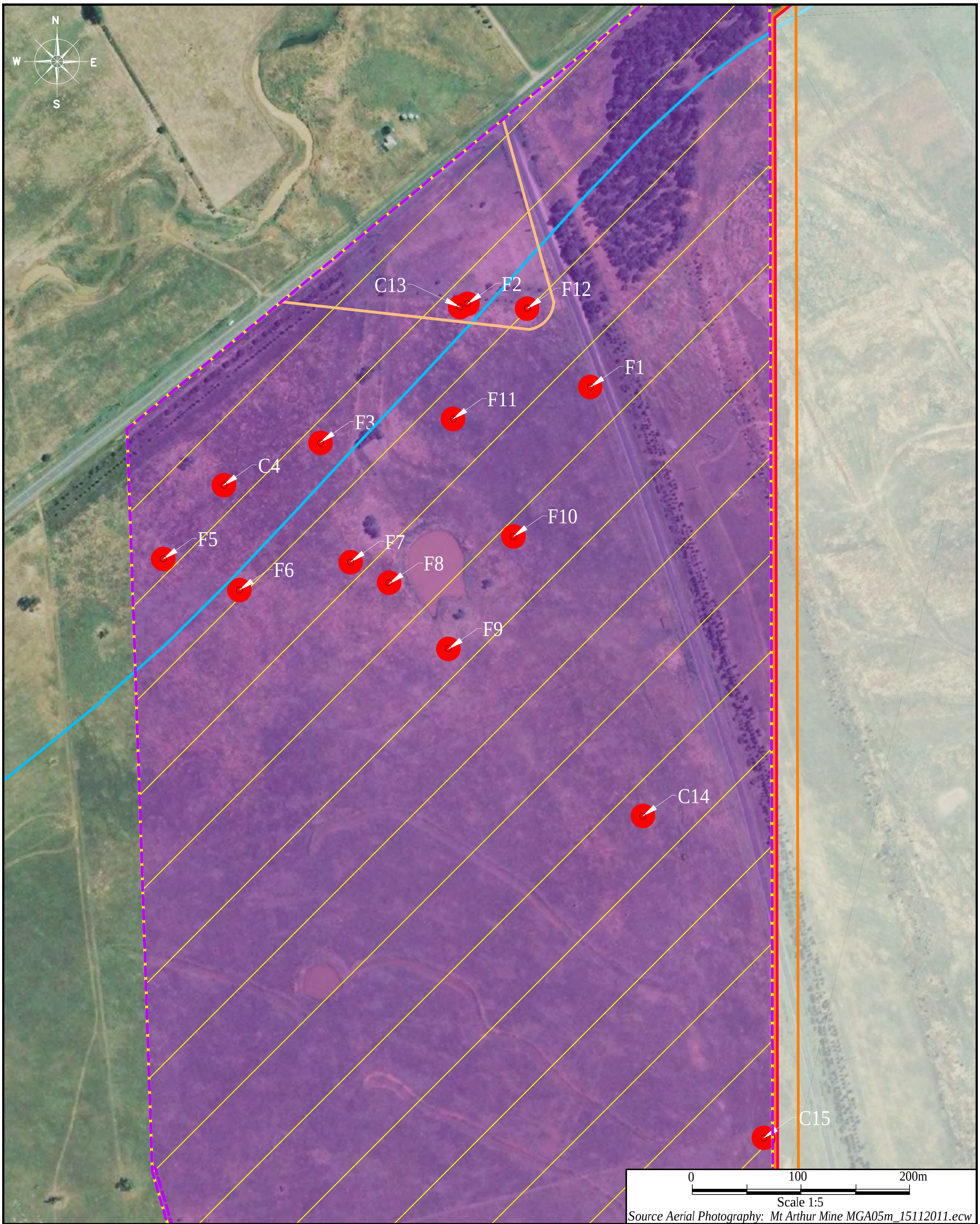

LEGEND

- Mt Arthur Coal Consolidated Disturbance Boundary
- Currently Approved Open Cut Area
- Proposed Open Cut Extension
- Study Area
- Government Reference Mapping Boundary
- Ground Truthed Fertility Boundary
- Field Points

FIGURE 8

Fertility Boundary Assessment

Project: Mt Arthur Coal Open Cut Modification

Client: Hunter Valley Energy Coal Pty Ltd

File: Fg8_MAC01-029_FertilityBdyAssess_121212

Projection: GDA94 MGA Zone 56

Version	Date:	Author:	Checked:	Approved:
1	10/09/2012	LH	MH	CR
2	21/09/2012	KC	MH	CR
3	12/12/2012	LF	MF	CR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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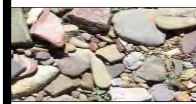
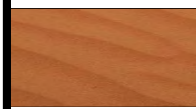
APPENDIX 1

GLOSSARY





GLOSSARY

APPENDIX 1

Table A1.1 – List of Glossary Terms and Definitions[1]

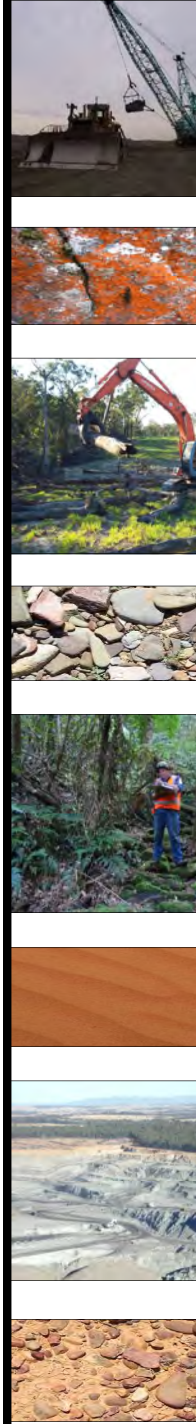
Term	Definition
Aggregate	A unit of soil structure usually formed by natural processes in contrast with natural processes, and generally <10 mm in diameter.
Aggregate Stability	Refers to the stability of soil structural units (aggregates) when immersed in water.
Alkalinity	A property expressed by the pH value when this exceeds 7.0 in a soil/water suspension.
Cation	An element with a positive charge.
Cation Exchange	Process whereby cations interchange between the soil solution and the clay or organic matter complexes in the soil.
Cation Exchange Capacity	The total amount of exchangeable cations that a soil can adsorb, expressed in centimoles of positive charge per kilogram of soil
Clay	A soil separate consisting of particles <0.002 mm in equivalent diameter.
Electrical Conductivity	A measure of the conduction of electricity through water or a water extract of soil. It can be used to determine the soluble salts in the extract and hence soil salinity. The unit of electrical conductivity is the Siemens and soil salinity is normally expressed as decisiemens per meter at 25˚C (dS/m).
Emerson Aggregate Test	A classification of soil aggregates based on their coherence in water.
Exchangeable Cation	A positively charged ion held on or near the surface of a solid particle by a negative surface charge of a colloid and which may be replaced by other positively charged ions in the soil solution.
Exchangeable Sodium Percentage	Exchangeable sodium fraction expressed as a percentage.
Field Texture Grade	Field texture is a measure of the behaviour of a small handful of soil when moistened and kneaded into a ball and then passes out between thumb and forefinger. The recommended field texture grades are characterised by the behaviour of the moist bolus.
Field Colour	The colour of soil material is determined by comparison with a standard Munsell colour chart.
Gravel	A mixture of coarse mineral particles larger than 2mm, but less than 75mm in diameter.
Hydraulic Conductivity	The flow of water through soil per unit of energy gradient. For practical purposes, it may be taken as the steady state of percolation rate of a soil when infiltration and internal drainage are equal, measured as depth per unit time.
pH (soil)	A measure of the acidity or alkalinity of a soil. It represents the negative logarithm of the hydrogen ion concentration in a specified soil/water suspension on a scale of 0 to 14.
Parent Material	The unconsolidated and more or less chemically weathered mineral or organic matter form which the solumn of soils is developed by pedogenic processes.
Particle Size Analysis	The laboratory determination of the amounts of the different separates in a soil sample such as clay, silt, fine sand, coarse sand and gravel. The amounts are normally expresses as percentages by weight of dry soil.
Ped	A unit of soil structure such as an aggregate, crumb, prism, block or granule, formed by natural processes (in contrast with a clod which is artificially formed).
Permeability (soil)	The ease with which gases, liquids or plant roots penetrate or pass through a bulk mass of soil or layer of soil.

Term	Definition
Physical Properties (soil)	Those characteristics, processes or reactions of a soil which is caused by physical forces and which can be described by, or expressed in, physical terms or equations. These can be difficult to separate from chemical properties; hence terms, physical-chemical or physico-chemical.
Pores	The part of the bulk volume of the soil not occupied by soil particles.
Sand	A soil particle that in the USDA soil texture system is of size 0.05 mm to 2.0 mm in diameter.
Silt	A soil particle that in the USDA soil texture system is of size 0.002 mm to 0.05 mm in diameter.
Sodicity	A property expressed by the amount of exchangeable sodium present relative to the cation capacity of a soil horizon.
Soil Classification	The systematic arrangement of soils into groups or categories on the basis of similarities and differences in their characteristics.
Soil Coherence	The degree to which soil material is held together at different moisture levels, If two-thirds or more of the soil material, whether composed of peds or not, remain united at a given moisture level, then the soil is described as coherent.
Soil Consistence	The resistance of soil material to deformation or rupture.
Soil Erodability	The susceptibility of a soil to the detachment and transportation of soil particles by erosive agents.
Soil Horizon	A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, biological properties such as colour structure, texture, consistency, kinds and number of organisms present, degrees or acidity or alkalinity.
Soil Profile	A vertical section of the soil through all its horizons.
Soil Salinity	The amount of soluble salts in a soil. The convention measure of soil salinity is the electrical conductivity of a saturation extract.
Soil Structure	Refers to the way soil particles are arranged and bound together to form aggregates or peds.
Soil Texture	The relative proportions of the various soil separates in as soil as described by the classes of soil texture. It is the general coarseness or fineness of soil material as it affects the behaviour of a moist ball (bolus) when pressed between the thumb and forefinger.
Solumn	The upper part of a soil profile above the parent material, in which current processes of soil formation are active. The solumn consists of either the A and B horizons or the A horizon alone when no B is present.
Structure Ped and Size	Refers to the distinctness, size and shape of peds.
Subsoil	Refers to B soil horizon
Topsoil	Refers to A1 and A2 soil horizons.

[1] Definitions have been sourced from: Charman and Murphy, 1991; Peverill et al., 1999; Mckensie et al., 2004; NCST, 2009.

APPENDIX 2

CERTIFICATE OF ANALYSIS



Certificate of Analysis

APPENDIX 2

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO12/120R1
REPORT TO:	M Hemingway GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Twenty one soil samples Ref: MAC01-029
REPORT STATUS:	Preliminary
DATE REPORTED:	25 May 2012
METHODS:	Information on test procedures can be obtained from Scone Research Centre

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

SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/120R1 (Preliminary)
Client Reference: M Hemingway
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C2B/3	C6A/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	Dry	Moist
1	Mt A 1 0-10	13	19	52	16	0	7	0.04	6.4	5.5	2.82	7.5YR4/4	7.5YR3/4
2	Mt A 1 10-25	21	17	46	16	0	3(2)	0.02	6.5	5.5	1.66	7.5YR4/4	7.5YR3/4
3	Mt A 1 25-60	64	10	18	8	0	2(1)	0.04	7.8	6.4	0.76	2.5YR4/6	2.5YR3/6
4	Mt A 1 60-100	50	9	22	16	3	4	0.19	8.9	7.9	0.42	5YR4/6	2.5YR4/6
5	Mt A 3 0-15	16	17	43	23	1	3(1)	0.04	6.3	5.6	2.27	7.5YR4/4	7.5YR2.5/3
6	Mt A 3 15-40	19	22	38	20	1	3(1)	0.03	6.6	5.9	1.06	7.5YR4/4	7.5YR2.5/3
7	Mt A 3 40-65	14	21	39	26	<1	2(1)	0.01	6.6	5.6	0.46	7.5YR5/4	7.5YR3/4
8	Mt A 3 65-100	57	11	24	8	0	1	0.08	7.7	6.6	0.36	7.5YR5/6	7.5YR4/6
9	Mt A 7 0-20	29	18	32	20	1	7	0.04	7.3	6.4	2.19	7.5YR4/2	7.5YR2.5/2
10	Mt A 7 20-55	58	28	10	4	<1	4	0.11	8.9	8.0	0.57	7.5YR5/3	7.5YR4/6
11	Mt A 7 55-100	53	39	6	2	0	4	0.13	9.2	8.4	0.30	10YR6/3	10YR5/4

S R Young

SOIL CONSERVATION SERVICE
Scone Research Service Centre

Report No: SCO12/120R1 (Preliminary)
Client Reference: M Hemingway
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/2 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C2B/3	C6A/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	pH ($CaCl_2$)	OC (%)	Dry	Moist
12	Mt A 8 0-20	8	14	37	39	0	5	0.01	5.1	4.2	1.50	10YR5/3	10YR3/3
13	Mt A 8 20-30	10	14	31	43	2	2(1)	<0.01	5.8	4.6	0.70	7.5YR6/3	7.5YR3/4
14	Mt A 8 30-60	40	11	24	25	2	2(1)	0.06	6.9	6.2	0.35	7.5YR6/6	7.5YR5/8
15	Mt A 9 0-20	29	22	38	11	0	7	0.05	7.2	6.3	2.13	7.5YR5/3	7.5YR3/3
16	Mt A 9 20-60	43	23	24	10	0	3(1)	0.28	9.2	8.1	0.54	7.5YR6/4	7.5YR5/4
17	Mt A 9 60-100	42	28	20	10	<1	2(1)	0.66	9.4	8.4	0.54	7.5YR6/4	7.5YR5/6
18	Mt A 10 0-15	8	36	49	6	0	7	0.03	6.3	5.7	1.57	7.5YR5/3	7.5YR3/4
19	Mt A 10 15-30	13	38	44	5	1	7	<0.01	6.0	5.0	1.29	7.5YR6/3	7.5YR4/4
20	Mt A 10 30-60	47	27	25	1	0	2(1)	0.11	6.4	5.7	0.34	5YR6/6	5YR4/6
21	Mt A 10 60-100	43	29	27	1	0	2(1)	0.13	6.3	5.6	0.30	7.5YR6/6	7.5YR5/8

END OF TEST REPORT

Soil Conservation Service

Experienced people protecting your resources

709 Gundy Road, Scone NSW 2337
PO Box 283, Scone NSW 2337
P: 02 6545 1666
F: 02 6545 2520
M: 0408 446 132

M Hemingway
GSS Environmental
PO Box 907
Hamilton NSW 2303

29 May 2012

SCO12/120R2

Dear M Hemingway

Analysis of 21 soil sample – Soil erodibility factor

The Soil Conservation Service has analysed 21 soil samples and the soil erodibility factor (K factor) has been determined (as described by Rosewell 1993) using the particle size analysis-mechanical dispersion and the organic carbon. The surface soil structure was assumed to be medium granular and the profile permeability was assumed to be slow to moderate.

Lab No	Sample Id	K factor	Rating
1	Mt A 1 0-10	0.039	Moderate
2	Mt A 1 10-25	0.043	High
3	Mt A 1 25-60	0.026	Moderate
4	Mt A 1 60-100	0.022	Moderate
5	Mt A 3 0-15	0.037	Moderate
6	Mt A 3 15-40	0.043	High
7	Mt A 3 40-65	0.049	High
8	Mt A 3 65-100	0.023	Moderate
9	Mt A 7 0-20	0.034	Moderate
10	Mt A 7 20-55	0.032	Moderate
11	Mt A 7 55-100	0.047	High
12	Mt A 8 0-20	0.037	Moderate
13	Mt A 8 20-30	0.035	Moderate
14	Mt A 8 30-60	0.024	Moderate
15	Mt A 9 0-20	0.036	Moderate
16	Mt A 9 20-60	0.033	Moderate
17	Mt A 9 60-100	0.039	Moderate
18	Mt A 10 0-15	0.064	Very high
19	Mt A 10 15-30	0.064	Very high
20	Mt A 10 30-60	0.049	High
21	Mt A 10 60-100	0.051	High

This interpretation was based on the soil samples being representative, and literature guidelines. If you have any queries, please contact me on (02) 6545 1666.

Yours sincerely

SR Young

References

Rosewell CJ (1993) Soiloss – A program to assist in the selection of management practices to reduce erosion. Department of Conservation and Land Management.

Department of Primary Industries

Diagnostic and Analytical Services
Environmental Laboratory
1243 Bruxner Highway WOLLONGBAR NSW 2477
Phone 02 6626 1103 Email wollongbar.csu@dpi.nsw.gov.au

Report No **WN12/0646/E**

Owner SOIL CONSERVATION SERVICE
709 GUNDY ROAD
SCONE NSW 2337

Submitted 16.5.12

Received 17.5.12

Submitter S YOUNG

Samples received 49 x soil

Soil Analysis Report

Analytical Method	Method number	Date Analysed
Determination of Gillman and Sumpter Exchangeable Cations by ICP	In-house methods 014 and 670	18/5/12

Results attached.

GLEN RANGOTT
CHEMIST
21 MAY, 2012 SGJ

FINAL REPORT S YOUNG

- *Samples air dried at 40°C in dehydrators according to Method 1B1 (Rayment and Higginson, 1992).*
- *These results apply to the sample(s) as provided and are expressed on a dry weight basis unless otherwise stated.*
- *This report should not be reproduced except in full.*
- *Samples will be retained for one month from the date of the final report. Samples will then be discarded. Clients wishing to recover their samples must contact the laboratory within this period. The laboratory will return residual samples at client expense when requested.*

NATA
Accredited for compliance with ISO/IEC 17025.
Accredited No: 14173

Email invoice 49 x 117107 → 136-1

Client ID		Sample Id	Aluminium	Calcium	Potassium	Magnesium	Sodium	Cation Exchange Capacity	Exchangeable Sodium (ESP)
	Units		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	%
	LOR		0.01	0.01	0.02	0.008	0.02		
12/120/1	5593	Mt A 1 0-10	0.01	6.6	1.20	3.0	0.11	11.0	1.0
12/120/2	5594	Mt A 1 10-25	0.02	5.6	0.98	3.0	0.11	9.7	1.2
12/120/3	5595	Mt A 1 25-60	0.01	8.9	0.92	10.0	0.86	21.0	4.2
12/120/4	5596	Mt A 1 60-100	0.01	12.0	0.53	10.0	1.30	24.0	5.6
12/120/5	5597	Mt A 3 0-15	0.02	8.0	1.30	2.3	0.10	12.0	0.9
12/120/6	5598	Mt A 3 15-40	<0.01	7.5	0.88	1.9	0.08	10.0	0.8
12/120/7	5599	Mt A 3 40-65	<0.01	4.4	0.47	1.6	0.14	6.7	2.1
12/120/8	5600	Mt A 3 65-100	<0.01	9.1	0.43	7.4	1.50	18.0	8.1
12/120/9	5601	Mt A 7 0-20	<0.01	13.0	1.20	4.9	0.07	19.0	0.4
12/120/10	5602	Mt A 7 20-55	0.01	13.0	0.60	13.0	0.34	28.0	1.2
12/120/11	5603	Mt A 7 55-100	0.01	11.0	0.43	16.0	0.84	28.0	3.0
12/120/12	5604	Mt A 8 0-20	0.95	1.6	0.55	0.5	0.04	3.7	1.2
12/120/13	5605	Mt A 8 20-30	0.42	2.0	0.41	0.9	0.06	3.8	1.6
12/120/14	5606	Mt A 8 30-60	0.04	7.3	0.76	5.9	0.38	14.0	2.7
12/120/15	5607	Mt A 9 0-20	0.02	9.8	0.94	6.3	0.45	17.0	2.6
12/120/16	5608	Mt A 9 20-60	0.01	12.0	0.40	9.9	2.70	25.0	11.0
12/120/17	5609	Mt A 9 60-100	0.02	9.4	0.34	11.0	6.20	27.0	23.0
12/120/18	5610	Mt A 10 0-15	0.04	3.8	0.67	1.6	0.06	6.2	1.0
12/120/19	5611	Mt A 10 15-30	0.20	2.8	0.54	1.5	0.07	5.2	1.4
12/120/20	5612	Mt A 10 30-60	0.01	7.3	0.61	6.7	0.89	15.0	5.7
12/120/21	5613	Mt A 10 60-100	0.02	6.7	0.50	6.9	1.30	15.0	8.4

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (1)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F2 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.08	<0.15
pH	(1:5 $CaCl_2$)	5.98	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	16.01	See Percentage
Magnesium:	(Mg)(meq/100g)	5.81	See Percentage
Potassium:	(K)(meq/100g)	0.48	0.5-1.0
Sodium:	(Na)(meq/100g)	0.29	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**22.59**	
Exchangeable Cations (as a % of Total)			
Calcium:		70.89	65-80%
Magnesium:		25.72	15-20%
Potassium:		2.11	2-5%
Sodium:		1.28	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	6.8	
Phosphorus:	(mg/kg) (Colwell)	16.4	
Phosphorus Buffer Index (Col)		**70.7**	
Sulphur	(mg/kg) (KCl 40 S)	4.2	
Nitrate Nitrogen	(mg/kg) (water extract)	4.6	
Organic Carbon	(%) (Walkely & Black)	3.5	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.9	>0.4
Zinc	(mg/kg) (DTPA)	0.6	>2.0
Manganese	(mg/kg) (DTPA)	23.8	4-50
Iron	(mg/kg) (DTPA)	63.8	4-50
Boron	(mg/kg) (Hot CaCl)	0.6	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.76	3-5

s12-0681 (1)
GSS Environmental
MA F2 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Explanations:

1. The figure on the first page quoting a lime requirement is an indication of the amount of 100% available ag lime to reduce available aluminium to zero. This figure is only a guide as additional lime may be needed for individual crops &/or circumstances.

2. Since we have no control over your farming practices our liability is limited to the cost of this test.

3. We fully encourage you to RING & DISCUSS your results with us. As we are independent of fertiliser companies we can suggest the best blends to suit you, not us! Further, our aim is to assist you to farm sustainably & profitably.

4. An excellent reference for growers in all areas is "Soil Sense: Soil Management for North Coast Farmers:, a joint NSW Agriculture/SCS & CaLM publication, & is available from your local NSW Agriculture or Soil Conservation office.

6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC
SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (2)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F3 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.04	<0.15
pH	(1:5 $CaCl_2$)	5.19	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	5.78	See Percentage
Magnesium:	(Mg)(meq/100g)	2.49	See Percentage
Potassium:	(K)(meq/100g)	0.15	0.5-1.0
Sodium:	(Na)(meq/100g)	0.29	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**8.70**	
Exchangeable Cations (as a % of Total)			
Calcium:		66.38	65-80%
Magnesium:		28.62	15-20%
Potassium:		1.68	2-5%
Sodium:		3.31	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	9.8	
Phosphorus:	(mg/kg) (Colwell)	23.9	
Phosphorus Buffer Index (Col)		**178.5**	
Sulphur	(mg/kg) (KCl 40 S)	8.8	
Nitrate Nitrogen	(mg/kg) (water extract)	4.6	
Organic Carbon	(%) (Walkely & Black)	3.1	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.7	>0.4
Zinc	(mg/kg) (DTPA)	0.7	>2.0
Manganese	(mg/kg) (DTPA)	31.5	4-50
Iron	(mg/kg) (DTPA)	147.8	4-50
Boron	(mg/kg) (Hot CaCl)	0.9	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.32	3-5

s12-0681 (2)
GSS Environmental
MA F3 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

1. The figure on the first page quoting a lime requirement is an indication of the amount of 100% available ag lime to reduce available aluminium to zero. This figure is only a guide as additional lime may be needed for individual crops &/or circumstances.

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3. We fully encourage you to RING & DISCUSS your results with us. As we are independent of fertiliser companies we can suggest the best blends to suit you, not us! Further, our aim is to assist you to farm sustainably & profitably.

4. An excellent reference for growers in all areas is "Soil Sense: Soil Management for North Coast Farmers:, a joint NSW Agriculture/SCS & CaLM publication, & is available from your local NSW Agriculture or Soil Conservation office.

6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (3)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F5 0-10CM **INTEDED USE:**

			RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)			0.06	<0.15
pH	($1:5\ CaCl_2$)		5.31	5.2-5.5
Exchangeable Cations: (Measured)				
Calcium	(Ca)(meq/100g)		7.09	See Percentage
Magnesium:	(Mg)(meq/100g)		2.08	See Percentage
Potassium:	(K)(meq/100g)		0.26	0.5-1.0
Sodium:	(Na)(meq/100g)		0.07	Zero
Aluminium:	(Al)(meq/100g)		0.00	Zero
Total Cation Exchange Capacity (CEC):			**9.49**	
Exchangeable Cations (as a % of Total)				
Calcium:			74.67	65-80%
Magnesium:			21.86	15-20%
Potassium:			2.70	2-5%
Sodium:			0.76	<3%
Aluminium:			0.00	<5%
Phosphorus:	(mg/kg)	(Bray-1)	8.9	
Phosphorus:	(mg/kg)	(Colwell)	21.7	
Phosphorus Buffer Index (Col)			**102.4**	
Sulphur	(mg/kg)	(KCl 40 S)	5.5	
Nitrate Nitrogen	(mg/kg)	(water extract)	6.9	
Organic Carbon	(%)	(Walkely & Black)	3.2	>2
Trace Elements				
Copper	(mg/kg)	(DTPA)	1.1	>0.4
Zinc	(mg/kg)	(DTPA)	0.5	>2.0
Manganese	(mg/kg)	(DTPA)	37.7	4-50
Iron	(mg/kg)	(DTPA)	124.8	4-50
Boron	(mg/kg)	(Hot CaCl)	0.7	>1.5
Calculations:				
Lime Requirement (Cregan)			0.00	
Calcium/Magnesium Ratio:			3.42	3-5

s12-0681 (3)
GSS Environmental
MA F5 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (4)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F1 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.03	<0.15
pH	(1:5 $CaCl_2$)	5.13	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	5.25	See Percentage
Magnesium:	(Mg)(meq/100g)	2.08	See Percentage
Potassium:	(K)(meq/100g)	0.47	0.5-1.0
Sodium:	(Na)(meq/100g)	0.29	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**8.09**	
Exchangeable Cations (as a % of Total)			
Calcium:		64.93	65-80%
Magnesium:		25.66	15-20%
Potassium:		5.84	2-5%
Sodium:		3.57	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	8.0	
Phosphorus:	(mg/kg) (Colwell)	19.4	
Phosphorus Buffer Index (Col)		**89.7**	
Sulphur	(mg/kg) (KCl 40 S)	4.9	
Nitrate Nitrogen	(mg/kg) (water extract)	4.6	
Organic Carbon	(%) (Walkely & Black)	2.7	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.3	>0.4
Zinc	(mg/kg) (DTPA)	0.8	>2.0
Manganese	(mg/kg) (DTPA)	34.2	4-50
Iron	(mg/kg) (DTPA)	93.8	4-50
Boron	(mg/kg) (Hot CaCl)	0.9	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.53	3-5

s12-0681 (4)
GSS Environmental
MA F1 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC
SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (5)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F 6 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.04	<0.15
pH	(1:5 $CaCl_2$)	5.32	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	5.78	See Percentage
Magnesium:	(Mg)(meq/100g)	1.66	See Percentage
Potassium:	(K)(meq/100g)	0.37	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**7.87**	
Exchangeable Cations (as a % of Total)			
Calcium:		73.35	65-80%
Magnesium:		21.08	15-20%
Potassium:		4.65	2-5%
Sodium:		0.92	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	9.2	
Phosphorus:	(mg/kg) (Colwell)	22.5	
Phosphorus Buffer Index (Col)		**86.0**	
Sulphur	(mg/kg) (KCl 40 S)	5.7	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	2.6	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.9	>0.4
Zinc	(mg/kg) (DTPA)	0.7	>2.0
Manganese	(mg/kg) (DTPA)	38.9	4-50
Iron	(mg/kg) (DTPA)	86.7	4-50
Boron	(mg/kg) (Hot CaCl)	1.0	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		3.48	3-5

~ASPAC~
WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (5)
GSS Environmental
MA F 6 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (6)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F7 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity	(dS/m)(1:5 water)	0.05	<0.15
pH	(1:5 $CaCl_2$)	4.90	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	4.73	See Percentage
Magnesium:	(Mg)(meq/100g)	1.66	See Percentage
Potassium:	(K)(meq/100g)	0.73	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.11	Zero
Total Cation Exchange Capacity (CEC):		**7.30**	
Exchangeable Cations (as a % of Total)			
Calcium:		64.77	65-80%
Magnesium:		22.75	15-20%
Potassium:		10.04	2-5%
Sodium:		0.99	<3%
Aluminium:		1.45	<5%
Phosphorus:	(mg/kg) (Bray-1)	7.8	
Phosphorus:	(mg/kg) (Colwell)	18.9	
Phosphorus Buffer Index (Col)		**190.6**	
Sulphur	(mg/kg) (KCl 40 S)	4.8	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	2.4	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.0	>0.4
Zinc	(mg/kg) (DTPA)	0.7	>2.0
Manganese	(mg/kg) (DTPA)	30.2	4-50
Iron	(mg/kg) (DTPA)	181.4	4-50
Boron	(mg/kg) (Hot CaCl)	1.1	>1.5
Calculations:			
Lime Requirement (Cregan)		0.14	
Calcium/Magnesium Ratio:		2.85	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (6)
GSS Environmental
MA F7 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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SOILTEC
SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (7)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F9 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.03	<0.15
pH	(1:5 $CaCl_2$)	4.67	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	4.46	See Percentage
Magnesium:	(Mg)(meq/100g)	1.25	See Percentage
Potassium:	(K)(meq/100g)	0.26	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.13	Zero
Total Cation Exchange Capacity (CEC):		**6.16**	
Exchangeable Cations (as a % of Total)			
Calcium:		72.40	65-80%
Magnesium:		20.20	15-20%
Potassium:		4.16	2-5%
Sodium:		1.17	<3%
Aluminium:		2.07	<5%
Phosphorus:	(mg/kg) (Bray-1)	5.5	
Phosphorus:	(mg/kg) (Colwell)	13.4	
Phosphorus Buffer Index (Col)		**255.7**	
Sulphur	(mg/kg) (KCl 40 S)	6.6	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	2.4	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.1	>0.4
Zinc	(mg/kg) (DTPA)	0.6	>2.0
Manganese	(mg/kg) (DTPA)	43.9	4-50
Iron	(mg/kg) (DTPA)	202.4	4-50
Boron	(mg/kg) (Hot CaCl)	0.8	>1.5
Calculations:			
Lime Requirement (Cregan)		0.17	
Calcium/Magnesium Ratio:		3.58	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (7)
GSS Environmental
MA F9 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium,   potassium, with sodium, and aluminium. Phosphorus is sulphur is   and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is   manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (8)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F10 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.04	<0.15
pH	(1:5 $CaCl_2$)	5.32	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	7.35	See Percentage
Magnesium:	(Mg)(meq/100g)	3.32	See Percentage
Potassium:	(K)(meq/100g)	0.26	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**11.00**	
Exchangeable Cations (as a % of Total)			
Calcium:		66.83	65-80%
Magnesium:		30.19	15-20%
Potassium:		2.33	2-5%
Sodium:		0.66	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	5.8	
Phosphorus:	(mg/kg) (Colwell)	14.0	
Phosphorus Buffer Index (Col)		**76.5**	
Sulphur	(mg/kg) (KCl 40 S)	4.9	
Nitrate Nitrogen	(mg/kg) (water extract)	6.9	
Organic Carbon	(%) (Walkely & Black)	3.4	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.3	>0.4
Zinc	(mg/kg) (DTPA)	0.9	>2.0
Manganese	(mg/kg) (DTPA)	45.8	4-50
Iron	(mg/kg) (DTPA)	61.7	4-50
Boron	(mg/kg) (Hot CaCl)	0.7	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.21	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (8)
GSS Environmental
MA F10 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (9)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F11 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.03	<0.15
pH	(1:5 $CaCl_2$)	5.38	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	7.61	See Percentage
Magnesium:	(Mg)(meq/100g)	3.32	See Percentage
Potassium:	(K)(meq/100g)	0.29	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**11.30**	
Exchangeable Cations (as a % of Total)			
Calcium:		67.38	65-80%
Magnesium:		29.39	15-20%
Potassium:		2.59	2-5%
Sodium:		0.64	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	4.6	
Phosphorus:	(mg/kg) (Colwell)	11.2	
Phosphorus Buffer Index (Col)		**61.3**	
Sulphur	(mg/kg) (KCl 40 S)	4.2	
Nitrate Nitrogen	(mg/kg) (water extract)	6.9	
Organic Carbon	(%) (Walkely & Black)	3.2	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.4	>0.4
Zinc	(mg/kg) (DTPA)	0.8	>2.0
Manganese	(mg/kg) (DTPA)	23.3	4-50
Iron	(mg/kg) (DTPA)	74.9	4-50
Boron	(mg/kg) (Hot CaCl)	1.1	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.29	3-5

s12-0681 (9)
GSS Environmental
MA F11 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (10)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA F12 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.07	<0.15
pH	(1:5 $CaCl_2$)	5.46	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	8.93	See Percentage
Magnesium:	(Mg)(meq/100g)	4.57	See Percentage
Potassium:	(K)(meq/100g)	0.44	0.5-1.0
Sodium:	(Na)(meq/100g)	0.29	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**14.22**	
Exchangeable Cations (as a % of Total)			
Calcium:		62.77	65-80%
Magnesium:		32.11	15-20%
Potassium:		3.09	2-5%
Sodium:		2.03	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	8.8	
Phosphorus:	(mg/kg) (Colwell)	21.3	
Phosphorus Buffer Index (Col)		**145.9**	
Sulphur	(mg/kg) (KCl 40 S)	5.4	
Nitrate Nitrogen	(mg/kg) (water extract)	6.9	
Organic Carbon	(%) (Walkely & Black)	3.6	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.7	>0.4
Zinc	(mg/kg) (DTPA)	0.8	>2.0
Manganese	(mg/kg) (DTPA)	27.9	4-50
Iron	(mg/kg) (DTPA)	144.7	4-50
Boron	(mg/kg) (Hot CaCl)	1.0	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		1.96	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (10)
GSS Environmental
MA F12 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

1. The figure on the first page quoting a lime requirement is an indication of the amount of 100% available ag lime to reduce available aluminium to zero. This figure is only a guide as additional lime may be needed for individual crops &/or circumstances.

2. Since we have no control over your farming practices our liability is limited to the cost of this test.

3. We fully encourage you to RING & DISCUSS your results with us. As we are independent of fertiliser companies we can suggest the best blends to suit you, not us! Further, our aim is to assist you to farm sustainably & profitably.

4. An excellent reference for growers in all areas is "Soil Sense: Soil Management for North Coast Farmers:, a joint NSW Agriculture/SCS & CaLM publication, & is available from your local NSW Agriculture or Soil Conservation office.

6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (11)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C4 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.04	<0.15
pH	(1:5 $CaCl_2$)	5.32	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	5.25	See Percentage
Magnesium:	(Mg)(meq/100g)	1.66	See Percentage
Potassium:	(K)(meq/100g)	0.37	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**7.35**	
Exchangeable Cations (as a % of Total)			
Calcium:		71.44	65-80%
Magnesium:		22.59	15-20%
Potassium:		4.99	2-5%
Sodium:		0.99	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	4.8	
Phosphorus:	(mg/kg) (Colwell)	11.6	
Phosphorus Buffer Index (Col)		**109.0**	
Sulphur	(mg/kg) (KCl 40 S)	2.9	
Nitrate Nitrogen	(mg/kg) (water extract)	4.6	
Organic Carbon	(%) (Walkely & Black)	3.7	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.8	>0.4
Zinc	(mg/kg) (DTPA)	1.1	>2.0
Manganese	(mg/kg) (DTPA)	31.8	4-50
Iron	(mg/kg) (DTPA)	105.4	4-50
Boron	(mg/kg) (Hot CaCl)	0.8	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		3.16	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (11)
GSS Environmental
MA C4 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC
SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (12)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C4 20-30CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.03	<0.15
pH	(1:5 $CaCl_2$)	5.62	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	5.78	See Percentage
Magnesium:	(Mg)(meq/100g)	2.49	See Percentage
Potassium:	(K)(meq/100g)	0.18	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**8.52**	
Exchangeable Cations (as a % of Total)			
Calcium:		67.78	65-80%
Magnesium:		29.22	15-20%
Potassium:		2.15	2-5%
Sodium:		0.85	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	3.8	
Phosphorus:	(mg/kg) (Colwell)	9.2	
Phosphorus Buffer Index (Col)		**248.3**	
Sulphur	(mg/kg) (KCl 40 S)	0.9	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	1.0	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.6	>0.4
Zinc	(mg/kg) (DTPA)	0.9	>2.0
Manganese	(mg/kg) (DTPA)	23.4	4-50
Iron	(mg/kg) (DTPA)	137.7	4-50
Boron	(mg/kg) (Hot CaCl)	0.5	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.32	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (12)
GSS Environmental
MA C4 20-30CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (13)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C4 50-60CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.13	<0.15
pH	(1:5 $CaCl_2$)	5.61	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	7.88	See Percentage
Magnesium:	(Mg)(meq/100g)	3.74	See Percentage
Potassium:	(K)(meq/100g)	0.26	0.5-1.0
Sodium:	(Na)(meq/100g)	0.50	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**12.37**	
Exchangeable Cations (as a % of Total)			
Calcium:		63.66	65-80%
Magnesium:		30.19	15-20%
Potassium:		2.07	2-5%
Sodium:		4.08	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	3.6	
Phosphorus:	(mg/kg) (Colwell)	8.9	
Phosphorus Buffer Index (Col)		**304.4**	
Sulphur	(mg/kg) (KCl 40 S)	0.9	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	0.4	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.4	>0.4
Zinc	(mg/kg) (DTPA)	0.7	>2.0
Manganese	(mg/kg) (DTPA)	16.8	4-50
Iron	(mg/kg) (DTPA)	150.2	4-50
Boron	(mg/kg) (Hot CaCl)	0.4	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.11	3-5

s12-0681 (13)
GSS Environmental
MA C4 50-60CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (14)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C13 0-10CM **INTEDED USE:**

			RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)			0.35	<0.15
pH	(1:5 $CaCl_2$)		6.22	5.2-5.5
Exchangeable Cations: (Measured)				
Calcium	(Ca)(meq/100g)		18.11	See Percentage
Magnesium:	(Mg)(meq/100g)		7.06	See Percentage
Potassium:	(K)(meq/100g)		0.40	0.5-1.0
Sodium:	(Na)(meq/100g)		0.72	Zero
Aluminium:	(Al)(meq/100g)		0.00	Zero
Total Cation Exchange Capacity (CEC):			**26.29**	
Exchangeable Cations (as a % of Total)				
Calcium:			68.89	65-80%
Magnesium:			26.83	15-20%
Potassium:			1.53	2-5%
Sodium:			2.74	<3%
Aluminium:			0.00	<5%
Phosphorus:	(mg/kg)	(Bray-1)	3.3	
Phosphorus:	(mg/kg)	(Colwell)	8.0	
Phosphorus Buffer Index (Col)			**75.4**	
Sulphur	(mg/kg)	(KCl 40 S)	2.0	
Nitrate Nitrogen	(mg/kg)	(water extract)	6.9	
Organic Carbon	(%)	(Walkely & Black)	3.4	>2
Trace Elements				
Copper	(mg/kg)	(DTPA)	1.0	>0.4
Zinc	(mg/kg)	(DTPA)	1.0	>2.0
Manganese	(mg/kg)	(DTPA)	28.4	4-50
Iron	(mg/kg)	(DTPA)	54.8	4-50
Boron	(mg/kg)	(Hot CaCl)	1.1	>1.5
Calculations:				
Lime Requirement (Cregan)			0.00	
Calcium/Magnesium Ratio:			2.57	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (14)
GSS Environmental
MA C13 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC
SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (15)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C13 10-20CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.32	<0.15
pH	(1:5 $CaCl_2$)	7.10	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	19.43	See Percentage
Magnesium:	(Mg)(meq/100g)	8.30	See Percentage
Potassium:	(K)(meq/100g)	0.26	0.5-1.0
Sodium:	(Na)(meq/100g)	0.72	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**28.70**	
Exchangeable Cations (as a % of Total)			
Calcium:		67.68	65-80%
Magnesium:		28.92	15-20%
Potassium:		0.89	2-5%
Sodium:		2.51	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	2.6	
Phosphorus:	(mg/kg) (Colwell)	6.3	
Phosphorus Buffer Index (Col)		**60.6**	
Sulphur	(mg/kg) (KCl 40 S)	0.9	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	1.0	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.8	>0.4
Zinc	(mg/kg) (DTPA)	0.9	>2.0
Manganese	(mg/kg) (DTPA)	20.2	4-50
Iron	(mg/kg) (DTPA)	68.1	4-50
Boron	(mg/kg) (Hot CaCl)	0.6	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		2.34	3-5

s12-0681 (15)
GSS Environmental
MA C13 10-20CM

Chemists Comments:

This soil saline, , calcium magnesium,   potassium, with sodium, and aluminium. Phosphorus is sulphur is   and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is   manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (16)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C13 40-50CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.35	<0.15
pH	(1:5 $CaCl_2$)	7.85	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	19.69	See Percentage
Magnesium:	(Mg)(meq/100g)	11.21	See Percentage
Potassium:	(K)(meq/100g)	0.15	0.5-1.0
Sodium:	(Na)(meq/100g)	1.80	Zero
Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):		**32.84**	
Exchangeable Cations (as a % of Total)			
Calcium:		59.95	65-80%
Magnesium:		34.12	15-20%
Potassium:		0.45	2-5%
Sodium:		5.48	<3%
Aluminium:		0.00	<5%
Phosphorus:	(mg/kg) (Bray-1)	2.4	
Phosphorus:	(mg/kg) (Colwell)	5.9	
Phosphorus Buffer Index (Col)		**100.0**	
Sulphur	(mg/kg) (KCl 40 S)	0.4	
Nitrate Nitrogen	(mg/kg) (water extract)	2.3	
Organic Carbon	(%) (Walkely & Black)	0.4	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	0.7	>0.4
Zinc	(mg/kg) (DTPA)	0.6	>2.0
Manganese	(mg/kg) (DTPA)	19.8	4-50
Iron	(mg/kg) (DTPA)	70.9	4-50
Boron	(mg/kg) (Hot CaCl)	0.5	>1.5
Calculations:			
Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:		1.76	3-5

s12-0681 (16)
GSS Environmental
MA C13 40-50CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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SOILTEC

SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (17)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C14 0-10CM **INTEDED USE:**

			RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)			0.24	<0.15
pH	(1:5 $CaCl_2$)		5.32	5.2-5.5
Exchangeable Cations: (Measured)				
	Calcium	(Ca)(meq/100g)	6.30	See Percentage
	Magnesium:	(Mg)(meq/100g)	2.49	See Percentage
	Potassium:	(K)(meq/100g)	0.26	0.5-1.0
	Sodium:	(Na)(meq/100g)	0.29	Zero
	Aluminium:	(Al)(meq/100g)	0.00	Zero
Total Cation Exchange Capacity (CEC):			**9.33**	
Exchangeable Cations (as a % of Total)				
	Calcium:		67.49	65-80%
	Magnesium:		26.67	15-20%
	Potassium:		2.75	2-5%
	Sodium:		3.09	<3%
	Aluminium:		0.00	<5%
Phosphorus:	(mg/kg)	(Bray-1)	2.3	
Phosphorus:	(mg/kg)	(Colwell)	5.7	
Phosphorus Buffer Index (Col)			**68.0**	
Sulphur	(mg/kg)	(KCl 40 S)	2.8	
Nitrate Nitrogen	(mg/kg)	(water extract)	9.2	
Organic Carbon	(%)	(Walkely & Black)	3.0	>2
Trace Elements				
	Copper	(mg/kg) (DTPA)	0.9	>0.4
	Zinc	(mg/kg) (DTPA)	0.7	>2.0
	Manganese	(mg/kg) (DTPA)	36.6	4-50
	Iron	(mg/kg) (DTPA)	55.7	4-50
	Boron	(mg/kg) (Hot CaCl)	0.9	>1.5
Calculations:				
	Lime Requirement (Cregan)		0.00	
Calcium/Magnesium Ratio:			2.53	3-5

~ASPAC~

WE ARE PROUD MEMBERS OF THE AUSTRALASIAN SOIL AND PLANT ANALYSIS COUNCIL

s12-0681 (17)
GSS Environmental
MA C14 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium, potassium, with sodium, and aluminium. Phosphorus is sulphur is and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

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2. Since we have no control over your farming practices our liability is limited to the cost of this test.

3. We fully encourage you to RING & DISCUSS your results with us. As we are independent of fertiliser companies we can suggest the best blends to suit you, not us! Further, our aim is to assist you to farm sustainably & profitably.

4. An excellent reference for growers in all areas is "Soil Sense: Soil Management for North Coast Farmers:, a joint NSW Agriculture/SCS & CaLM publication, & is available from your local NSW Agriculture or Soil Conservation office.

6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

SOILTEC SOIL AND PLANT ANALYSIS

2/37 OWENS CR (PO BOX 374) ALSTONVILLE NSW 2477
PHONE 02 66281411 FAX 02 66285868 EMAIL : chemist@soiltec.com.au

Soil Test Report #s12-0681 (18)

Client: *GSS Environmental* **Sample Received: 17.7.2012**
Account: **Report Reply: 26.7.2012**
PO Box 907
Hamilton NSW 2292

SAMPLE I.D: MA C15 0-10CM **INTEDED USE:**

		RESULT	OPTIMAL
Conductivity (dS/m)(1:5 water)		0.26	<0.15
pH	(1:5 $CaCl_2$)	4.91	5.2-5.5
Exchangeable Cations: (Measured)			
Calcium	(Ca)(meq/100g)	4.99	See Percentage
Magnesium:	(Mg)(meq/100g)	1.66	See Percentage
Potassium:	(K)(meq/100g)	0.26	0.5-1.0
Sodium:	(Na)(meq/100g)	0.07	Zero
Aluminium:	(Al)(meq/100g)	0.15	Zero
Total Cation Exchange Capacity (CEC):		**7.13**	
Exchangeable Cations (as a % of Total)			
Calcium:		69.99	65-80%
Magnesium:		23.29	15-20%
Potassium:		3.60	2-5%
Sodium:		1.02	<3%
Aluminium:		2.10	<5%
Phosphorus:	(mg/kg) (Bray-1)	6.4	
Phosphorus:	(mg/kg) (Colwell)	15.6	
Phosphorus Buffer Index (Col)		**64.0**	
Sulphur	(mg/kg) (KCl 40 S)	4.9	
Nitrate Nitrogen	(mg/kg) (water extract)	6.9	
Organic Carbon	(%) (Walkely & Black)	2.9	>2
Trace Elements			
Copper	(mg/kg) (DTPA)	1.1	>0.4
Zinc	(mg/kg) (DTPA)	0.9	>2.0
Manganese	(mg/kg) (DTPA)	34.1	4-50
Iron	(mg/kg) (DTPA)	68.9	4-50
Boron	(mg/kg) (Hot CaCl)	1.0	>1.5
Calculations:			
Lime Requirement (Cregan)		0.19	
Calcium/Magnesium Ratio:		3.00	3-5

s12-0681 (18)
GSS Environmental
MA C15 0-10CM

Chemists Comments:

This soil saline, , calcium magnesium,   potassium, with sodium, and aluminium. Phosphorus is sulphur is   and organic carbon is Nitrate nitrogen is .
Copper levels are zinc is   manganese is iron is and boron is .

Recommendations:

Referred to Mat Hemmingway

Explanations:

1. The figure on the first page quoting a lime requirement is an indication of the amount of 100% available ag lime to reduce available aluminium to zero. This figure is only a guide as additional lime may be needed for individual crops &/or circumstances.

2. Since we have no control over your farming practices our liability is limited to the cost of this test.

3. We fully encourage you to RING & DISCUSS your results with us. As we are independent of fertiliser companies we can suggest the best blends to suit you, not us! Further, our aim is to assist you to farm sustainably & profitably.

4. An excellent reference for growers in all areas is "Soil Sense: Soil Management for North Coast Farmers:, a joint NSW Agriculture/SCS & CaLM publication, & is available from your local NSW Agriculture or Soil Conservation office.

6. Nitrate nitrogen values are reliable only if soil sample is air dried immediately after sampling.

ATTACHMENT B

CASE STUDIES

CASE STUDY

NEW SOUTH WALES MINERALS COUNCIL LTD

APRIL 2012

Mining and horse breeding coexisting in the Hunter Valley – Edinglassie Stud and BHP Billiton Mt Arthur Coal mine

Mining and horse breeding have been important industries in the Hunter Valley for many years. They continue to exist side by side, and in the case of Edinglassie, the property is owned by a coal company, BHP Billiton Mt Arthur Coal.

About Edinglassie

Edinglassie is a historic 500-acre property on the banks of the Hunter River. It is an Australian heritage listed property, initially settled by the White family 150 years ago. More recently, Edinglassie was the home of Rosemount Wines, but is currently operated as Edinglassie Thoroughbred Stud.

BHP Billiton Mt Arthur Coal purchased Edinglassie in 1998. It continues to be operated as a thoroughbred stud by its current leases, Mick and Michelle Talty, both of whom completed an Associate Diploma in Horse Management from Glenormiston Agricultural College in 1987.

Since the land was purchased by BHP Billiton, the stud has continued to produce high quality thoroughbred race horses. Edinglassie's Group One race winners include Bentley Biscuit, Wonderful World, Gods Own, Nadeem, Tell a Tale, Sharscay, Miss Margaret, Suntain, Emerald dream and Lasserfaire. Approximately 50 foals were born at Edinglassie stud in 2011.

Although the hilly country of the Mt Arthur Coal mine site is only suitable for limited to low intensity agriculture, the bordering alluvial lands of the Hunter River, on which Edinglassie is situated, provide fertile irrigated pastures with undulating hills for young stock and lucerne pastures for mares and foals.

Relationship with Mt Arthur Coal

Edinglassie is located approximately 500 metres from the boundary of Mt Arthur Coal and is separated from the mine by Denman Road. The property was purchased by BHP Billiton as it was considered to be within an area which would be impacted by the mine.

Despite the close proximity of the two properties, Edinglassie's lower elevation means that the Mt Arthur Coal mine is not visible from the horse stud.

Mt Arthur Coal also monitors its potential impacts on the Edinglassie stud and homestead, which include vibration from blasting, dust and noise, using a range of monitors located at the property..

A thoroughbred mare and foal, with a blast monitor in the foreground, outside the Edinglassie historic homestead

According to lessee Mick Talty, Edinglassie continues to produce winning race horses despite its proximity to nearby mines.

"Edinglassie stud has a good reputation in the local industry for breeding good race horses and selling quality foals.

"Both industries have been around a long time and the fact that we are continuing to provide the local industry with quality horses shows that mining and thoroughbred farmers have worked side by side.

"There have been a number of benefits of Edinglassie being owned by a mine. These include upgrades to facilities and ongoing maintenance to ensure the property is kept to a high standard and retains its aesthetic value," he said.

Mt Arthur Coal Environmental Advisor Rebecca Smith monitoring the depositional dust gauge at Edinglassie homestead

Due to its European historical significance, Edinglassie is one of three properties owned by Mt Arthur Coal that are intended to protect areas of cultural heritage. As such, the Edinglassie stables and homestead are kept in accordance with their heritage value.

Since BHP Billiton has owned the property, a number of restorations have been undertaken with the supervision of qualified engineers and builders. These include improvements to the homestead, butcher's hut and the stables, post and rail fencing, waste water management and drainage improvements, lawn and garden maintenance and tree trimming to ensure Edinglassie is maintained to a high standard.

Edinglassie (shaded orange) and neighbouring Bengalla and Mt Arthur Coal mines

New South Wales Minerals Council Ltd

CASE STUDY

APRIL 2012

Mining – Land Management – BHP Billiton Mt Arthur Coal's Ogilvie View

Mining companies frequently own land that is not part of the mine's operation. Ensuring that this land continues to be commercially productive makes good business sense. It also allows the properties to be maintained in a way that is sustainable and continues to contribute to the region's economy and diversity, both now and in the future.

History of Ogilvie View

Ogilvie View, the former Roxburgh Estate, is a 485-hectare property located 12 kilometres southwest of Muswellbrook in the Hunter Valley. BHP Billiton Mt Arthur Coal purchased the property from Fosters in 2009.

Mt Arthur Coal's open cut mine is situated 5 kilometres south of Muswellbrook and employs around 1,900 people. Ogilvie View is located 2 kilometres west of Mt Arthur Coal, and was purchased by BHP Billiton as a buffer zone for the mine's operation.

Ogilvie View today

Since the property was purchased, decisions about the most productive use of the land have been made in accordance with the demands of the local market.

While the breakup of the Rosemount Estate saw many properties change land use – including the incorporation of Giants Creek and Denman vineyards into the Patinack Thoroughbred Farm – Ogilvie View continues to operate as a vineyard with 40 hectares under vines.

The property is managed by an experienced vineyard manager, who is responsible for the day-to-day running of the vineyard, including maintaining the vines. In addition, an experienced viticulturist supports the day-to-day management of the vineyard, including providing technical support.

Ogilvie View is predominately planted to Chardonnay, with small areas of Semillon and Verdelho.

Ogilvie View with Mt Arthur Coal in the background

The main focus of the vineyard is to produce fruit for sale to other winemakers. The fruit is primarily sold by BHP Billiton to Hunter Valley wineries or corporate wine makers who often sell their wine interstate.

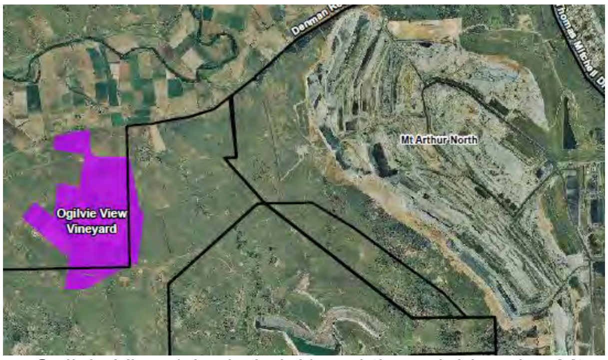
Like many vineyards throughout Australia, Ogilvie View has been impacted by the global oversupply of wine. After taking advice from consultants, vines that were less productive or had lower-demand fruit were removed from the property, creating a more manageable and cost effective vineyard.

Those areas have been recultivated and are now used for cattle grazing and intensive dry land cropping. This action was supported by other growers in the area, as it reduced local competition at a time when prices for fruit were low.

Ogilvie View has commercially positioned itself apart from other fruit producers in the area. Some of the Chardonnay fruit is produced from the vineyard's 40-year-old historic vines that are scarce and high in value. However, in response to the oversupply of Chardonnay and to meet growing market demand for diversity, Ogilvie View has replaced some of its less valuable Chardonnay holding with new fruit varieties, such as Vermentino.

Ogilvie View also has plantings of two French Chardonnay Bernard clones, the first in the Hunter Valley.

The fruit from these clones have a different flavour spectrum and they also ripen faster, which makes them less vulnerable to harsh weather conditions.



Ogilvie View (shaded pink) and the neighbouring Mt Arthur Coal mine

The viticulturist engaged to manage the property, Liz Riley, said the planting of these clones at Ogilvie View is an important educational resource for the local wine industry.

"The progress of these clones will provide benchmark information for other vineyards in the region looking to change their commercial strategy by demonstrating the viability of using different clones to produce new fruit variations and flavours.

"Due to oversupply, there is a competitive market for fruit growers in the area. However, Ogilvie View provides an alternative resource for fruit for the local industry, and provides diverse varieties, such as Vermentino.

"The vineyard's operation supports local agricultural suppliers and helps retain employment in the industry," she said.

Since its purchase, Mt Arthur Coal has made significant improvements to the property, including removing less productive vines, undertaking regular maintenance and implementing a soil and fertiliser program. A three-year program has also been implemented to further enhance the property's quality and productivity.

"The work undertaken by Mt Arthur Coal at Ogilvie View to maintain the social fabric of the land suggests the company understands the impacts their operations have on the community," Ms Riley said.

CASE STUDY

NEW SOUTH WALES MINERALS COUNCIL LTD

JUNE 2012

Mining and cattle farming in the Hunter Valley – Edderton and Mt Arthur Coal

Mining companies often own land that is not used for mining, but instead continues to support other local industries in the area. In the case of Edderton, a property owned by Mt Arthur Coal in the NSW Hunter Valley, the land is currently used to produce Angus and Wagyu beef.

The history of Edderton

Edderton, a large 3,000 acre property located just south of Muswellbrook, has been owned by BHP Billiton Mt Arthur Coal since 1992.

Constructed in 1908, the Edderton homestead features a unique design inspired by a range of different architectural styles. The homestead, which boasts regional heritage significance related to its historical association with the expansion of the wool industry in the Upper Hunter, is now a NSW heritage listed property.

Edderton was purchased by Hector Cameron McDonald in 1914. Over a five year period, the McDonald family purchased and consolidated land in the Saddlers Creek area, creating a single, 12,000 acre pastoral holding.

The McDonalds ran up to 16,000 sheep on the property, later replacing most of them with cattle. As larger estates became less viable in the late 1950s, Edderton was subdivided into smaller holdings, many becoming dairy farms.

Edderton today

The current lessees, Trevor and Narelle Petith, have operated the property as an Angus and Wagyu beef enterprise since October 2005 as part of their business HV Wagyu.

The property's 1,450 hectares of mostly native grasses provide an ideal pastoral environment for the Petith's herd of 400 Angus cattle and 30 full-blood Wagyu cows that are used to breed Wagyu bulls.

The Petiths run Edderton in conjunction with their operations at Whites Creek – a property located approximately 12 kilometres away – which is also owned by Mt Arthur Coal.

Edderton is utilised for the first and second stages of beef production, from birth and weaning to approximately eight months old. The cattle are then sent to Whites Creek for approximately 100 days for fattening prior to being sold direct to feedlot buyers in NSW and Queensland. Some cattle are also sold through the local sale yards.

Edderton, located 2 kilometres from Mt Arthur Coal, is operated as an Angus and Wagyu Beef business

Relationship with Mt Arthur Coal

Edderton is located just 2 kilometres from the Mt Arthur Coal mine. Despite the mine's close proximity, Trevor Petith does not believe it is impacting the family's business, and highlights the opportunities provided by leasing the property from Mt Arthur Coal.

"We used to run a farm in the Hastings Valley in Northern NSW, but didn't have as much land as we do now at Edderton," Mr Petith said.

"Mining is an important industry in this region and we knew that we would be operating our farm and business side by side with a mine.

“We wouldn’t be farming here if it weren’t for Mt Arthur Coal and the work they have done to maintain and restore this property.

“Mt Arthur Coal also has requirements for how we manage the land, including ensuring that we do not over graze to prevent soil erosion,” he said.

The Petiths occupy the property’s homestead as part of Mt Arthur Coal’s strategy to preserve its condition, ensure its security and maintain its value as a heritage structure. They are responsible for the ongoing maintenance of the property, including weed and pest control, and undertake their own improvement projects as necessary.

Each year, the lessees also submit a works’ program to Mt Arthur Coal for further improvements at Edderton which are funded by Mt Arthur Coal.

A number of significant improvements have been made to the property by Mt Arthur Coal, including building a new dam and repairing two existing dams on the property, the main source of water for Edderton farm apart from Saddlers Creek.

Mt Arthur Coal has also rebuilt the property’s heritage meat house, re-painted the homestead and established 3.5 kilometres of perimeter fencing for additional security.

Monitoring equipment has been installed at Edderton by Mt Arthur Coal to measure any impact of dust, vibration and overpressure from mining activities on this important cultural heritage site.

Edderton (shaded blue), White’s Creek (shaded yellow) and the neighbouring Mt Arthur Coal mine

ATTACHMENT C

ECONOMIC REVIEW OF POTENTIAL AGRICULTURAL IMPACTS

MT ARTHUR COAL MINE

OPEN CUT MODIFICATION

ECONOMIC REVIEW OF POTENTIAL AGRICULTURAL IMPACTS

PREPARED BY
GILLESPIE ECONOMICS

October 2012

TABLE OF CONTENTS

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1 INTRODUCTION

Hunter Valley Energy Coal (HVEC), a wholly-owned subsidiary of BHP Billiton, owns and operates the Mt Arthur Coal Mine located south-west of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW).

HVEC seeks to modify the current Project Approval (09_0062) for extension of open cut coal mining at the Mt Arthur Coal Mine for a period of four years at the currently approved rate of 32 million tonnes per annum run-of-mine coal (the Modification).

GSS Environmental (GSSE) (2012a,b) undertook an assessment of the physical and farm budget impacts of the Modification from the use of agricultural land and water resources as shown in Attachment 1. This report utilises the information provided by GSSE to assess these impacts in terms of economic efficiency and regional economic impacts. Section 2 provides some context on agricultural and mining activities in NSW. Section 3 examines agricultural and mining industries in the Upper Hunter region. The economic efficiency and regional economic impact assessment frameworks for consideration of the economic impacts of projects, that impact land and water resources, are identified in Section 4. Section 5 examines the economic efficiency and regional economic impacts of the Modification's use of land and water resources.

2 AGRICULTURAL AND MINING INDUSTRIES IN NEW SOUTH WALES

2.1 Land Use

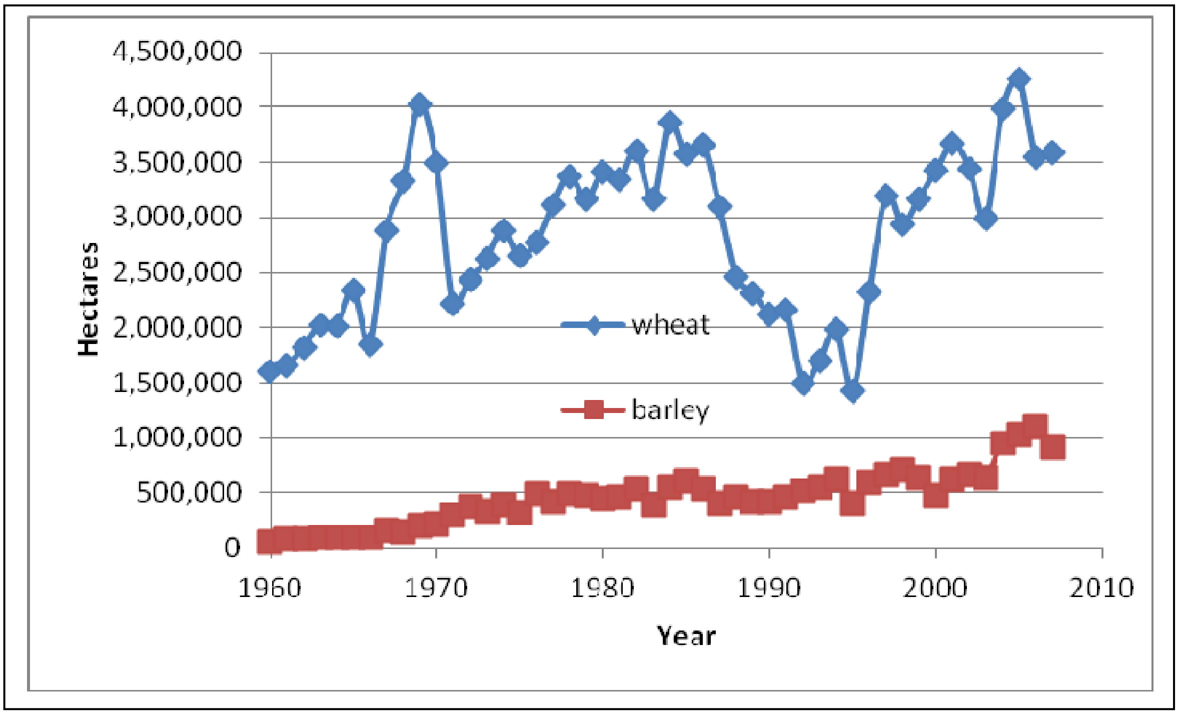
Agricultural lands are important to NSW and cover approximately 81 percent (%) of NSW (i.e. 65 million [M] hectares [ha]) (Australian Natural Resources Atlas [ANRA], 2009a). While the total agricultural land area in NSW has declined marginally since 1960 (Table 2.1), the area of land under major food crop production (i.e. wheat and barley[1]) has actually increased (Figure 2.1).

Table 2.1
NSW Agricultural Land Area

Area of Agricultural Land (M ha)	1960	1980	1997
	69.95	65.01	60.90

Source: ANRA (2009b).

Figure 2.1 - NSW Land Area Allocated to Wheat and Barley



Source: Australian Bureau of Statistics (ABS) (2009).

The NSW agricultural industry directly provides employment for 76,261 people or 2.7% of total employment in NSW (ABS, 2006)[2]. Payment to agriculture, forestry and fishing employees in 20010-11 was Australian dollars (AUD)[3] $1,539M and value-added was $7,062M. Gross operating surplus and gross mixed income from agriculture, forestry and fishing was $6,908M (ABS, 2011a).

1 Wheat and barley are the two largest food crops produced in Australia
2 This is based on the ABS sector of Agriculture, forestry and fishing.
3 For the duration of this report all $ are AUD unless otherwise specified.

Mining land use is a small fraction of the area of NSW (i.e. less than 0.1% of the total NSW land area) (Bureau of Rural Science, 2009) and directly employs 19,026 or 0.7% of total employment in NSW (ABS, 2006). Payment to mining employees in 2010-11 was $2,466M and value-added was $10,633M. Gross operating surplus and gross mixed income from mining was $10,035M (ABS, 2011a).

In this comparison, mining is a more significant sector than agriculture in terms of payments to employees, value-added and gross operating surplus and gross mixed income. However, agriculture does employ more people, albeit while using a much larger area of NSW to achieve this employment.

Nevertheless, no policy implication should be drawn from the relative magnitudes of existing sectors. What is relevant in a policy context is whether moving from one land use to another is more economically efficient or not. That is, do the benefits to the community from changing land uses exceed the costs to the community. This is discussed in more detail in Section 4.

2.2 Economic Growth in Regional Areas

Agricultural lands have historically supported the economies of regional areas. However, regional economies are facing a number of trends including:

- loss of significant industries such as abattoirs and timber mills from many rural areas;
- increased mechanisation of agriculture and aggregation of properties, resulting in loss of employment opportunities in this industry;
- preference of Australians for coastal living, particularly for retirement; and
- preference of many of today's fastest growing industries for locating in large cities (Collits, 2001).

The result is that there has been declining populations in 47 out of 96 rural statistical local areas that are located in non-coastal statistical subdivisions in NSW (excluding Hunter Statistical Division) (ABS, 2011). There has also been a decline in the population of smaller towns even in regions that have been growing.

Trends in agriculture are leading to improved productivity, but reduced economic stimulus in regional areas, as demand for inputs such as labour decline. In general, the prosperity of rural areas that are reliant on agriculture has also been in decline.

It is increased or new spending in regions that contributes to additional economic stimulus and growth. One potential source of new spending is mining projects that utilise the resource endowments of a region. Studies (Gillespie Economics, 2003, 2007) have shown that mining projects provide significant new economic activity to regional and rural economies through direct expenditures on inputs to production as well as the expenditure of employees. This latter stimulus is enhanced by the high wages paid in the mining sector.

Mining projects can also broaden the economic base of regions, thereby insulating the economy from external shocks such as droughts and downturns in agricultural commodity prices (Collits, 2001).

2.3 Prime Agricultural Land and Other Land Uses

In NSW, dryland and irrigated cropping land covers an area of 84,878 square kilometers (km^2). Mining (and waste disposal) covers an area of 630 km^2, 0.74% of the area of cropping lands (Table 2.2).

Table 2.2
NSW Land Uses

Land use	Area (km^2)	Area (%)
Nature conservation	61,058	7.6%
Other protected areas	2,478	0.3%
Minimal use	59,178	7.4%
Grazing native vegetation	309,428	38.6%
Production forestry	25,242	3.2%
Plantation forestry	4,200	0.5%
Grazing modified pastures	222,164	27.7%
Dryland cropping	74,692	9.3%
Dryland horticulture	390	0.0%
Irrigated pastures	3,160	0.4%
Irrigated cropping	10,186	1.3%
Irrigated horticulture	1,073	0.1%
Land in transition	951	0.1%
Intensive animal and plant production	243	0.0%
Intensive uses (mainly urban)	10,218	1.3%
Rural residential	4,387	0.5%
Mining and waste	630	0.1%
Water	11,352	1.4%
Total	**801,030**	**100.0%**

Source: Bureau of Rural Science (2009).

Note: Figures in the table may have discrepancies due to rounding.

The threat to cropping land from mining would therefore appear to be minimal at a macro level. Nevertheless, the desirability of proposals that impact this land should be addressed at a micro level through a consideration of costs and benefits, including the costs to society of impacting high value, agricultural land.

3 AGRICULTURAL AND MINING INDUSTRIES IN THE UPPER HUNTER REGION

3.1 Agriculture

The Upper Hunter region (i.e. the Singleton, Muswellbrook and Upper Hunter Shire local government areas [LGAs]) has a combined land area of 1.6M ha, of which 56% is agricultural land (Table 3.1). Of this agricultural land, 2.8% is irrigated with annual irrigation volumes of approximately 89,513 megalitres (ML) (Table 3.1). The total value of agricultural production in this region in 2006 is estimated at $143M (Table 3.1).

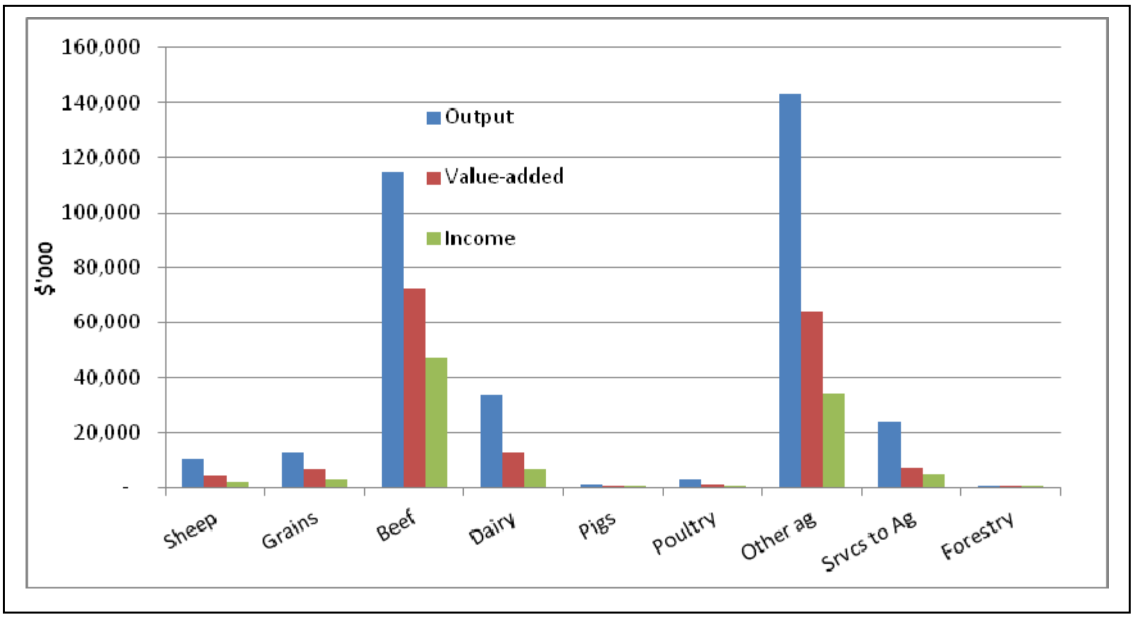
Table 3.1
Agricultural Land Use and Value of Production in Upper Hunter Region 2006

	Units	Singleton LGA	Muswellbrook LGA	Upper Hunter Shire LGA	Total
Area					
Land Area	ha '000	490	341	810	1,640
Area of Agricultural Land	ha '000	156	122	647	925
Irrigation					
Area Irrigated	ha '000	7	9	10	26
Irrigation Volume Applied	ML	27,394	30,894	31,225	89,513
Other Agricultural Uses	ML	2,015	1,728	4,792	8,535
Total Water Use	ML	29,409	32,621	36,017	98,047
Area Irrigated as Proportion of Agricultural Land	%	4.5	7.4	1.5	2.8
Value					
Gross Value of Crops	$M	8.2	9.6	8.5	26.3
Gross Value of Livestock Slaughterings	$M	17.4	11.3	49.6	78.3
Gross Value of Livestock Products	$M	11.5	13.1	13.5	38.1
Total Gross Value of Agricultural Production	**$M**	**37.1**	**34.0**	**71.6**	**142.7**

Source: ABS (2011b, 2011c, 2011d).
Note: Totals may have minor discrepancies due to rounding.

The input-output table developed for the Upper Hunter region (Gillespie Economics, 2012) provides an indication of the direct relative significance of the different agricultural sectors, affirming beef cattle and other agriculture (which includes grape growing and horse breeding) as the main agricultural sectors (Figure 3.1).

Figure 3.1
Agricultural Sectors in Upper Hunter Region



Source: Gillespie Economics (2012).

Total employment in the agricultural industry in the Upper Hunter region in 2006 was 2,288 (ABS, 2011e). Table 3.2 provides a more detailed employment by industry breakdown which indicates that the main agricultural employment is in beef cattle farming, horse breeding, dairy cattle farming and grape growing.

Table 3.2
Employment by Agricultural Sectors in the Upper Hunter Region

Sector	No.
0100 Agriculture, not further defined (nfd)	57
0112 Nursery Production (Outdoors)	4
0113 Turf Growing	3
0115 Floriculture Production (Outdoors)	3
0121 Mushroom Growing	37
0123 Vegetable Growing (Outdoors)	22
0130 Fruit and Tree Nut Growing, nfd	6
0131 Grape Growing	122
0136 Citrus Fruit Growing	4
0137 Olive Growing	8
0139 Other Fruit and Tree Nut Growing	3
0141 Sheep Farming (Specialised)	38
0142 Beef Cattle Farming (Specialised)	791
0143 Beef Cattle Feedlots (Specialised)	3
0144 Sheep-Beef Cattle Farming	154
0145 Grain-Sheep or Grain-Beef Cattle Farming	51
0149 Other Grain Growing	25
0159 Other Crop Growing, not elsewhere classified (nec)	40
0160 Dairy Cattle Farming	217
0170 Poultry Farming, nfd	4
0171 Poultry Farming (Meat)	4
0172 Poultry Farming (Eggs)	4
0191 Horse Farming	580
0192 Pig Farming	4
0199 Other Livestock Farming, nec	3
0301 Forestry	3
0420 Hunting and Trapping	3
0520 Agriculture and Fishing Support Services, nfd	7
0522 Shearing Services	8
0529 Other Agriculture and Fishing Support Services	67
A000 Agriculture, Forestry and Fishing, nfd	13
Total	**2,288**

Source: ABS (2011e)

3.2 Coal Mining

NSW Department of Primary Industries (DPI) (2011) identifies 18 coal mines in the Hunter Coalfield producing 81.77 million tonnes (Mt) of saleable coal in 2008/09. Conservatively assuming all of this production is steaming coal with a value of AUD$100 per tonne, this level of saleable coal production is estimated to have a value of around $8 billion (Table 3.3) which is significantly greater than the value of all agricultural production in the Upper Hunter region (reported as $143M in Table 3.1). Direct employment in mining in the Hunter Coalfield as reported by DPI (2011) is 9,191 which is also significantly greater than total employment in the agricultural sectors in the Upper Hunter region in 2006 which was 2,288 (Table 3.2).

Table 3.3
Coal Mining Production, Gross Value and Direct Employment in the Hunter Coalfield

Coal Mining	**Units**	**Total**
Coal Saleable Production (2008/2009)	Mt	80.44
Gross Value of Coal Production (2008/2009)	$M	8,044*
Direct Mining Employment (2009)	No.	9,191

Source: DPI (2011).
*Conservatively assuming only steaming coal production and a value of AUD$100/tonne.

4 ECONOMIC FRAMEWORKS FOR THE ASSESSMENT OF PROPOSALS THAT IMPACT AGRICULTURAL LAND AND WATER

4.1 Economic Efficiency

From an economic perspective, it is desirable to use scarce resources, such as capital, labour, land and water, to maximise economic welfare or community fulfilment. This is referred to as economic efficiency and refers to a situation where production costs are as low as possible (technical or productive efficiency), and consumers want the combination of goods and services that is being produced (allocative efficiency).

Economic efficiency can be achieved for market goods, where there are no externalities, through competitive markets. In this situation, the price mechanism (interaction of supply and demand) functions to allocate resources in a manner that maximises the net benefits to society as a whole.

Agricultural land and water (where property rights have been established) are market goods. The market will allocate these resources to their most productive use for society. The exception is where a change in land use or water use may result in market failure through the occurence of externalities. In these circumstances, markets will not allocate resources to maximise economic welfare. Government intervention may therefore be required to determine how resources should be allocated.

In these situations, any Government intervention should be guided by a consideration of the costs and benefits of the intervention. The method that economists use to do this is benefit cost analysis (BCA). The essence of BCA is:

- the estimation of the extent to which a community is made better off by a resource reallocation;
- the estimation of the extent to which the community is made worse off by a resource reallocation; and
- a comparison of these two figures.

If the benefits of the intervention are greater than the costs of the intervention then it provides net benefits to the community and results in an improvement in economic efficiency.

In a simple BCA framework, the potential costs and benefits of a mining project that impacts agricultural land and water may be as shown in Table 4.1.

Table 4.1
Potential Costs and Benefits of a Mining Proposal that Impacts Agricultural Land

	Costs	Benefits
Net Production Benefits	**Production**	
	Opportunity costs of land, water and capital equipment	Value of mineral resource
	Development and operating costs (including impact mitigation and rehabilitation)	Residual value of land and capital
Net Externalities	**Externalities**	
	Residual environmental impacts after impact mitigation	Non-use employment benefits of mining *

* These benefits have been estimated using choice modelling in Gillespie Economics (2008), Gillespie Economics (2009a) and Gillespie Economics (2009b).

Where the proposal uses agricultural land and water there is an opportunity cost to society of using these resources for mining instead of agriculture. The magnitude of this opportunity cost is reflected in the market value of land and water.

The market value of the land reflects, among other things, the discounted future net income that can be earned from the property while income reflects how much the community values the outputs from the land. Where agriculture production becomes increasingly scarce, this will be reflected in the value of agricultural products and the value of agricultural land. However, the long term trend for agricultural commodity prices has been a decline in real value rather than an increase in value, reflecting that with growth in productivity, supply has strengthened more rapidly than demand (Australian Bureau of Agricultural and Resource Economics and Sciences [ABARES], 2011). Between 1961 and 2008, world population grew by 117% while food production grew by 179 per cent (ABARES, 2011). While commodity price increases have risen over the last few years this is partly a response to government subsidies and mandates regarding the production of biofuels (ABARES, 2011). In the future, growth in global food consumption is expected to slow. Strong productivity growth and the utilisation of hitherto unused cropping should ensure the continuing adequacy of food supplies (ABARES, 2011). Consequently, substantial real increases in food prices are not anticipated.

Similiarly, the market value of agricultural water entitlements reflects, among other things, its value as an input to production (i.e. its marginal value product). Where water becomes increasingly scarce or the value of output that is produced from water becomes increasingly valuable, the value of water as an input to production increases.

The utlimate outcome of any BCA of a project is an empirical issue. But estimating the value of the opportunity cost of agricultural land and water is an integral component of the analysis.

4.2 Regional Economic Impact Assessment

Regional economic impact assessment (using input-output analysis) may provide additional information as an adjunct to economic efficiency analysis. Input-output analysis can be used to estimate the change in economic activity in a region from land and water resources being used for mining instead of agriculture. These changes in economic activity are defined in terms of a number of specific indicators of economic activity, such as:

- Gross regional output – the gross value of business turnover.
- Value-added – the difference between the gross value of business turnover and the costs of the inputs of raw materials, components and services bought in to produce the gross regional output.
- Household income – the wages paid to employees including imputed wages for self employed and business owners.
- Employment – the number of people employed (including full-time and part-time).

It is important not to confuse the results of regional economic impact assessment, which focuses on indicators of economic activity in a specific region, with the results of BCA which is concerned with the net benefits to Australia from a project.

5 MODIFICATION IMPACTS ON AGRICULTURAL RESOURCES

5.1 Opportunity Cost of Agriculture and Water Resources

5.1.1 Land Resources

The Modification will potentially impact agricultural land resources through the mine disturbance footprint and the provision of ecological offsets in the region.

Mine Disturbance Footprint

GSSE (2012a) identifies the following Agricultural Suitability Classes and potential agricultural production from the incremental mine disturbance footprint of the Modification (i.e. 229 ha) (Table 5.1). While information on beef grazing on Agricultural Suitability Class 1 and 3 land was also provided by GSSE (2012a), dryland lucerne hay production provides a higher value use of the land and has been used in this analysis.

Table 5.1
Potential Agricultural Activity on the Modification Disturbance Footprint

Agricultural Suitability Class	Area (ha)	Agricultural Enterprise	Total Revenue ($)	Total Variable Cost ($)	Total Gross Margin ($)
1	26.7	Lucerne	38,448	24,746	13,702
3	131	Lucerne	150,912	102,248	48,664
4	62.1	Beef	8,369	1,592	6,777
5	8.9	Beef	600	114	486
Total	**228.7**		**198,328**	**128,700**	**69,628**

Note: Figures in table may have discrepancies due to rounding.

With the Modification, potential agricultural use of the subject land would cease for four years (2022 to 2026). The land would then be rehabilitated and would be capable of supporting the agricultural production identified in Table 5.2. There is some reduction in the potential agricultural production from the subject land due to a change in the areas within each Agricultural Land Capability Class.

Table 5.2
Potential Agricultural Activity on the Modification Rehabilitation

Agricultural Suitability Class	Area (ha)	Agricultural Enterprise	Total Revenue ($)	Total Variable Cost ($)	Total Gross Margin ($)
1	26.7	Lucerne	38,448	24,746	13,702
3	100.3	Lucerne	115,546	78,286	37,259
4	53	Beef	7,142	1,358	5,784
5	48.7	Beef	3,281	624	2,657
Total	**228.7**		**164,417**	**105,015**	**59,402**

Note: Figures in table may have discrepancies due to rounding.

The net impact of a loss of agricultural production (gross margin) for four years and a reduced level of agricultural production in perpetuity, post mining, is estimated at $0.2M present value (at 7% discount rate).

Biodiversity Offset Area

GSSE (2012b) identify the following potential agricultural activities from the proposed offset property (Table 5.3).

Table 5.3
Potential Agricultural Activity on the Proposed Offset Property

Land Capability Class	Area (ha)	Agricultural Enterprise	Total Revenue ($)	Total Variable Cost ($)	Total Gross Margin ($)
V	276.9	Beef	94,844	35,859	58,985
VI	128.5	Beef	26,697	5,078	21,619
VII	5.9	Beef	828	158	671
Total	**411.3**		**122,369**	**41,094**	**81,275**

Note: Figures in table may have discrepancies due to rounding.

With the Modification, potential agricultural use of subject land would cease in perpetuity from the commencement of the Modification. The impact of a loss of agricultural production (gross margin) in perpetuity from the offset land is estimated at $0.5M present value (at 7% discount rate).

Total Land Resources

In total, foregone net agricultural production (gross margin) from agricultural land resources required for the Modification is estimated at $0.7M present value (using a 7% discount rate).

5.1.2 Water Resources

The Modification will carry forward 6,935ML in water licences for four years that could otherwise have been released for agricultural use. GSSE (2012b) identifies that this water could otherwise be used to grow 693.5 ha of irrigated lucerne. The maximum potential gross margin from lucerne hay production over this area of land is estimated at $924,089 per annum. The alternative of dryland lucerne production over this area of land is estimated to have a gross margin of $257,621 per annum.

The net impact of a loss of agricultural production for four years during the Modification life is estimated at $1.1M present value (at 7% discount rate).

5.2 Regional Impacts

The regional impacts of the level of annual agricultural production forgone as a result of the Modification were estimated from the sectors in the regional input-output table (Gillespie Economics, 2012) within which production is located i.e. the *beef sector* and the *other agriculture sector.* Table 5.4, Table 5.5 and Table 5.6 summarise the estimated direct and indirect regional impacts of the Modification on annual agricultural production.

Table 5.4
Regional Economic Impacts of Agricultural Land Required for the Modification Disturbance Footprint

	Direct Effect	Production Induced	Consumption Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	198	46	30	76	274
Type 11A Ratio	1.00	0.23	0.15	0.38	1.38
VALUE ADDED ($'000)	90	18	14	32	123
Type 11A Ratio	1.00	0.20	0.16	0.36	1.36
INCOME ($'000)	49	13	12	25	74
Type 11A Ratio	1.00	0.27	0.24	0.51	1.51
EMPLOYMENT (No.)	1	0	0	0	1
Type 11A Ratio	1.00	0.17	0.16	0.34	1.34

Note: Figures in table may have discrepancies due to rounding.

Table 5.5
Regional Economic Impacts of Agricultural Land Required for the Biodiversity Offsets

	Direct Effect	Production Induced	Consumption Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	122	21	27	48	170
Type 11A Ratio	1.00	0.17	0.22	0.39	1.39
VALUE ADDED ($'000)	77	9	13	21	98
Type 11A Ratio	1.00	0.11	0.17	0.28	1.28
INCOME ($'000)	50	6	11	17	67
Type 11A Ratio	1.00	0.12	0.21	0.33	1.33
EMPLOYMENT (No.)	1	0	0	0	1
Type 11A Ratio	1.00	0.10	0.18	0.28	1.28

Note: Figures in table may have discrepancies due to rounding.

Table 5.6
Net Regional Economic Impacts of Water Resources

	Direct Effect	Production Induced	Consumption Induced	Total Flow-on	TOTAL EFFECT
OUTPUT ($'000)	651	152	97	249	900
Type 11A Ratio	1.00	0.23	0.15	0.38	1.38
VALUE ADDED ($'000)	291	61	45	106	397
Type 11A Ratio	1.00	0.21	0.16	0.36	1.36
INCOME ($'000)	157	44	37	82	239
Type 11A Ratio	1.00	0.28	0.24	0.52	1.52
EMPLOYMENT (No.)	3	1	1	1	5
Type 11A Ratio	1.00	0.18	0.16	0.34	1.34

Note: Figures in table may have discrepancies due to rounding.

Table 5.7 provides a summary of the annual regional economic impacts that would be arise from the Modification's use of agricultural land and water resources (Section 5.1).

Table 5.7
Annual Regional Economic Impacts of the Foregone Agriculture

	Agriculture Land Disturbed by Modification	Agricultural Land Biodiversity Offsets	Water Resources	Total
Production Type	Lucerne and Beef	Beef	Lucerne	
Direct Output Value ($000)	198	122	651	971
Direct Value Added ($000)	90	77	291	459
Direct Income ($000)	49	50	157	256
Direct Employment (No.)	1	1	3	5
Direct and Indirect Output Value ($000)	274	170	900	1,345
Direct and Indirect Value Added ($000)	123	98	397	618
Direct and Indirect Income ($000)	74	67	239	380
Direct and Indirect Employment (No.)	1	1	5	7

Note: Figures in table may have discrepancies due to rounding.

The annual agricultural direct output from the agricultural resources that would potentially be impacted by the Modification is estimated to be $1M (Table 5.7).

The Modification is estimated to provide considerable stimulus to the regional economy that is far in excess of the regional economic impacts associated with the maximum level of annual agricultural production that would be forgone as a result of the Modification (refer to main Socio-Economic Assessment report [Gillespie Economics, 2012]).

5.3 Economic Efficiency of Reallocation of Agricultural Resources to the Modification

The BCA completed for the Modification included estimation of the present value of production costs and benefits of the Modification. The present value of the net production benefit of the Modification has been estimated and is detailed in the main Socio-Economic Assessment report (Gillespie Economics, 2012).

This value can be compared to the present value of net production benefits from future use of agricultural lands that would be utilised by the Modification which is estimated at $1.8 M (Table 5.8).

Table 5.8
Net Production Benefits of Agricultural Resources Potentially Affected by the Modification

	Agricultural Production
Annual Net Production Benefits	$0.8 M
Net Production Benefits[1]	$1.8 M

Source: Gillespie Economics (2012).
[1] Discounting is at 7%.

The Modification is estimated to provide a considerable net production benefit that is far in excess of the net production benefit of continued use of land and water resources for agriculture.

6 CONCLUSION

In the Upper Hunter region:

- The regional output value of existing coal production is considerably greater than agricultural production.
- The annual output value of the Modification would be greater than the output value of agriculture production in the Upper Hunter region in 2006.
- Direct employment provided by the Modification would be significantly higher than that provided by continued agricultural use of the land/water resources required for the Modification.
- The net production benefits of the Modification would be significantly higher than the continued agricultural production and use of water in the Modification area.
- Incorporating the opportunity costs of land and water resources and the value of environmental, cultural and social impacts, the Modification is estimated to have net benefits to Australia.

The Modification is considered on this basis to be more economically efficient than the agricultural production that would be displaced.

7 REFERENCES

Australian Bureau of Agricultural and Resource Economics and Sciences (2011) *Global Food Security: facts, issues and implications*, Science and Economic Insights, Issue 1.

Australian Bureau of Statistics (2006) *Census of Population and Housing.*
Website: http://www.censusdata.abs.gov.au/

Australian Bureau of Statistics (2009) *Historical Selected Agriculture Commodities, by State (1861 to Present), 7124.0.*

Australian Bureau of Statistics (2011) *Regional Population Growth, Australia, 3218.0*.

Australian Bureau of Statistics (2011a) *Australian National Accounts: State Accounts*, 2010-11, Website: http://www.abs.gov.au/AusStats/ABS@.nsf/MF/5220.0

Australian Bureau of Statistics (2011b) *National regional Profile: Singleton (A) Local Government Area*.

Australian Bureau of Statistics (2011c) *National Regional Profile: Muswellbrook (A) Local Government Area.*

Australian Bureau of Statistics (2011d) *National Regional Profile: Upper Hunter Shire (A) Local Government Area*.

Australian Bureau of Statistics (2011e) *Census of Population and Housing, Customised Data Report, Place of Usual Residence by Industry, Upper Hunter SSD, Place of Work: Upper Hunter SSD, Place of Usual Residence: Upper Hunter SSD, Outside Upper Hunter SSD, No Usual Address, Industry of Employment: ANZSIC 2006 4 digit (Count of Employed Persons).*

Australian Natural Resources Atlas (2009a) *Landuse in New South Wales*:
Website: http://www.anra.gov.au/topics/land/landuse/nsw/index.html

Australian Natural Resources Atlas (2009b) *Landuse Change, Productivity & Development – Historical and Geographical Context*.
Website: http://www. anra.gov.au/topics/land/pubs/landuse-historical.html

Bureau of Rural Science (2009) *Land Use Summary: NSW State Report*.
Website: http://adl.brs.gov.au/landuse/docs/1_State_NSW.pdf

Collits, P. (2001) *Small Town Decline and Survival: Trends, Success Factors and Policy Issues*. Website: http://www.regional.org.au/au/countrytowns/global/collits.htm

Gillespie Economics (2003) *Wambo Development Project Economic Assessment*. In *Wambo Project Environmental Impact Statement*.

Gillespie Economics (2007) *Cadia Valley Operations Economic and Social Impact Review*. Prepared for Cadia Holdings Pty Ltd.

Gillespie Economics (2008) *Managing the Impacts of a Mine in the Southern Coalfield; A Survey of Community Attitudes*. Prepared for Helensburgh Coal Pty Ltd.

Gillespie Economics (2009a) *Bulli Seam Operations Socio-Economic Assessment*. Prepared for Illawarra Coal Holding Pty Ltd.

Gillespie Economics (2009b) *Proposed Warkworth Extension Benefit Cost Analysis*. Prepared for Warkworth Mining Limited.

Gillespie Economics (2012) *Mount Arthur Coal Mine Open-Cut Modification Socio-Economic Assessment*, prepared for Resource Strategies Pty Ltd.

GSS Environmental (2012a) *Farm Budget Calculations*.

GGS Environmental (2012b) *Farm Budget Calculations (Middle Deep Creek Offset)*.

New South Wales Department of Primary Industries (2011) *NSW Coal Industry Profile*.

ATTACHMENT 1

FARM BUDGET CALCULATIONS

Our Ref: MAC01-29_Farm_Budgets_Draft_120914_V2

14th September, 2012

Sarah Bailey
Manager Approvals
Mt Arthur Coal
NSW Energy Coal
BHP Billiton
Thomas Mitchell Drive, Muswellbrook, 2333, NSW, Australia

Sent via: Email Transmission

Dear Sarah,

RE: FARM BUDGET CALCULATIONS

BACKGROUND

GSS Environmental (GSSE) was engaged by Hunter Valley Energy Coal Pty Limited (HVEC), a wholly owned subsidiary of BHP Billiton, to undertake farm budget calculations on each Agricultural Suitability Land Class for the proposed Mt Arthur Coal Open Cut Modification (the Project). This work is in addition to the original Soil and Land Resources Assessment conducted by GSSE.

The Mt Arthur Coal Mine is located approximately 5 kilometres (km) south-west of the town of Muswellbrook, New South Wales (NSW). The disturbance areas of the Project include the following:

- Open cut extension areas - this includes the 400 hectare (ha) extension area, of which approximately 171 ha has been previously mapped. Approximately 229 ha of land is approved consolidated open cut disturbance area, which constitutes the Study Area for the farm budget calculations.
- Minor site infrastructure changes - disturbance from the relocation or provision of new infrastructure will occur on areas previously mapped and will not be part of the Study Area.

The Study Area mentioned above is comprised of three sites; the first is located to the west of the existing open cut operations and covers an area of 119.2 ha. The second is located to the south of the existing open cut operations and covers an area of 80.8 ha. The third is located to the south east of the current operations and covers an area of 28.9 ha.

This letter report provides the results of farm budget calculations for each Agricultural Suitability Class as determined by the NSW Industry & Investment (I&I) Gross Margin Budgets.

SCOPE OF WORKS

The GSSE scope of works is as follows:

i. Prepare farm budget calculations for each Agricultural Suitability Class (both pre and post mining) within the Study Area, including:

   a. agricultural enterprise;

   b. enterprise revenue per ha;

   c. variable costs per ha; and

   d. gross margin per ha.

ii. Prepare farm budget calculations which account for any water diverted from agriculture by the Project, with a comparison of dryland agricultural production vs. irrigated agricultural production for each impacted Agricultural Suitability Class.

CALCULATION APPROACH & ASSUMPTIONS

Agricultural activities for each Agricultural Suitability class were determined for the Muswellbrook area and the relevant gross margin budgets were sourced from the I&I. Livestock stocking rates, calculated in Dry Sheep Equivalents (DSE), were determined using the (former) NSW Department of Primary Industries *Beef Stocking Rates & Farm Size – Hunter Region*.

Upon analysis of ground and surface water impacts of the Modification, no irrigation water will be removed from agricultural enterprises in the Study Area, although it is anticipated there will be a 0.02 percent (%) reduction in the catchment reporting to the Hunter River nearby, which would have negligible impact. As such, no figures were calculated for a reduction in irrigated agriculture.

Potential agricultural activities for the four Agricultural Suitability Classes present in the Study Area are shown in **Table 1**.

Table 1 – Potential Agricultural Activities

Agricultural Suitability Class	Potential Agricultural Activity
1*	Dryland lucerne production, cattle grazing improved pasture
3	Dryland lucerne production, cattle grazing improved pasture
4	Cattle grazing native pasture
5	Very light grazing of native pasture with cattle

*Note: Although there are a number of potential agricultural activities which can be carried out on Class 1 land no further budgets were calculated as there is no impact from the Project on that land class.

The predominant grazing enterprise in the area is cattle grazing with a cow and calf unit turning off yearling stock for sale. A cow and calf unit is equivalent to 16.89 DSE when averaged across the year. Financial assumptions relating to the cow and calf unit which were used to determine the farm budget calculations are shown in **Table 2**.

Table 2 - Financial Assumptions

Agricultural Activity	Value
Annual income per cow and calf unit	$561.50
Improved pasture grazing system variable costs per cow and calf unit	$212.30
Native pasture grazing system variable costs per cow and calf unit	$106.80

Pasture type was determined according to the appropriate fit for each Agricultural Suitability Class. **Table3** identifies pasture systems which would best fit each land class.

Table 3 – Pasture Type

Agricultural Suitability Class	Pasture System
1	Improved pasture; paspalum, kikuyu and clover with regular phosphorus and sulfur fertiliser application.
3	Grass pasture with irregular application of phosphorus and sulfur fertiliser, some clover present
4	Native grass only, no fertiliser
5	Native grass and timber, no fertiliser

CALCULATION OF GROSS INCOME

Activity One – Beef Cattle Grazing

Beef cattle grazing is the predominant enterprise in the area, with a cow and calf unit turning off yearling stock for sale. Livestock carrying capacity was determined for each land class and subsequent from that the number of cow and calf units per ha was calculated.

These livestock figures were then utilised with the I&I gross margin budgets and the revenue per ha, variable costs per ha and gross margin per ha were calculated for each Agricultural Suitability Class, which are shown in **Table 4**.

Table 4 – Cattle Grazing Gross Margin

Agricultural Suitability Class	Livestock carrying capacity (DSE)	Cow & calf per ha	Revenue per ha	Variable Costs per ha	Gross Margin per ha
1	15	0.89	$499.73	$188.95	$310.78
3	8	0.47	$263.91	$99.78	$164.13
4	4	0.24	$134.76	$25.63	$109.13
5	2	0.12	$67.38	$12.82	$54.56

As would be expected when running the same grazing enterprise across differing Agricultural Suitability Classes the highest gross margin per ha is from the Class 1 land and the lowest gross margin is on the Class 5 land.

From the gross margins in **Table 4**, income per land class can then be determined. **Table 5** shows gross income per land class both pre and post disturbance.

Table 5 – Cattle Grazing Gross Income

Agricultural Suitability Class	Pre-Disturbance (ha)	Gross Income Pre-Disturbance	Post-Disturbance (ha)	Gross Income Post-Disturbance
1	26.7	$8,297.03	26.7	$8,297.03
3	131.0	$21,501.03	100.3	$16,462.24
4	62.1	$6,776.97	53.0	$5,783.89
5	8.9	$485.58	48.7	$2,657.07
Total	**228.7**	**$37,060.61**	**228.7**	**$33,200.23**

Across the 228.7 ha there is a difference of $3,860.38 less in potential gross income from the cattle grazing enterprise after mine disturbance and subsequent rehabilitation. It must be noted this is a gross figure and does not include any fixed costs.

Note: Three HVEC-owned groundwater bores are predicted to experience additional drawdown greater than 2 metres as a result of the Modification. Two of the HVEC-owned bores are used for stock or domestic purposes. For the remaining groundwater bores, there is expected to be negligible impacts on groundwater levels or yield for groundwater users with privately-owned bores in any groundwater system attributable to the Modification (AGE Groundwater & Environmental, 2012).

Activity Two – Dryland Lucerne Hay Production

Dryland lucerne hay production would be suited to both Class 1 and Class 3 land, with yield differing between the two land classes.

Lucerne hay yield was determined for both land classes and these figures were then utilised with the I&I gross margin budgets and the revenue per ha, variable costs per ha and finally gross margin per ha were calculated for Agricultural Suitability Class 1 and 3, which are show in **Table 6**.

Table 6 – Dryland Lucerne Hay Gross Margin

Agricultural Suitability Class	Hay Tonnes per ha	Revenue per ha	Variable Costs per ha	Gross Margin per ha
1	5	$1,440	$926.82	$513.18
3	4	$1,152	$780.52	$371.48

Again, as expected the higher gross margin is on the better land class. From these gross margins the gross income was determined for pre and post land disturbance. As shown in **Table 7,** over the 228.7 ha the potential gross income is $11,404.44 less after mine disturbance. Again this is a gross figure which does not factor in fixed costs.

Table 7 – Dryland Lucerne Hay Gross Income

Agricultural Suitability Class	Pre-Disturbance (ha)	Gross Income Pre-Disturbance	Post-Disturbance (ha)	Gross Income Post-Disturbance
1	26.7	$13,701.91	26.7	$13,701.91
3	131.0	$48,663.88	100.3	$37,259.44
Total	**157.7**	**$62,365.79**	**127**	**$50,961.35**

KEY FINDINGS

As a result of mine disturbance and rehabilitation, there is a reduction in potential agricultural income of approximately 10% for beef cattle grazing and 18% for dryland lucerne hay production.

If cattle grazing enterprises are reliant on either of the two stock and domestic bores which are predicted to dry up, alternate water sources should be identified to allow these activities to continue.

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

Yours Faithfully

GSS Environmental

Murray Fraser

Agronomist

BIBLIOGRAPHY

AGE Groundwater & Environmental *Mt Arthur Open Cut Modification Groundwater Impact Assessment 2012*

NSW Industry & Investment *Dryland Lucerne Hay Gross Margin Budget Northern Zone Summer 2010-11*

NSW Industry & Investment *Beef Cattle Gross Margin Budget Yearling (Southern/Central NSW) June 2012*

NSW Department of Primary Industries *Beef Stocking Rates& Farm Size – Hunter Region 2006*

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Our Ref: MAC01-29_Farm_Budgets_Draft_121003

9th October, 2012

Sarah Bailey
Manager Approvals
Mt Arthur Coal
NSW Energy Coal
BHP Billiton
Thomas Mitchell Drive, Muswellbrook, 2333, NSW, Australia

Sent via: Email Transmission

Dear Sarah,

RE: FARM BUDGET CALCULATIONS

BACKGROUND

GSS Environmental (GSSE) was engaged by Hunter Valley Energy Coal Pty Limited (HVEC), a wholly owned subsidiary of BHP Billiton, to undertake farm budget calculations on each Land Capability Class on the proposed Middle Deep Creek Offset, located in Timor, New South Wales (NSW), and determine the agricultural potential of water licenses held by HVEC.

This was received as the following request by Resource Strategies:

- *Calculate the estimated carrying capacity and subsequent farm budgets (cattle grazing) for each land capability class present (V, VI and VII) within the Middle Deep Creek Offset Area;*
    - I. *Revenue per hectare;*
    - II. *Variable cost per hectare; and*
    - III. *Gross margin per hectare.*
- *Calculate potential area and farm budgets for agriculture (irrigated lucerne) which could be derived from water held by HVEC at cessation of mining.*

A key assumption for this scope of works is that information regarding the area of each Land Capability Class present will be supplied by Resource Strategies.

This work is in addition to the original Soil and Land Resources Assessment conducted by GSSE.

This letter report provides the results of farm budget calculations for each Land Capability Class as determined by the NSW Department of Primary Industries (DPI) Gross Margin Budgets.

SCOPE OF WORKS

The GSSE scope of works is as follows:

i. Prepare farm budget calculations for each Land Capability Class within the Middle Deep Creek Offset Area (the Study Area), including:

   a. agricultural enterprise;

   b. enterprise revenue per hectare;

   c. variable costs per hectare; and

   d. gross margin per hectare.

ii. Calculate potential area of irrigated agriculture which could be derived from 2,597 megalitres (ML) of high security water licence and 4,338 ML of general security water licence held by HVEC.

iii. Calculate potential gross margin of irrigated lucerne for the area in (**ii**).

CALCULATION APPROACH & ASSUMPTIONS

Agricultural activities for each Land Capability Class were determined for the Timor area and the relevant gross margin budgets were sourced from the DPI. Cattle stocking rates, calculated in Dry Sheep Equivalents (DSE), were determined using the DPI *Beef Stocking Rates & Farm Size – Hunter Region*.

As annual rainfall at Timor is 44 millimetres higher than Muswellbrook, so too will the potential stocking rate be higher.

Potential agricultural activities for the three Land Capability Classes present in the Study Area are shown below in **Table 1**.

The previous information provided for the Mt Arthur Extension Area was calculated for each Agricultural Suitability Class, of which the equivalent Land Capability Class is also shown for reference.

Table 1 – Potential Agricultural Activities

Land Capability Class	Agricultural Suitability Class	Potential Agricultural Activity
V	**3**	Cattle grazing improved pasture
VI	**4**	Cattle grazing native pasture
VII	**5**	Very light grazing of native pasture with cattle

The predominant agricultural enterprise in the area is cattle grazing with a cow and calf unit turning off yearling stock for sale. A cow and calf unit is equivalent to 16.89 DSE when averaged across the year. Financial assumptions relating to the cow and calf unit which were used to determine the farm budget calculations are shown in **Table 2**.

Table 2 - Financial Assumptions

Agricultural Activity	Value
Annual income per cow and calf unit	$561.50
Improved pasture grazing system variable costs per cow and calf unit	$212.30
Native pasture grazing system variable costs per cow and calf unit	$106.80
Large bale lucerne hay production per tonne	$220.00
Small bale lucerne hay production per tonne	$275.00

Pasture type was determined according to the appropriate fit for each Land Capability Class. **Table 3** identifies pasture systems which would best fit each land class.

Table 3 – Pasture Type

Land Capability Class	Pasture System
V	Grass and clover pasture with irregular application of phosphorus and sulfur fertiliser
VI	Native grass only, no fertiliser
VII	Native grass and timber, no fertiliser

CALCULATION OF GROSS INCOME

Activity One – Beef Cattle Grazing

As stated above, beef cattle grazing is the predominant enterprise in the area, with a cow and calf unit turning off yearling stock for sale. Livestock carrying capacity was determined for each land class and subsequent from that the number of cow and calf units per hectare was calculated.

These livestock figures were then utilised with the NSW DPI gross margin budgets and the revenue per hectare, variable costs per hectare and gross margin per hectare were calculated for each Land Capability Class, which are shown below in **Table 4**.

Land Capability Class for the Middle Deep Creek offset was determined using an overlay from the NSW Lands Department, supplied by Resource Strategies.

Table 4 – Cattle Grazing Gross Margin

Land Capability Class	Livestock carrying capacity (DSE)	Cow & calf per hectare	Revenue per hectare	Variable Costs per hectare	Gross Margin per hectare
V	10.3	0.61	$342.52	$129.50	**$213.02**
VI	6.3	0.37	$207.76	$39.52	**$168.24**
VII	4.3	0.25	$140.38	$26.70	**$113.68**

As would be expected when running the same grazing enterprise across differing Land Capability Classes the highest gross margin per hectare is from the Class V land and the lowest gross margin is on the Class VII land.

From the gross margins in **Table 4**, income per land class can then be determined. **Table 5** shows gross income per land class and the total potential gross income.

Table 5 – Cattle Grazing Gross Income

Land Capability Class	Area Hectares	Gross Income Per Hectare	Total Potential Gross Income
V	276.9	$213.02	$58,985.24
VI	128.5	$168.25	$21,620.13
VII	5.9	$113.68	$670.71
Total	**411.3**	**$197.6078**	**$81,276.08**

Across the 411.3 hectares of the Study Area there is a potential for just under $81,300 gross income from cattle grazing per annum. It must be noted this is a gross figure and does not include any fixed costs.

Activity Two – Potential Irrigable Area

HVEC currently holds licences for 2,597 ML of high security Hunter River water and 4,338 ML of general security entitlements. The area which could be potentially irrigated by this amount of water is dependent upon the enterprise being undertaken, such as broadacre crop, vegetable, orchard or irrigated lucerne. **Table 6** shows average ML per annum needed for some of the crops with the potential to be grown on the Hunter River and the area which could be grown with the 6,935 ML available.

ML per hectare per crop has been calculated as the amount required to adequately water the crop in 4 out of 5 years.

Table 6 – Potential Irrigated Crop Area

Potential Crop	ML Required per Annum	Potential Area of Irrigated Crop (hectares)
Maize	7.15	969.9
Soybean	6.00	1115.8
Sorghum	3.80	1825.0
Tomato	8.00	866.9
Pumpkin	8.00	866.9
Orange	0.50*	13870.0*
Lucerne Hay	**10.00**	**693.5**

Source: NSW DPI Gross Margin Budgets 2012

***Note**: * 0.50 ML/ha for Orange production is supplementary sprinkler irrigation and is not representative in comparison to the other crops which are all carried out under flood irrigation.*

Lucerne hay has been selected for the gross margin calculations. The potential area of irrigated lucerne which can be grown with 6,935 ML of water entitlements from the Hunter River is 693.5 hectares.

Of this area 259.7 hectares could be maintained through times of low water allocation as this area could be watered with the high security entitlement water, whilst the remaining 433.8 hectares would be serviced by the general security water.

Activity Three – Irrigated Lucerne Gross Margins

Lucerne hay gross margin was determined for both large bales (tonnes per hectare) and small square bales (bales per hectare) using the NSW DPI gross margin budgets and the revenue per hectare, variable costs per hectare and finally gross margin per hectare were calculated. These are shown in **Table 7**. Once again it should be noted these values do not include fixed costs.

In the Hunter Valley large bale lucerne hay is produced primarily for beef cattle and dairy enterprises, whilst small square bales are generally sourced by the thoroughbred and pleasure horse industry, along with hobby farms.

Table 7 – Irrigated Lucerne Hay Gross Margin

Lucerne Enterprise	Yield	Revenue per hectare	Variable Costs per hectare	Gross Margin per hectare
Large Bales	10 tonnes/hectare	$2,090	$757.50	**$1,332.50**
Small Square Bales	532 bales/hectare	$3,664	$2,830.28	**$833.72**

Note that small square bale lucerne hay production is an extremely volatile market, with large price fluctuations. The above price was determined at $275 per tonne, however it is not uncommon for the price to reach over $500 per tonne during peak demand in winter (giving a gross margin of over $3,700 per hectare).

Potential gross income from lucerne hay production over 693.5 hectares irrigated with 6,935 ML of general and high security Hunter River water is $924,088.75 for large bales or $578,184.82 as small square bales.

KEY FINDINGS

Lost agricultural opportunity calculated for a cattle grazing enterprise on the Middle Deep Creek offset is approximately $81,300 per annum over the 411.3 hectares. However, it is noted that some strategic grazing would be undertaken in the offset areas as a management tool to control weeds and biomass or to manipulate species composition or sward structure.

Potential irrigable area from 6,935 ML of water entitlements, held as 2,597 ML high security and 4,338 ML general security, is 693.5 hectares of irrigated lucerne hay production, using 10 ML per hectare per annum.

Potential gross income from 693.5 hectares of irrigated lucerne hay production is $924,088.75.

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

Yours faithfully

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BIBLIOGRAPHY

Bureau of Meteorology website, accessed 4 October 2012

French R.J. *"Future Productivity on our Farmlands"* Proceedings of Fourth Australian Agronomy Conference, Latrobe University, 1987

NSW Department of Primary Industries *Flood Irrigated Lucerne: Maintenance Winter 2012*

NSW Department of Primary Industries *Surface Irrigated Lucerne – Established Stand Summer 2011-2012*

NSW Department of Primary Industries *Beef Cattle Gross Margin Budget Yearling (Southern/Central NSW) June 2012*

NSW Department of Primary Industries *Beef Stocking Rates & Farm Size – Hunter Region 2006*

NSW Department of Primary Industries *Farm Budget Handbook 2003 NSW Citrus*

NSW Department of Primary Industries *Surface Irrigated Maize Summer 2011-12*

NSW Department of Primary Industries *Surface Irrigated Soybeans Summer 2011-12*

NSW Department of Primary Industries *Gross Margin Budgets 2012*

NSW Department of Primary Industries *Surface Irrigated Sorghum Summer 2011-2012*

NSW Department of Primary Industries *Tomatoes (Fresh) Sydney Basin 2009*

NSW Agriculture Farm Enterprise Budget *Pumpkin – Butternut Furrow Irrigation 2001*