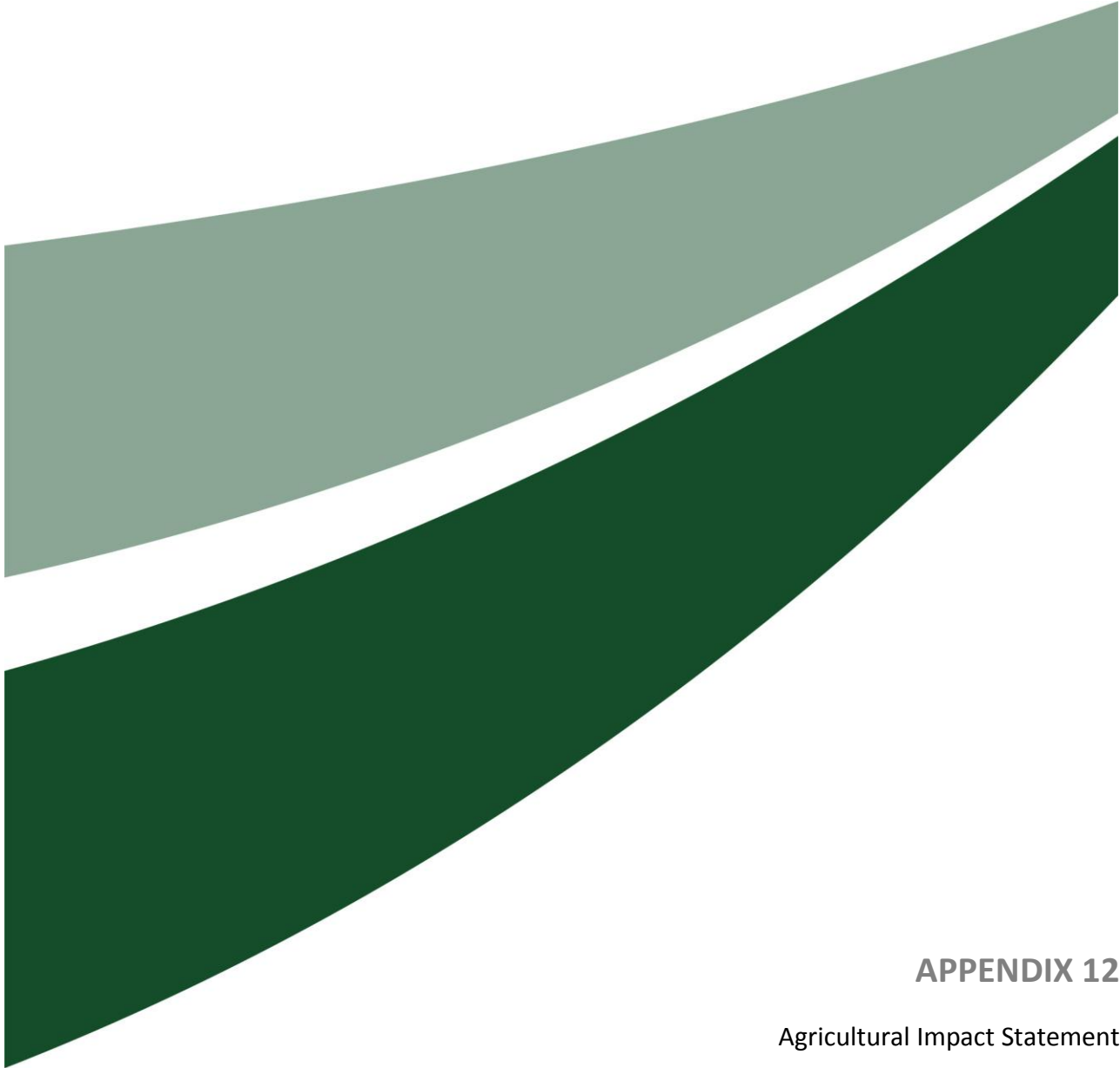
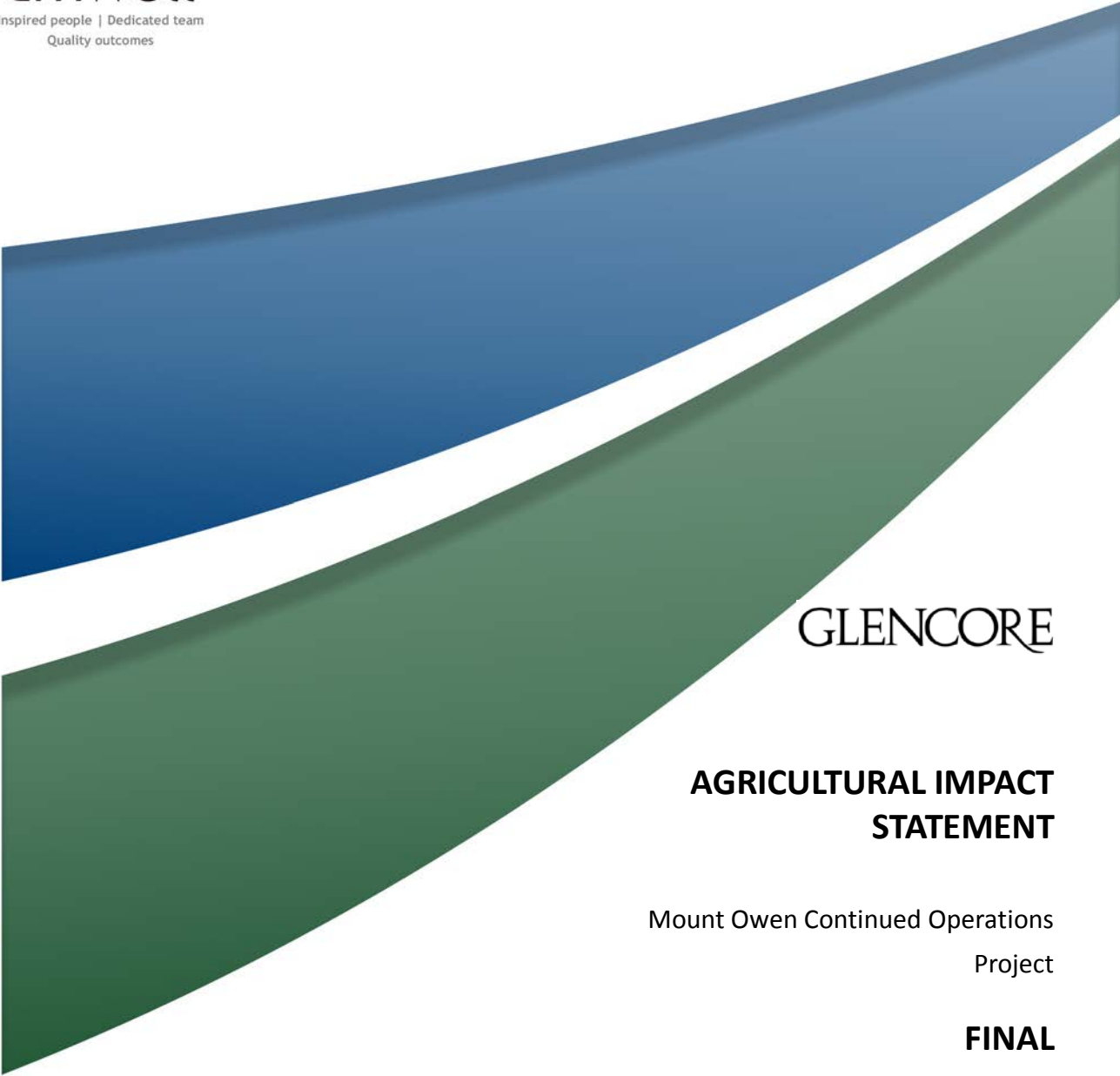




APPENDIX 12

Agricultural Impact Statement



GLENCORE

**AGRICULTURAL IMPACT
STATEMENT**

Mount Owen Continued Operations
Project

FINAL

October 2014



AGRICULTURAL IMPACT STATEMENT

Mount Owen Continued Operations Project

FINAL

October 2014

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Mount Owen Continued Operations

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Executive Summary

The Mount Owen Continued Operations Project (The Project) is located on the northern slopes of the Hunter Valley, between Ravensworth and Falbrook. The Project has a Proposed Disturbance Area of approximately 485 hectares, including the North Pit Continuation (approximately 381 hectares), Hebden Road Upgrade (approximately 13 hectares) and the Rail Upgrade (approximately 91 hectares). The Project Area is entirely contained within existing Mining Leases and the North Pit Continuation disturbance area is entirely in the ownership of Mount Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited (formerly Xstrata Coal Pty Limited).

Three proposed biodiversity offset areas (Cross Creek, Esparanga and Stringybark Creek Habitat Corridor) are also part of the overall Project and have a total area of approximately 767 hectares. These areas will be managed for biodiversity conservation, but their agricultural resources (such as landform, soil and water resources), will not be changed by the Project.

This Agricultural Impact Statement (AIS) has been prepared to assess the potential risks and impacts of the Project in relation to agricultural resources and enterprises, including mitigation measures to minimise any potential impacts.

The AIS was prepared in accordance with the Director-General's Requirements for the Project and in accordance with the requirements of the *Guidelines for Preparing Agricultural Impact statements* (DP&I 2012), *Agricultural Impact Statement Technical Notes* (DPI 2013), *Interim protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (BSAL) (OEH 2013).

A preliminary risk assessment was conducted to scope the potential impacts on agricultural resources and industries, including resources and uses within the Proposed Disturbance Area and the locality. The risk assessment was revisited after detailed studies and assessment of the agricultural resources and industries of the area and the risks reviewed, based on the outcomes of the analysis. With management and mitigation measures in place, risks associated with the Project, affecting agricultural resources, enterprises, infrastructure and industries, are low to moderate.

A minor area of potential impact on BSAL was mapped in the Hebden Road Upgrade part of the Proposed Disturbance Area, based on the *Upper Hunter Strategic Regional Land Use Plan 2012* (UHSRLUP). Mapping for the UHSRLUP was conducted at the 1:250,000 scale, based on previous soil landscape and land and soil capability mapping, also at 1:250,000 scale. Soil survey and soil testing (including soil structure, texture, pH, sodicity, cation exchange capacity and soil fertility) was conducted in the small mapped area and in the other parts of the Proposed Disturbance Area, to verify the soil types present and the actual Land and Soil Capability (LSC) classes of the Project Area. The detailed soil analysis indicates that no land within the Proposed Disturbance Area meets the criteria to be a LSC Class better than Class 4. Class LSC 4 land is not BSAL land. No land in the Proposed Disturbance Area meets the criteria for fertility relevant to BSAL land. There is therefore no BSAL land in the Proposed Disturbance Area.

The proposed closure plan, final landform and final land use for the Proposed Disturbance Area includes:

- Maintaining agricultural use in the Hebden Road area, except for a very small area of land that will be used for the road and bridge upgrade. These works will improve road safety for residents and commercial enterprises (e.g. quarries) along Hebden Road, as well as improving road access to the Mount Owen Complex.

- The Rail Upgrade area will be rehabilitated for native vegetation and habitat. This area is already used as a regrowth and habitat enhancement area as part of the existing approved operations of Mount Owen Complex.
- The North Pit Continuation Area will be rehabilitated primarily for native vegetation (woodland). This is consistent with the significant biodiversity connectivity values currently at Mount Owen Mine and continues the existing approved final land use strategy. Only approximately 25 hectares of the North Pit Continuation Area is currently used for grazing. Approximately 77 hectares within the North Pit will be focused on topsoil replacement, to achieve LSC class 4 or 5 land. These parts of the post mining rehabilitation will be revegetated with a mix of native and introduced pasture grasses as well as scattered woodland species and may be suitable for sustainable grazing uses.

In accordance with the requirements, the AIS also documents and maps existing agricultural resources, land uses agricultural enterprises and production history in the locality of the Proposed Disturbance Area, defined in this case at a radius of 10 kilometres from the Project Area. Where necessary for context, information is also presented about the broader regional status and production of agricultural land uses.

Land within the immediate vicinity of the Mount Owen Complex is part of the broader landholdings owned by Glencore and is managed as a grazing enterprise.

Existing agricultural use in the Mount Owen Complex Locality, outside the land owned by Glencore, is dominated by cattle grazing, but also includes fodder crops on irrigated floodplain and terrace landforms along Glennies Creek. There are also several rural residential properties and Camberwell village is located within the Mount Owen Complex Locality.

Three rural residential properties (totalling approximately 7 hectares), which are not currently subject to acquisition rights have been identified as meeting acquisition criteria based on potential noise and air quality impacts. If land owners request acquisition of these properties, ownership would transfer to Glencore. There are currently some 800 farms in the Singleton and Muswellbrook local government areas and as these properties are rural residential this change in ownership represents a negligible impact on agricultural resources, production and enterprises.

Mount Owen proposes to update and implement existing management plans during mine operation and closure. These will set out final closure objectives and indicators, including landform, soil condition, vegetation, water management and land use. The Landscape Management Plan is the overarching Plan to guide future rehabilitation for agricultural and other uses. The plans will be prepared in consultation with relevant stakeholders from agencies and community. Ongoing monitoring of biophysical and other landscape parameters will be reported annually in the Annual Environmental Management Report (AEMR), so that progress towards post mining agricultural resources and land use commitments can be tracked and management responses adapted as necessary.

TABLE OF CONTENTS

1.0	Introduction.....	1.1
1.1	The Project.....	1.1
1.2	Project Overview	1.2
1.3	The Project Area, Proposed Disturbance Area and Locality	1.3
1.4	Report Structure	1.5
2.0	Agricultural Impact Assessment Requirements and Project Scope and Approach.....	2.1
2.1	Aims and Objectives of Assessment.....	2.1
2.1.1	Director-General's Requirements.....	2.1
2.1.2	SEPP Mining 2013	2.2
2.1.3	Upper Hunter Strategic Regional Land Use Plan.....	2.2
2.2	Agricultural Impact Statement Guideline Requirements.....	2.2
2.3	Scope and Method of Assessment	2.4
2.3.1	Data and Methods	2.5
2.3.2	Review of other biophysical, social and economic studies as they relate to agriculture. Integration of Physical Resources and Socio-Economic Studies	2.5
2.3.3	Preliminary Agricultural Risk Assessment	2.6
2.3.4	Consultation	2.13
3.0	Agricultural Resources within the Project Area and Region	3.1
3.1	Agricultural Resources - Climate and Climate Variability – Upper Hunter	3.1
3.2	Agricultural Resources - Water Availability in the Locality of the Project Area	3.3
3.2.1	Water Resources in the Project Area	3.5
3.3	Agricultural Resources - Significant Vegetation Communities – Regional Context.....	3.6
3.3.1	Vegetation of the Project Area and Offset Areas	3.7
3.4	Regional Soil Landscapes	3.9
3.5	Land and Soil Capability	3.13
3.5.1	Land and Soil Capability of the Upper Hunter Region.....	3.14
3.6	Factors influencing the land and soil capability of the Project Area	3.16
3.6.1	Slope and Terrain of the Proposed Disturbance Area and Offset Areas.....	3.16
3.6.2	Rock Outcrop in the Proposed Disturbance Area and Offset Areas	3.19
3.7	Soils of the Proposed Disturbance Area and Offset Areas.....	3.20
3.7.1	Regional Scale Mapping of Land and Soil Resources in the Proposed Disturbance Area and Offset Areas.....	3.20
3.7.2	Soil Sampling Program	3.21
3.7.3	Project Scale Soil Mapping and Information.....	3.24
3.7.4	Soil Resources of the Proposed Offset Areas	3.28
3.8	Strategic Agricultural Land.....	3.28
3.8.1	Critical Industry Clusters	3.29

3.8.2	Verification of Biophysical Strategic Agricultural Land	3.29
4.0	Agricultural Land Uses and Production	4.1
4.1	Land Ownership in the Project Area and Mount Owen Complex Locality.....	4.1
4.1.1	Land Tenure in the Mount Owen Complex Locality	4.1
4.1.2	Project Area	4.1
4.2	History of Agricultural Enterprises in the Upper Hunter Region, Mount Owen Complex Locality and the Project Area.....	4.2
4.2.1	Land Use History of the region and the Mount Owen Complex Locality	4.2
4.2.2	Land Use History of the Project Area	4.4
4.3	Current Agricultural Enterprises in the Locality and the Region..	4.5
4.3.1	Regional Agricultural Production Statistics	4.7
4.3.2	Agricultural Communities	4.14
4.3.3	Local Production Details and Issues from Consultation	4.16
4.3.4	Supporting Infrastructure for agriculture	4.17
4.3.5	Value of Agricultural Enterprises in the Locality of the Project	4.18
4.4	Current Agricultural Land Use of the Project Area and Offset Areas	4.19
4.4.1	Proposed Biodiversity Offset Areas.....	4.20
4.4.2	Colinta – Grazing Management in Existing Mine Owned Land.....	4.20
5.0	Assessment of Impacts	5.1
5.1	Impacts on Agricultural Resources of the Proposed Disturbance Area	5.2
5.1.1	Potential Impact on Landforms and Soils of the Proposed Disturbance Area	5.4
5.1.2	Potential Impacts on Land and Soil Capability of the Proposed Disturbance Area	5.5
5.1.3	Potential Physical Movement of Water Away from Agriculture – Proposed Disturbance Area and Context.....	5.6
5.1.4	Vegetation and Biodiversity	5.8
5.2	Impacts on Agricultural Resources of the Proposed Offset Areas	5.8
5.3	Impacts on Agricultural Uses/Enterprises of the Proposed Disturbance Area and Offset Areas	5.10
5.3.1	Proposed Disturbance Area.....	5.10
5.3.2	Offset Areas	5.10
5.4	Impacts on Agricultural Resources in the locality	5.12
5.5	Impacts on Agricultural Enterprises in the Locality.....	5.12
5.5.1	Direct and Indirect Impacts on Rural Enterprises.....	5.12
5.5.2	Land Acquisition	5.13
5.6	Impacts on Agricultural Support Services	5.14
5.6.1	Impacts on Visual Amenity.....	5.14
5.6.2	Impact on Agricultural Employment.....	5.14
5.7	Other Social and Economic Impacts Affecting Rural Land Uses	5.15
5.8	Uncertainty and Significance of Potential Impacts	5.16
5.8.1	Significance of potential Project impacts	5.17
5.8.2	Uncertainty	5.18

6.0	Mitigation and Management of Impacts on Agriculture	6.1
6.1	Planning for Post Mining Land Uses	6.1
6.1.1	Land and Soil Quality Goals for the region	6.1
6.1.2	Land and Soil Quality Objectives for the Project Area	6.3
6.2	Indicative Post Mining Land Use.....	6.5
6.3	Aspects of Operations and Closure to deliver Sustainable Land and Soil Resources	6.6
6.3.1	Stable and Productive Landform Design	6.6
6.3.2	Soil Profile Rehabilitation for Improved Land and Soil Capability	6.7
6.4	Research and Development in Land and Soil Rehabilitation	6.7
6.5	Agricultural Use of Surrounding Mount Owen Owned Lands	6.8
6.5.1	Management of Pests, Diseases and Invasive Plant Species.....	6.8
6.5.2	Stock Management across Shared Boundaries.....	6.9
6.5.3	Property Management Plans for Surrounding Mount Owen Owned Land Used for Agriculture and Offset Areas	6.9
6.6	Ongoing Community Engagement.....	6.9
6.7	Monitoring and Reporting the Condition of Agricultural Resources and Industries	6.10
6.8	Adaptive Management to Achieve Agreed Land and Soil Goals.....	6.11
6.8.1	Summary of Proposed Management Plans Relevant to Agricultural Resources and Enterprises	6.11
7.0	References	7.1

FIGURES

1.1	Locality Plan.....	1.1
1.2	Proposed Mount Owen Continued Operations Project	1.1
1.3	Mount Owen Complex Locality Regional Setting.....	1.2
1.4	Mount Owen Complex Mining Titles.....	1.2
3.1	Catchment Context	3.3
3.2	Hunter Valley Remnant Vegetation	3.6
3.3	Vegetation Communities within the Project Area	3.7
3.4	Vegetation Communities in the Proposed Esparanga Offset Area	3.8
3.5	Cross Creek Offset Area Vegetation Communities.....	3.8
3.6	Stringybark Creek Habitat Corridor Vegetation Communities	3.8
3.7	Regional Soil Landscapes.....	3.9

3.8	Esparanga Offset Area Soil Landscapes	3.9
3.9	Regional Land and Soil Capability	3.14
3.10	Existing Landforms and Slopes	3.16
3.11	Cross Creek Offset Area Slope Analysis	3.16
3.12	Esparanga Offset Area Slope Analysis	3.16
3.13	Regional Soil Fertility	3.21
3.14	Proposed Hebden Road Upgrade Works Area – Soil Types	3.22
3.15	Proposed North Pit Continuation Area – Soil Types.....	3.22
3.16	Proposed Rail Upgrade Works Area – Soil Types.....	3.22
3.17	Proposed Hebden Road Upgrade Works Area Land and Soil Capability	3.26
3.18	Proposed North Pit Continuation Area Land and Soil Capability	3.26
3.19	Proposed Rail Upgrade Works Area Land and Soil Capability	3.26
3.20	Esparanga Offset Area Soil Fertility	3.28
3.21	Esparanga Offset Area Land and Soil Capability	3.28
3.22	Potential Biophysical Strategic Agricultural Land and Critical Industry Clusters – Upper Hunter SRLUP Mapping	3.29
4.1	Land Ownership.....	4.1
4.2	Land Use.....	4.1
5.1	Proposed Hebden Road/Rail Overpass and Proposed Bowmans Creek Bridge Duplication	5.8

PLATES

3.1	Soil Farming Materials in the Stratic Rudosol Soil at Site 14 (K).....	3.24
3.2	Soil Farming Materials in the Clastic Rudosol Soil at Site 25 (B)	3.24
3.3	Soil Farming Materials in the Brown Sodosol Soil at Site 24 (D).....	3.24
3.4	Soil Farming Materials in the Brown Kurosol Soil at Site 26	3.24
4.1	View of the Colinta Feedlot on the banks of Glennies Creek facing south.....	4.21

APPENDICES

A	Soil Assessment	
B	Correspondence from Peer Reviewer	

1.0 Introduction

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres north-west of Singleton, 24 kilometres south-east of Muswellbrook and to the north of Camberwell village (refer to **Figure 1.1**).

Mount Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited (formerly Xstrata Coal Pty Limited (Xstrata)), currently owns and operates the three existing open cut operations in the Mount Owen Complex; Mount Owen (North Pit), Ravensworth East (West Pit) and Glendell (Barrett Pit). Mount Owen anticipate that mining will commence in the northern portion of the Ravensworth East in an area known as the Bayswater North Pit (BNP) in 2015. The mining operations at the Mount Owen Complex include the integrated use of the Mount Owen coal handling and preparation plant (CHPP), coal stockpiles and the rail load out facility.

1.1 The Project

Mount Owen (North Pit) has an approved production rate of 10 million tonnes per annum (Mtpa) of run of mine (ROM) coal, and blended with Ravensworth East (approved 4 Mtpa) and Glendell (approved 4.5 Mtpa) ROM coal, feed the Mount Owen CHPP and associated infrastructure, which has a current processing capacity of 17 Mtpa of ROM coal. Processed coal, both semi soft and thermal, are transported via the Main Northern Rail Line to the Port of Newcastle for export, or by conveyor for domestic use as required.

Mount Owen expects, subject to market conditions, that mining will be completed within the currently approved area of the North Pit and the West Pit by 2018 and late 2014 respectively; and Glendell by 2022. Mount Owen has undertaken extensive exploration of its mining tenements and identified substantial additional mineable coal tonnes to the south of the currently approved North Pit. Further exploration verified economically viable reserves within an area located in the northern portion of the existing approved Ravensworth East Mine, referred to as the BNP. The proposed Ravensworth East Resource Recovery (RERR) Mining Area, is located immediately east of the West Pit and is proposed to be mined sequentially after mining has been completed in the BNP.

Mount Owen is seeking development consent for the Mount Owen Continued Operations Project (the Project) to extract these additional mineable coal tonnes through continued open cut mining methods. The Project proposes to continue the existing mining operations within the North Pit to the south beyond the current approved North Pit mining limit (the North Pit Continuation) in addition to undertaking mining operations within the BNP area, sequentially followed by the proposed RERR Mining Area (refer to **Figure 1.2**).

The Project seeks to maintain the current approved North Pit extraction rate of 10 Mtpa of ROM coal, extracting approximately 74 million tonnes (Mt) of ROM coal from the North Pit Continuation. The extraction of these additional mineable coal tonnes would continue the North Pit life to approximately 2030 (an additional 12 years). Additionally, the Project seeks to maintain the current approved Ravensworth East extraction rate of 4 Mtpa of ROM coal, and to extract approximately 12 Mt of ROM coal from the BNP. Subject to market conditions, mining within the BNP area would be undertaken from approximately 2015 to 2022, with the mining in the proposed RERR Mining Area to follow sequentially from approximately 2022 to 2027 and extract approximately 6 Mt of ROM coal.



FIGURE 1.1
Locality Plan

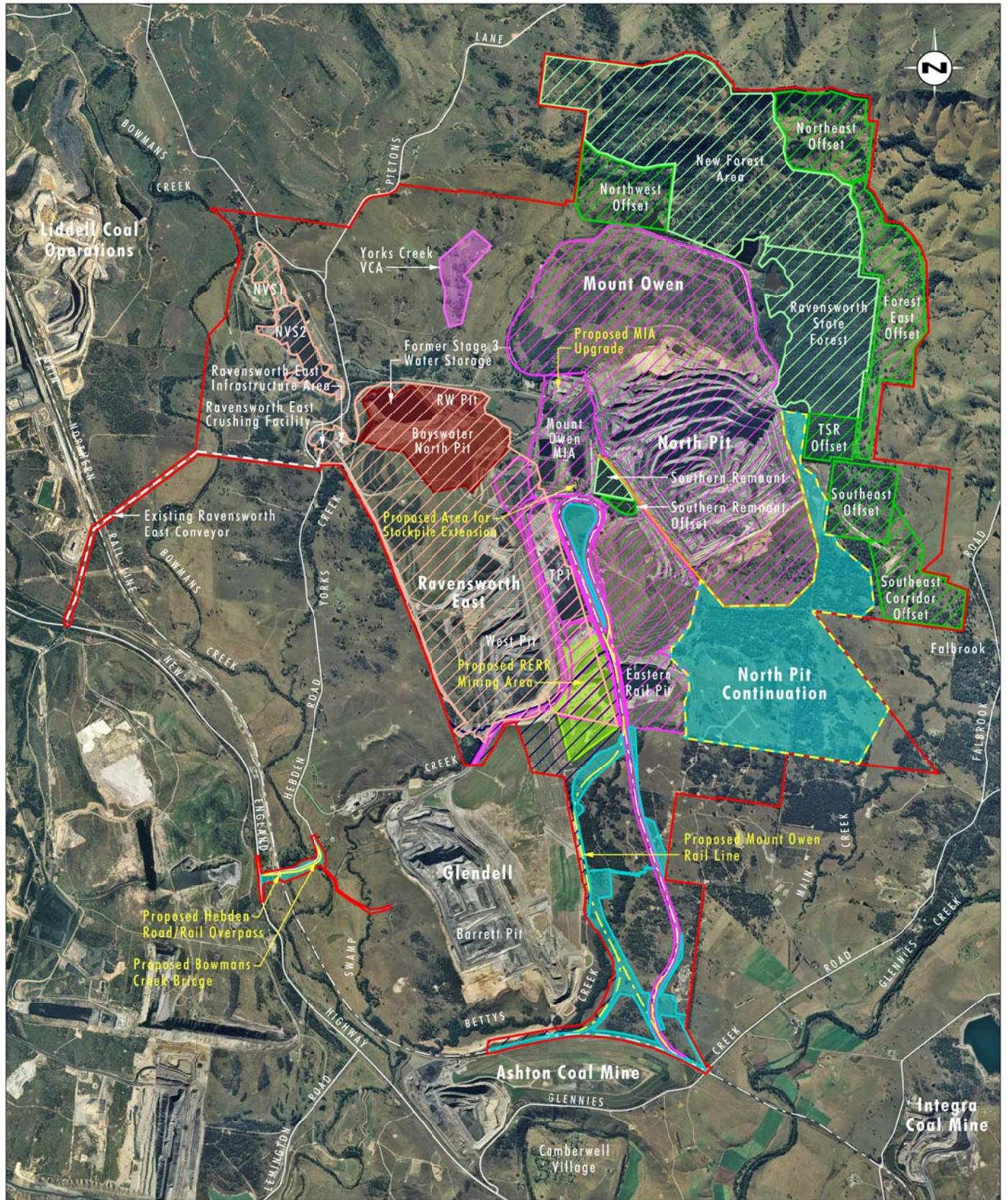


Image Source: Mount Owen (2012-2013)
Data Source: Mount Owen (2014)

0 1 2 3 km
1:60 000

Legend

- | | |
|--|---|
| Project Area | Yorks Creek VCA |
| Approved North Pit Mining Extent | Bayswater North Pit |
| Proposed North Pit Continuation | Mount Owen Operational Area |
| Proposed Rail Upgrade Works | Glendell Operational Area |
| Proposed Hebden Road Upgrade Works | Ravensworth East Operational Area |
| Proposed Disturbance Area | Existing Biodiversity Offset Area |
| Proposed RERR Mining Area | Ravensworth State Forest |

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FIGURE 1.2

Proposed Mount Owen
Continued Operations Project

The Project will enable the consolidation of the Mount Owen and Ravensworth East Operations to provide for further operational efficiency by providing a single development consent for continued operations. The Project does not include any aspect of the ongoing operations at Glendell Mine and it will continue to operate in accordance with its current development consent.

The Project is State Significant Development as defined by the provisions of the State Environmental Planning Policy (State and Regional Development) 2011 and requires development consent under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Minister for Planning is the consent authority for the Project.

An Environmental Impact Statement (EIS) has been prepared for the Project to accompany a Project Application following Department of Planning and Environment (DP&E) issuing Director-General's Requirements (DGRs) for the Project in March 2013. The following Agricultural Impact Statement (AIS) has been prepared in accordance with the DGRs to assess the potential impact of the Project on the agricultural resources, agricultural productivity and agricultural enterprises of the Project Area and the surrounding locality.

1.2 Project Overview

A key Project design consideration has been to maximise the efficient use of the existing infrastructure and areas previously approved for disturbance and as a result, minimise the overall surface disturbance area required for the Project as far as practicable.

The key features of the Project are outlined in **Table 1.1**. **Figure 1.2** shows the general layout of the Project and **Figure 1.3** shows the location of existing and proposed biodiversity offsets as well as the Project Area and Mount Owen Complex Locality for this assessment. For a detailed description of the existing approved operations and the Project refer to Section 2.0 of the Environmental Impact Statement.

The continuation of operations would be located wholly on land owned by Mount Owen and entirely within existing mining leases areas (refer to **Figure 1.4**).

Table 1.1 – Key Proposed Features of the Project

Key Feature	Proposed Operations
Mine Life	Consent will be sought for 21 years (from date of Project Approval) to provide for mining until approximately 2030 and contingency for other activities such as rehabilitation and capping of tailings emplacement areas.
Limits on Extraction	No change in approved extraction rates. - North Pit – up to 10 Mtpa ROM. - Ravensworth East – up to 4 Mtpa ROM.
Mine Extent	- Continuation of the North Pit footprint to the south of current approved North Pit mining limit. - Mining within the approved BNP, followed sequentially by mining within the proposed RERR Mining Area within the Ravensworth East Mine. - Mining depths to approximately 300 m (North Pit). - Total additional mineable coal tonnes of approximately 92 Mt ROM (comprising 74 Mt ROM (North Pit Continuation), 12 Mt ROM (BNP) and 6 Mt ROM (proposed RERR Mining Area). - Changes to mine water management system.

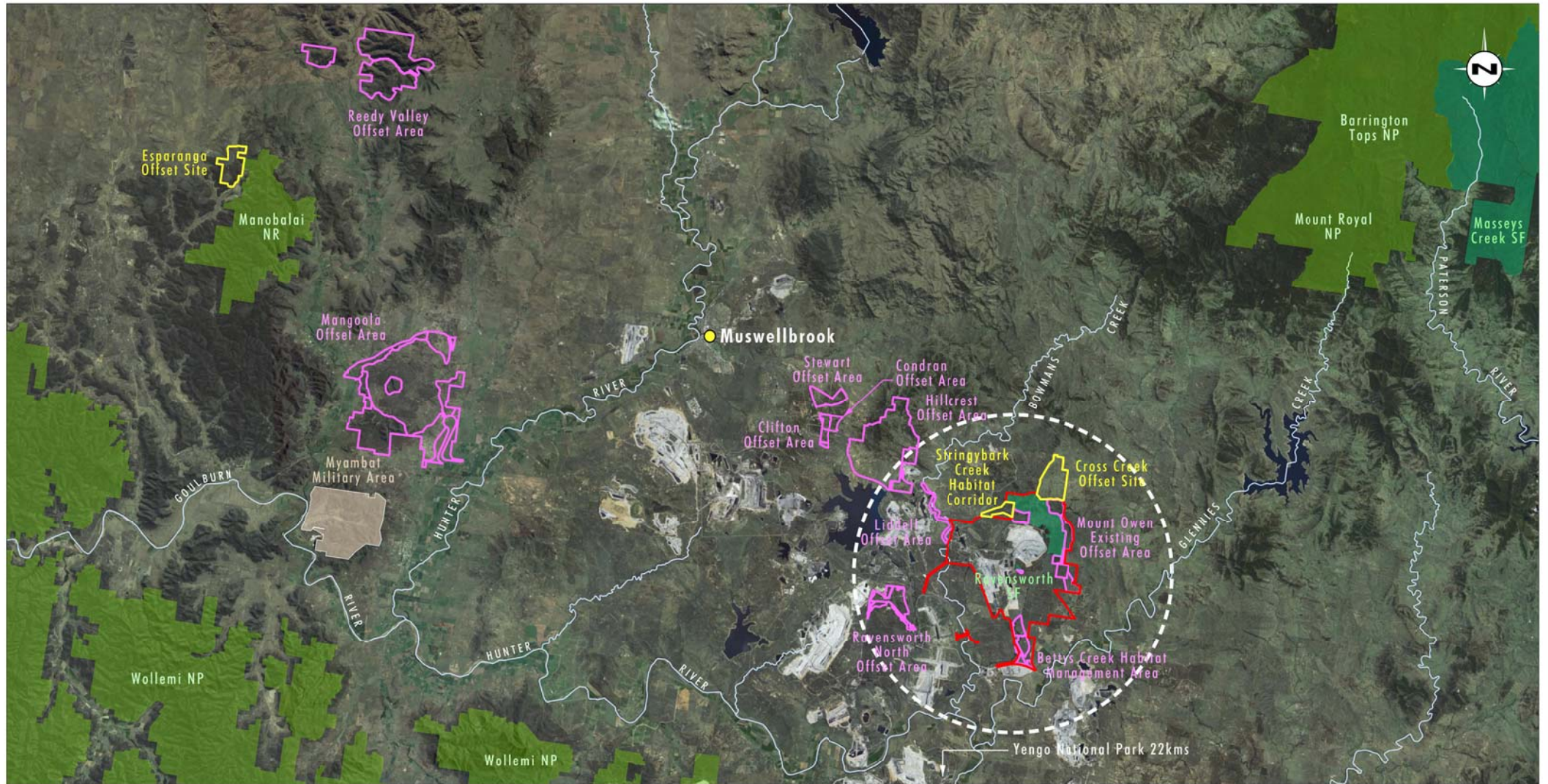


Image Source: Google Earth (2009)
Data Source: Department of Lands (2003), LPI (2012), OEH (2013), State of NSW (2013), Mount Owen (2014)

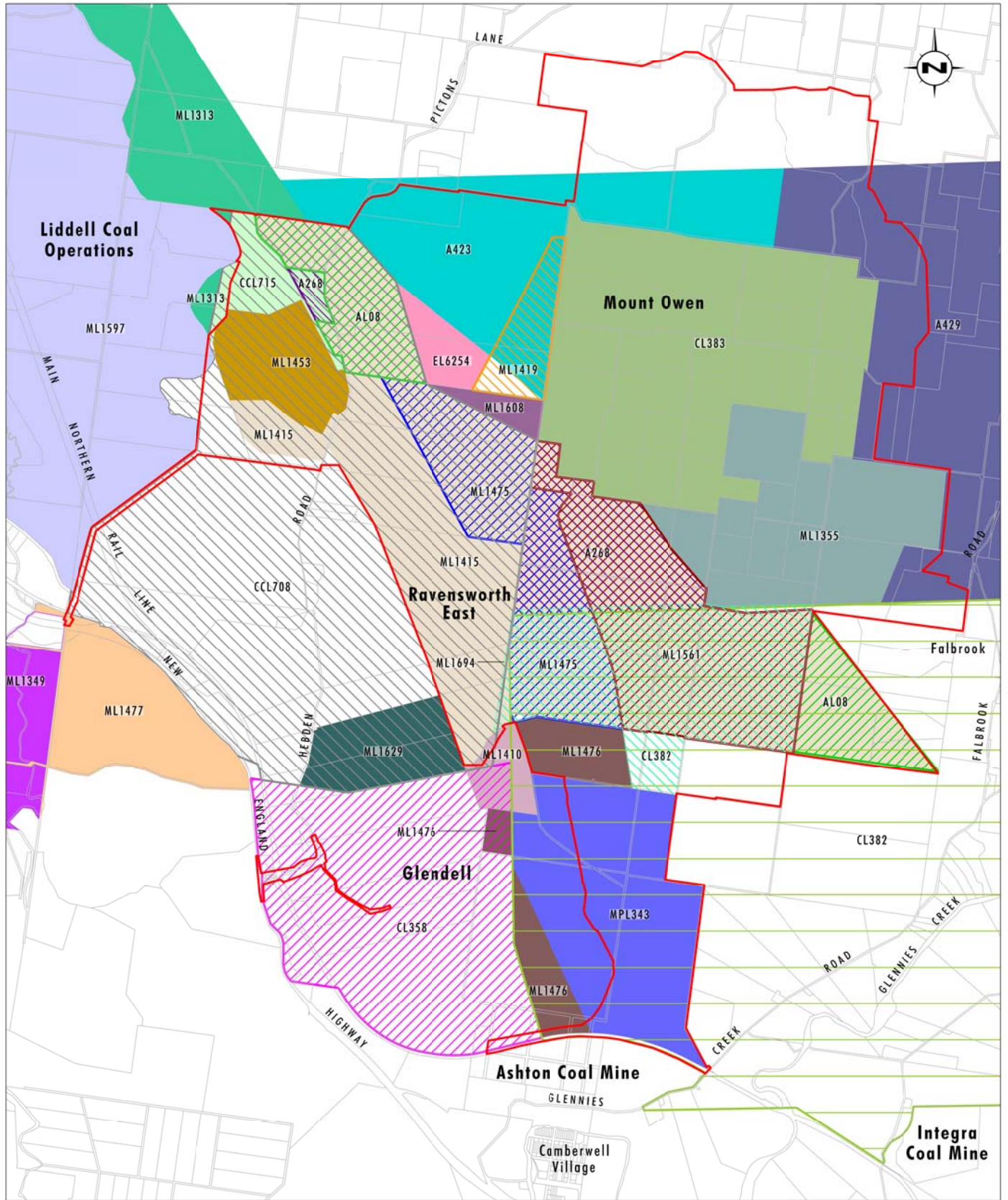
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- Project Area
- Existing Glencore Offsets
- Proposed Mount Owen Offsets
- National Park/Nature Reserve (NP/NR)
- State Forest (SF)
- Crown Reserve
- Mount Owen Complex Locality (10km Radius from Rail Loop)

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FIGURE 1.3

Mount Owen Complex Locality
Regional Setting



Data Source: Mount Owen (2014), Department of Lands (2009)

0 1.0 2.0 3km
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Legend

Project Area	CL715	ML1349	ML1475	ML1629
AL08	CL358	ML1355	ML1476	ML1694
A423	CL382	ML1410	ML1477	MPL343
A268	CL383	ML1415	ML1561	
A429	EL6254	ML1419	ML1597	
CCL708	ML1313	ML1453	ML1608	

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FIGURE 1.4
Mount Owen Complex
Mining Titles

Table 1.1 – Key Proposed Features of the Project – cont.

Key Feature	Proposed Operations
Operating Hours	No change proposed - 24 hours per day, 7 days per week.
Workforce Numbers	- No significant change to workforce numbers is required. Current workforce required to operate North Pit and CHPP fluctuates and peaks at about 660 and the Ravensworth East development consent allows for a workforce of up to 260 to operate Ravensworth East operations. - Addition of approximately 330 personnel for construction phase for proposed infrastructure works (approximately 18 months).
Mining Methods	No change to mining methods proposed.
Mount Owen CHPP and MIA	- No change to existing approved CHPP capacity of 17 Mtpa ROM. - product stockpile extension; - CHPP improvements (including operational efficiencies) to increase processing capacity and tailings management; - MIA extensions and improvements;
Existing Mine Infrastructure	Continued utilisation of all existing mining infrastructure, including the existing crushing plant for the crushing of overburden.
Infrastructure Construction Activities	- Infrastructure upgrades including: - provision for a northern rail line turn-out and additional Mount Owen rail line; Hebden Road overpass over Main Northern Rail Line; and - New Hebden Road bridge crossing over Bowmans Creek.
Tailings and Coarse Reject Emplacement	- Continued use of the Ravensworth East voids for tailings emplacement and co-disposal of coarse reject and overburden within the North Pit Continuation, the West Pit / BNP and the proposed RERR Mining Area as mining progresses. - Tailings cells may be constructed and filled within the North Pit Continuation area as required to allow time for consolidation and drying of tailings in the West Pit and the proposed RERR Mining Area. - Allowance for the receipt of tailings from other mines.
Coal Transportation	- No change to current export coal transportation with the exception of the use of the proposed additional rail line. - No change to capacity of 17 Mtpa ROM coal. - Use of existing rail line for Glencore train park up. - Transportation of up to 2 Mtpa ROM coal and crushed gravel on an as required basis via the existing overland conveyor to Liddell Coal Operations and the RCT in addition to maintaining the current approval to transport ROM coal to Bayswater and Liddell power stations.

1.3 The Project Area, Proposed Disturbance Area and Locality

In this report, the terms relating to the definition of the Project Area and its context have the following meanings:

Project Area

For the purpose of the EIS and AIS, the Project Area is the area which will be covered by the Development Application. It encompasses the currently approved development consent areas for the Mount Owen Mine and Ravensworth East Mine as well as the North Pit Continuation, BNP and proposed RERR Mining Area and associated infrastructure upgrades.

The Project Area (refer to **Figure 1.2**) is approximately 4,940 hectares in area, of which approximately 2,119 hectares (approximately 43 per cent) is either disturbed land (largely by mining activities), or land in the process of being rehabilitated from approved mining activity or planted areas. Approximately 1,433 hectares (approximately 29 per cent) is derived native grassland. Approximately 27 per cent (approximately 1,355 hectares) of the Project Area comprises woodland, forest or riparian vegetation (either remnant or regenerating).

Proposed Disturbance Area

The Proposed Disturbance Area for the Project represents the total area that would be disturbed, outside of the areas that were previously approved for disturbance. The total area of the Proposed Disturbance Area is approximately 485 hectares, of which approximately 381 hectares is associated with the North Pit Continuation and approximately 104 hectares is associated with the infrastructure upgrades. The field and soil surveys for this report focused on the Proposed Disturbance Area (as shown in **Figure 1.2**).

Proposed Offset Areas

The three properties proposed for biodiversity offsets are known as Cross Creek Offset Area, Esparanga Offset Area and Stringybark Creek Habitat Corridor. The Cross Creek Offset Area adjoins the northern boundary of the Project Area. The Esparanga Offset Area is located on the northern slopes of the Upper Hunter Valley in an area identified by the Office of Environment and Heritage (OEH) as a strategic regional biodiversity corridor approximately 80 kilometres from the Project Area. The Stringybark Creek Habitat Corridor adjoins the north-western boundary of the Project Area (refer to **Figure 1.3**).

The AIS also addresses the resources and impacts of the three biodiversity offset properties (Cross Creek Offset Area, Esparanga Offset Area and Stringybark Creek Habitat Corridor) even though there is no physical disturbance proposed for these sites.

Mount Owen Complex Locality

The Project Area is surrounded by a local district of agricultural, mining and industrial land uses and by dispersed rural and rural residential communities. Camberwell Village is located approximately 4.5 kilometres south of the Project Area. The assessment considers the 'locality' of the Project to be an area contained within a 10 kilometre radius of the centre of Mount Owen Complex (indicatively from the existing rail loop). This context locality is shown in **Figure 1.3**.

Region

The Project Area and its locality are situated close to the boundary between the broader Singleton and Muswellbrook local government areas in the Upper Hunter Valley Region. 'Region' is used in this document to refer to the combination of these two local government areas.

1.4 Report Structure

The AIS provides an assessment of the potential agricultural impacts resulting from the Project, based on the requirements of NSW legislation, policy, plans and technical notes related to agricultural impact and strategic agricultural land.

Section 2.0 provides an overview of the NSW agriculture impact assessment requirements, aims and objectives of the assessment and scope, and scale of the assessment.

Section 3.0 provides information regarding the biophysical agricultural resources of the Project Area and its regional context. Information presented includes previous mapping of land and soil characteristics, climate data for the region, water availability, significant regional vegetation communities and biophysical strategic agricultural land (BSAL). For the Project Area, site specific details on slope and land characteristics, soil types and constraints/capability are presented, drawing on a site specific soil survey and sampling program (refer to **Appendix 1**).

Section 4.0 provides an outline of the agricultural enterprises and infrastructure of the Project Area, locality and its regional context (the Singleton and Muswellbrook areas of the Upper Hunter Valley). This includes estimated production values, historical agricultural enterprises, strategic rural land, and current agricultural uses and enterprises. It discusses the overall agricultural value of the Proposed Disturbance Area in the context of its surrounding locality and broader region.

Section 5.0 details the assessment of the level of impact the Project may have on agricultural resources and enterprises. Permanent and temporary impacts are identified.

Section 6.0 provides the recommended impact mitigation measures to be implemented to reduce the risk of impact on agricultural resources and enterprises.

2.0 Agricultural Impact Assessment Requirements and Project Scope and Approach

In this section:

- Aims and objectives of this assessment in relation to Director-General's Requirements and AIS Guideline requirements.
- Scope of assessment in regard to methods, data used, consultation, etc.
- Preliminary risk assessment, to focus the scope of the AIS.

2.1 Aims and Objectives of Assessment

This section outlines the agricultural impact assessment requirements which apply to the Project. These include the DGRs, the SEPP Mining 2013, and the *Upper Hunter Strategic Regional Land Use Plan* (DP&I 2012). Other guideline documents (noted below) describe the evidence required to demonstrate that the relevant requirements have been met.

2.1.1 Director-General's Requirements

The DP&E issued the DGRs for the Project on 13 March 2013. The DGRs outline the specific requirements to be addressed in the EIS for the Project, including the specific requirement for the assessment of impacts on strategic agricultural land. Specifically, the requirements in relation to the preparation of the AIS are provided in **Table 2.1** below.

Table 2.1 – Director-General's Requirements for the Agricultural Impact Statement

Assessment Requirement	Relevant Section of AIS
Agricultural 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 gateway criteria in the <i>Strategic Regional Land Use Policy</i> . The EIS must also include a detailed description of the potential impacts on:	Entire Document and Section 3.8
• soils and land capability;	Sections 5.1 and 5.2
• landforms and topography; and	Sections 5.1 and 5.2
• other land uses within the vicinity of the mine, including land within the nearby Ravensworth State Forest;	Sections 5.3 and 5.4

Consistent with the DGRs for the Project, the AIS has been prepared in accordance with the *Guideline for Agricultural Impact Statements* (DP&I 2012a) and the *Upper Hunter Strategic Regional Land Use Plan* (Upper Hunter SRLUP) (DP&I 2012b). In particular, the AIS describes and maps agricultural resources in the Project Area and its regional landscape context. It also describes and analyses the agricultural production of the Project Area and the surrounding rural landscape (the Mount Owen Complex Locality).

2.1.2 SEPP Mining 2013

The *State Environmental Planning Policy (Mining, Petroleum, Production and Extractive Industries Amendment) 2013* requires certain types of development to verify whether the proposed site is on BSAL and whether the Gateway Process applies to the development application. The Proposed Disturbance Area is wholly contained within existing Mining Leases, so is not subject to the Gateway Process. However, the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OAS&FS 2013) requires that regional scale mapping of BSAL is verified for all land within the Project Area, including surrounding land owned by Mount Owen and offset areas. The verification of BSAL within the Project Area has been undertaken as part of the detailed identification of soil resources (refer to **Appendix 1**).

For clarity and completeness, the AIS includes details of verification of landforms, soil types and land and soil capability occurring across the Proposed Disturbance Area, based on soil survey and sampling at the 1:25,000 scale.

2.1.3 Upper Hunter Strategic Regional Land Use Plan

The AIS evaluates the potential for the Project to impact on:

- Agricultural land that is mapped in the Upper Hunter SRLUP as BSAL (or could be mapped as BSAL), within or in close proximity (within 10 kilometres) to the Project Area. For land to qualify as BSAL in the Upper Hunter SRLUP, it must be land with a Land and Soil Capability (LSC) Class of either 1 or 2 and have moderate to high soil fertility (refer to **Section 3.5** for detail). Access to quality agricultural water supply is also considered. Class 3 land may also qualify as BSAL if it has high soil fertility. BSAL within the Proposed Disturbance Area has been assessed and mapped using the *Interim protocol for site verification and mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013).
- Agricultural land that is within a Critical Industry Cluster (CIC), within or in close proximity to the Project Area.
- Agricultural resources of the Proposed Disturbance Area and the surrounding locality.
- Other agricultural land uses and infrastructure, within or in close proximity to the Project Area, or where relevant, more broadly in the region.

An overview of how the assessment has been conducted is in **Section 2.3** with details of methods for specific tasks provided in relevant sections.

2.2 Agricultural Impact Statement Guideline Requirements

The DP&E have issued guidelines (DP&I 2012a) which were supported by technical notes (DPI 2013a) for the preparation of agricultural impact statements. Specific requirements of the guidelines and technical notes are summarised in **Table 2.2**, which also identifies the relevant section of the AIS where the required information is provided.

Table 2.2 – Summary of AIS Guidelines

Assessment Requirement	Relevant Section of AIS
PROJECT AREA¹	
Detailed assessment of the agricultural resources and agricultural production of the Project Area.	Sections 3.0 and 4.4
Sampling of soils in the Proposed Disturbance Area at a scale of 1:25,000 or larger, targeted after desktop analysis of spatial variations in landscape and soil types.	Section 3.7
A table showing the area of land and soil capability (LSC) Classes in the Project Area, before and after mining.	Section 5.1 and Table 5.1
Verification assessment and mapping of biophysical agricultural land in the Project Area and buffer zones and offset areas.	Section 3.8
Ten years of history of agricultural enterprises in the Project Area, including crop yields and stock numbers where possible. Include information on management, such as fertiliser inputs, levels of cultivation, livestock intensity etc.	Section 4.4
Location (mapped) and areas of land to be temporarily and permanently removed from agriculture during and post mining. Provide evidence to support proposed sustainable land capability for any land proposed to be returned to agriculture. Map and explain any reductions in agricultural land or productivity. Identify and map buffer and offset areas and proposed agricultural uses of these areas.	Sections 5.3, 5.4 and 5.5 Figure 5.1 and Tables 5.1 and 5.3 Sections 6.1.2, 6.4, 6.5, 6.7, Tables 6.1 and 6.2
SURROUNDING LOCALITY	
Identify the agricultural resources within the surrounding locality of the Project Area. The AIS must contain maps/information of the locality surrounding the Project, which describes existing agricultural resources.	Sections 3.1 to 3.5
Use available soil maps and terrain mapped with a minimum of 20 m contour intervals.	Section 3.6.1 and Figures 3.10, 3.11, 3.12, 3.17, 3.18 and 3.19
Provide information about water resources and extraction locations.	Section 3.2
Provide information about vegetation type and condition, particularly if the vegetation has a bearing on the agricultural resources of the locality.	Section 3.3
Describe climate conditions as they relate to agriculture, using data from Bureau of Meteorology.	Section 3.1
Describe current agricultural enterprises and commodities being produced in the surrounding locality. Identify locations and production levels of different commodities and variations over time, as affected by market conditions and climate variability.	Section 4.3
Identify and assess the impacts of the Project on agricultural resources or industries, including land and/or agricultural infrastructure that would be temporally or permanently removed from production. When referring to agricultural resources, consider both biophysical resources and infrastructure.	Section 5.0, particularly Sections 5.3, 5.4 and 5.5
Present a risk matrix for each possible consequence of the project (as per Appendix 3 of Interim Protocol for site verification and mapping of BSAL).	Table 2.3
Identify uncertainty associated with the project's impacts and proposed mitigation measures.	Section 8.2

Table 2.2 – Summary of AIS Guidelines (cont.)

Assessment Requirement	Relevant Section of AIS
Consider indirect risks such as: weeds, feral animals and other pests/diseases that could affect agricultural productivity. Impact of dust on agriculture; impact of vibration and explosions on animal welfare; impacts of noise on surrounding properties (on humans and animals).	Section 6.5.1 Sections 5.5.1 and 5.5.2
Account for any physical movement of water away from agriculture.	Section 5.1.3
Assessment of Socio Economic Impacts. The AIS must include description (and quantification) of impacts on: • agricultural support services; • processing and other value adding industries; and • visual amenity, landscape values and tourism infrastructure for farm based agricultural tourism. Describe and quantify the impact on the pool of labour for agriculture and whether labour will be sourced from outside the locality (e.g. FIFO). Identify relevant critical mass thresholds of agricultural enterprises needed to attract and maintain investment in agriculture.	Sections 5.5 and 5.6
In quantifying impacts on current levels of agricultural support services, processing and value adding industries, consider the extent to which mining is the 'causal' factor.	Section 5.7
Identify and cost options for minimising adverse impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level: • describe project alternatives; • describe monitoring programs to assess predicted versus actual impacts and consultation with affected land users; • describe measures to manage mine impacts in adverse conditions (such as trigger points for production to cease in dry, windy conditions); • discuss assumptions made about the effectiveness of mitigation /remedial actions; and • all proposals for rehabilitation to a specified standard should be backed up with evidence (previous successful examples and/or peer reviewed journal articles).	Section 6.0 These are discussed in the main volume of the EIS and in Sections 6.4, 6.5, 6.6 and 6.7
Document consultation with adjoining land-users and government departments, including a consultation strategy and results of its implementation.	Section 2.3.4, Section 4.3.3 and Section 4.4.2

¹ The assessment has concentrated on the determination of impacts within the Proposed Disturbance Area, as it represents the area that has not previously been approved for disturbance.

2.3 Scope and Method of Assessment

The scope of assessment for the AIS is determined by the DGRs (refer to **Section 2.1**) for the Project and the requirements of the *Guideline for Agricultural Impact Statements* (DP&I 2012a), the *Agricultural Impact Statement Technical Notes* (DPI 2013) and the *Upper Hunter Strategic Regional Land Use Plan* (Upper Hunter SRLUP) (DP&I 2012b). This section discusses the information and approach used to prepare the AIS and to evaluate the proposed management of risks to agricultural resources and enterprises that may occur as a result of this Project.

2.3.1 Data and Methods

The AIS has taken into account the following information:

- A preliminary risk scoping exercise based on desk top review of relevant literature on land capability, land use and rehabilitation, and regional agricultural production data, as well as initial input from local landholders, collected during the consultation phase. The preliminary risk assessment informs the level of detail required in the definition of agricultural resources and assessment of impact.
- Regional scale mapping of land and soil resources, prepared by the NSW Soil Conservation Service and others over the last 20 years.
- Regional scale mapping of Land and Soil Capability (LSC) and soil fertility prepared for the *Upper Hunter Strategic Regional Land Use Plan* (DP&I 2012b).
- Detailed terrain mapping using contours produced from LiDAR analysis and aerial photogrammetry, both dated 2012.
- Site inspection, detailed soil survey and soil sampling. Samples of topsoil and subsoil tested by a NATA registered laboratory for parameters set out in references identified in the AIS Technical Notes (DPI 2013a). Further details are provided in **Section 3.4.2** and **Appendix 1**.
- Desktop mapping and ground truthing of actual land use in the local context of the Project.
- Regional statistical information on agricultural production.
- Interviews with local land holders and land managers, including the manager of Colinta Holdings Pty Ltd (Colinta) who currently manages agricultural production within the area surrounding the existing Mount Owen Complex.

2.3.2 Review of other biophysical, social and economic studies as they relate to agriculture. Integration of Physical Resources and Socio-Economic Studies

The AIS addresses the biophysical resources (which support agricultural land uses) of the landscape (i.e. Project Area and the Mount Owen Complex Locality). It also considers the value of agricultural land use to the communities that live in this landscape in terms of social well being and economic viability.

Close interaction and feedback between these biophysical and socio-economic values is a feature of the regional landscape over the entire period of European settlement in the Upper Hunter, with the condition of the biophysical resources and farmer choices about agricultural enterprises and products varying with climate variability, land management practices, regulation, social trends and economic conditions.

To provide a thorough analysis of the potential impact of the Project on agricultural resources and agricultural land uses and communities, the AIS draws on several other studies which have been completed as part of the EIS for the Project to provide detailed analysis of water and biodiversity resources, social issues and economic issues associated with agricultural resources and land uses.

Relevant detailed technical reports prepared for the Project, which have informed the AIS, include:

- Economic Impact Assessment;
- Social Impact and Opportunities Assessment;
- Surface Water Assessment;
- Groundwater Impact Assessment;
- Historic Heritage Assessment;
- Ecological Assessment; and
- Mine Closure and Rehabilitation Strategy.

A key issue for both the Project and for rural land users in the locality is how the landscape, land use and socio-economic future of the region should be shaped both during and post-mining, to sustain strong social values but also to maintain and enhance the biodiversity and economic prosperity of the region (including agriculture and other land uses). This broader context of post mining land use and ongoing engagement regarding land use and land management issues is discussed in **Section 6.0**.

2.3.3 Preliminary Agricultural Risk Assessment

The *NSW Interim Protocol for Site Verification and Mapping of Strategic Biophysical Agricultural Land* (OEH and OASFS 2013) requires the preparation of a risk assessment as part of the scoping process for agricultural impact assessment and for determining the appropriate sampling strategy for mapping and analysis of soil characteristics.

The Proposed Disturbance Area is entirely within existing Mining Lease Areas (refer to **Figure 1.4**) and is therefore not subject to the Gateway process specified in the 2013 Mining SEPP. The proposed Project Area includes a small area of land mapped at the regional scale as BSAL in the *Upper Hunter Strategic Regional Land Use Plan* (DP&I 2012) associated with the proposed Hebden Road Upgrade (refer to **Section 3.7.2** for information about the verification of soil types and capability in this area).

Detailed soil survey, testing and assessment found that this land does not meet the criteria for BSAL (refer to **Section 3.8.2**).

2.3.3.1 Risk Assessment Method

A preliminary agricultural risk assessment was conducted for the Project. This risk assessment considers the potential scope and significance of impacts of the Project on agricultural resources and industries, taking into consideration methods outlined in:

- *NSW Interim protocol for Site Verification and Mapping of Strategic Biophysical Agricultural Land* (OEH and OASFS 2013).
- The previous *Land Use Conflict Risk Assessment (LUCRA) Guide* (DPI 2011), which is aimed at identifying management strategies for potential land use conflicts which could help reduce the level of conflicts/risks effecting existing agricultural enterprises/land uses and proposed new uses.

- *SRLUP Guideline for Agricultural Impact Statements at the Exploration Stage* (DTIRIS 2012). The Guideline provides descriptors for likelihood and consequence to be used in Agricultural Impact Risk Assessment. These have been adopted in this assessment. The guideline distinguishes between short and long term (approximately 20 years) impacts on agricultural resources and also considers the extent to which impacts are irreversible. In relation to agricultural land uses and enterprises, the guideline requires assessment relating to agricultural enterprises to extend to farm productivity, land values and flow on impacts to regional communities.

2.3.3.2 Input information

The preliminary risk assessment was based on the existing regional scale mapping of soil types (land capability and soil landscapes), soil fertility classes, the extent of disturbance associated with the Project and existing land uses. Approximately half of the proposed North Pit Continuation area is currently regenerating native woodland. Existing 'agricultural' lands are currently managed on behalf of Glencore by Colinta and are used for a range of grazing enterprises.

2.3.3.3 Scoping Of Potential Aspects/Threats to Agricultural Resources and Land Uses

The focus of the risk assessment is potential risks associated with impacts of the Project on agricultural resources and agricultural industries/production. Direct impacts/risks within the Proposed Disturbance Area are considered separately to potential impacts/risks on surrounding lands. The proposed biodiversity offsets are considered as part of the surrounding locality.

The *SRLUP Guideline for Agricultural Impact Statements* (DP&I 2012a) defines the term 'agricultural resources or industries' as:

Agricultural resources: the land on which agriculture is dependent and the associated water resources. 'Land' is characterised by soil characteristics (types, depth, fertility, hazards), topography and slope, climate conditions and water resources; agricultural resources also includes key agricultural support infrastructure such as roads and railways for transporting produce.

Agricultural industries: industries that produce plants or livestock or are a directly associated service, processing or marketing industry, commercially reliant on agricultural products. Agricultural industries are made up of agricultural enterprises.

Table 2.3 lists aspects of agricultural resources and industries considered to be potentially impacted by the Project in the preliminary agricultural risk assessment. It also provides a brief commentary on each aspect.

Likelihood and consequence scores are based on descriptors used in Tables 8 and 9 of Appendix 3 of the SRLUP Guideline. Risk categories are determined according to Table 7 of Appendix 3 of the SRLUP Guideline.

The preliminary risk assessment identified three issues as potentially high risks to agricultural resources and enterprises:

- The potential impact of the Project on land/soil that is of moderate to high fertility;
- Potential permanent removal of productive agricultural land from agricultural use, outside of the Proposed Disturbance Area; and
- Indirect impacts on agricultural productivity and the amenity of rural communities, such as through changes to air quality or access to water resources.

These findings helped to shape the focus of the AIS assessment, which addresses these issues in detail. Other issues were assessed as moderate to low risks.

Table 2.3 – Preliminary Risk Scoping Risk Evaluation

Aspect	Likelihood	Consequence	Risk Category	Comments on AIS Findings
Site Specific (impact area)				
Direct impact to land	A	3	High	The Project will have a direct impact on land which has some physical agricultural resources, but which also has a number of constraints.
Impact to BSAL (regional map)	A	4	Medium	A small part (approximately 11 hectares) of the Project Area (Hebden Road Upgrade) is mapped as BSAL at the regional scale.
Impact to land and soil Class 1 and Class 2	E	3	Low	There is no Class 1 or 2 Land and Soil Capability (LSC) Class land mapped within or near the Project Area.
Impact to land that is moderate, moderately high or high soil fertility (Proposed Disturbance Area)	D	3	Medium	The proposed pit does not intersect any land mapped as being LSC Class 1 or Class 2.
Impact to land that is moderate, moderately high or high soil fertility (Infrastructure upgrade areas)	B	3	High	11 hectares of land mapped as a floodplain, and as BSAL at the regional scale. Note that detailed assessment shows that this land does not comply with the BSAL criteria, in relation to fertility.
Impact surface and groundwater drainage	B	4	Medium	Soil drainage characteristics of sandy soils on the Bowmans Creek floodplain/terrace will not be affected. Post mining soil drainage can be managed to minimise ponding or waterlogging hazard, by careful final landform design and soil rehabilitation.

Table 2.3 – Preliminary Risk Scoping Risk Evaluation (cont.)

Aspect	Likelihood	Consequence	Risk Category	Comments on AIS Findings
Change from non stony to stony soils	C	3	Medium	Post mining landform reconstruction and soil regeneration will tend to increase stoniness of soils (float, not outcrop), as overburden is used; limited topsoil replacement. Note: existing soils are often subject to severe sheet erosion; but stoniness is not the limiting factor for agricultural use.
Impact to soil chemical characteristics	B	4	Medium	Soils currently of low fertility; some are dispersible. Post mining soils will have similar chemical characteristics.
Site Specific (impact area) (cont.)				
Impact to rooting depth	C	4	Low	Current rooting depth likely to be less than 75 cm for most soils in Project Area (other than on Bowmans Creek floodplain).
Direct impact to existing agricultural enterprises private	E	4	Low	There is no private agricultural land in the Project Area. All land within the Proposed Disturbance Area is owned by Mount Owen.
Direct impact to existing agricultural enterprises currently managed by Colinta on Glencore owned land	A	2	Medium	The Project will impact on agricultural land and resources currently managed by Colinta within the Project Area. The direct impact is on lower quality land, not on the better quality land currently managed by Colinta along Glennies Creek
Direct impact to Critical Industry Clusters	E	4	Low	There are no CIC areas within 10 km of the Project.

Table 2.3 – Preliminary Risk Scoping Risk Evaluation (cont.)

Aspect	Likelihood	Consequence	Risk Category	Comments on AIS Findings
Off Site Impacts				
Impact to downstream water users	C	4	Low	No stream or creek diversions are required. Offsite draw down effects on groundwater are limited by Hunter Thrust.
Permanent / temporary impact to agriculture (offsite)	B	3	High	There is no impact, permanent or temporary, proposed to agricultural properties as a result of the Project.

Table 2.3 – Preliminary Risk Scoping Risk Evaluation (cont.)

Aspect	Likelihood	Consequence	Comments	Risk Category
Indirect impacts (amenity) to local farming activities (air/noise/blasting etc)	B	3	Within potential acquisition zone for the Project.	High
Soil erosion	D	3	Land management at Mount Owen Complex is highly regulated and controlled. Controls on surface runoff will be in place to ensure that there will be minimal change to sediment loads in surface runoff which may result in poor water quality offsite.	Medium
Land Management (Feral animals and invasive species and bushfire)	D	4	Land management at Mount Owen Complex is highly regulated and compliant with invasive species controls.	Low
Impact on critical industry cluster (equine or viticulture)	D	5	CIC lands are remote from this Project Area (more than 10 km distant).	Low
Impact on quality of BSAL land outside the Project Area	D	4	Local BSAL limited to parts of Bowmans Creek floodplain	Low

2.3.4 Consultation

The AIS Guideline (DP&I 2012a) requires information about engagement with stakeholders, including landholders and government departments.

Various local landholders, agricultural support industries and government agencies were consulted during the preparation of the EIS and specifically as part of this AIS to obtain an understanding of the nature of the agricultural industry in the area and how agriculture interacts with the mining industry at the local scale. The people and organisations consulted and the nature of the consultation are summarised in **Table 2.4**.

Offers of face-to-face meetings were made to potentially affected private agricultural landholders along Middle Falbrook Road. These agricultural and rural landholders are located between the Mount Owen and Integra Coal mines. Several landholders declined the opportunity for a meeting at their property.

Table 2.4 – Consultation Undertaken for Agricultural Impacts Statement

Organisation	Nature of Consultation
DPI Agriculture	Discussion about technical and reporting requirements at AIS training days. Phone conversations about specific soil testing and reporting requirements. Meeting and a site inspection to discuss draft AIS, impacts on agriculture and proposed management measures on 11 October 2013.
Two land holders (agricultural producers), Middle Falbrook Road	Face-to-face meetings and extended interviews at the properties, specifically about agricultural land use and production.
Local community members	Information days and open days at Mount Owen Complex about the Project. Face to face meetings about general environmental, social and economic issues; agriculture was mentioned in discussion at these meetings.
Property manager, Colinta	Extended phone interview.

A full response to submissions from agencies, local councils and the community and other stakeholders will be provided following public exhibition of the EIS.

A summary of comments provided in consultation during the preparation of the AIS is presented in **Table 4.7**. This information was used to qualify the potential impacts of the Project on local agricultural enterprises and communities.

3.0 Agricultural Resources within the Project Area and Region

In this section:

- Agricultural resources of the Mount Owen Complex Locality and the region (i.e. Singleton and Muswellbrook Local Government Areas (LGAs)) of the Hunter Valley – terrain, soils, climate, water resources and vegetation. These resources are the context for the Project Area.
- Agricultural resources of the Project Area – the quality and significance of agricultural resources in the Project Area.

At the regional scale, natural resources which are relevant to potential agricultural uses of the landscape have been mapped and documented in multiple studies in the Hunter Region over more than 30 years. Mapping of these resources is generally at scales of 1:100,000 to 1:250,000, suitable for distinguishing broad classes, spatial patterns and regional gradients of terrain, water supply, soil type and vegetation. Key references for understanding these regional patterns of agricultural resources include:

- Kovac M. and Lawrie J.W. (1991). *Soil Landscapes of the Singleton 1:250 000 Sheet*. Soil Conservation Service of NSW, Sydney.
- Office of Environment and Heritage (OEH). (2012). *The Land and Soil Capability Assessment Scheme; Second Approximation*.
- Regional soil fertility mapping (OEH 2012).
- Contour mapping at 1:25,000.
- Regional Vegetation maps, prepared for HCRCMA.
- Rainfall and climate statistics released by Bureau of Meteorology.
- *Water Sharing Plan for the Hunter Regulated River Water Source 2003* and *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*.

These regional studies, as they apply to the context locality of the Project Area, are outlined in **Sections 3.4** and **3.5**. Regional scale studies are also used to identify the resources of the three proposed offset properties.

3.1 Agricultural Resources - Climate and Climate Variability – Upper Hunter

Climate measurements including monthly rainfall distribution, evaporation, as well as maximum and minimum temperatures provide a key determinant of the agricultural potential of a district. Bureau of Meteorology (BoM) maintains a number of weather recording stations in the vicinity of Mount Owen Complex.

The Jerrys Plains Station (BoM Station 61086) has been used to characterise the rainfall and temperature data for the Upper Hunter region and the Project Area. The Scone SCS Station (BoM Station 61089) has been used to characterise the monthly evaporation. These records, presented in **Table 3.1**, have been selected as they are long term (recorded for over

100 years), considered to be representative of the Upper Hunter region and they are consistent with data used in analysis for other components of the EIS.

Table 3.1 – Mean Climate Statistics at Jerrys Plains and Scone

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	77.1	73.1	59.7	44.0	40.7	48.1	43.4	36.1	41.7	51.9	61.9	67.5	645.9
Max temp (°C)	31.7	30.9	28.9	25.3	21.3	18.0	17.4	19.4	22.9	26.2	29.1	31.2	25.2
Min temp (°C)	17.2	17.1	15.0	11.0	7.4	5.3	3.8	4.4	7.0	10.3	13.2	15.7	10.6
Monthly Evaporation – Scone SCS (mm)	220	174	155	105	68	48	56	84	117	155	183	220	1585
9am Relative Humidity (%)	67	72	72	72	77	80	78	71	65	59	60	61	70
3pm Relative Humidity (%)	47	50	49	49	52	54	51	45	43	42	42	42	47
9am wind speed (km/h)	9.6	9.0	8.8	8.6	9.0	9.4	10.6	11.0	11.7	10.9	10.5	9.9	9.9
3pm wind speed (km/h)	13.2	13.0	12.4	11.3	11.0	11.5	13.0	14.3	14.7	14.1	14.2	14.2	13.1

Source: BOM, 2012.

The rainfall of the Upper Hunter is summer dominant with 34 per cent of rainfall occurring in the three months December to February, compared with 20 per cent falling in the three months June to August. Sixty-one per cent of rain falls from October to March inclusive. The monthly evaporation exceeds rainfall in every month except June where evaporation is equal to rainfall.

The prevailing winds in winter are from the north-west direction, with winds in summer predominantly from the south-east. Wind speed is greatest from late winter through the spring, and lighter winds occur in autumn.

The climate of the central parts of the region is variable year on year and inter-decadally. Inter-decadal variability is associated with the Southern Oscillation Index (La Niña-like and El Niño-like periods). Examples of extended periods affected by these inter-decadal variations include a La Niña-like period from 1948 to 1976 (a period of heavier rainfall and higher flood frequency) and an El Niño-like period from 1977 to 2007 (a period of more frequent drought). Extended drought periods affect production on both floodplain lands and on hill country. Climate variability at a seasonal level also has a significant impact on agricultural production. This particularly includes seasons with below average rainfall or temperatures that can impact on the growth of pastures both in the affected season and into following seasons.

The region is affected by extreme rainfall and temperature events. These events can have major impact on agricultural production and access to markets, through flooding or ponding of cultivated floodplains and terraces. Extreme rainfall and temperature events relate to heat waves, cold snaps, floods and dry spells. In regard to temperature extremes, BoM defines very hot days as days with maximum temperatures greater than 40 degrees Celsius and very hot nights as nights with a minimum temperature above 25 degrees Celsius. Very cold days are defined as days with maximum temperatures less than 10 degrees Celsius and cold nights have minimum temperatures less than 5 degrees Celsius. Additionally, a 'warm spell' is defined as at least four consecutive days with daily maximum temperature above the 90th percentile. A 'cold spell' is defined as at least four nights with minimum temperature below the 10th percentile (BoM 2013).

For the Jerrys Plains weather station in the Upper Hunter, the top ten rainfall events (24 hour rainfall) over the last 60 years are:

- June 2007 134 millimetres
- February 1955 123.2 millimetres
- February 1950 103.9 millimetres
- June 1964 97.5 millimetres
- May 1981 89.2 millimetres
- May 1968 87.1 millimetres
- April 1964 86.6 millimetres
- June 1949 82.3 millimetres
- November 2007 82 millimetres
- January 1968 81.5 millimetres

Indicatively, the climate is suitable for a range of agricultural enterprises including permanent and annual horticulture, cropping enterprises and improved perennial and native pastures. The climate would support temperate to sub-tropical plants so long as there is a degree of frost tolerance or dormancy over winter. The growing season length would depend on the crop, however it would be reasonable to expect that temperate species would have suitable conditions for growth from September through to May inclusive and possible over the winter. Sub-tropical species could be expected to have a growing season of October through to March or April.

Permanent horticulture plantings and improved pastures would rely on irrigation to provide consistent productivity in this climate where there can be significant gaps between rainfall events and the evaporation rate is high.

3.2 Agricultural Resources - Water Availability in the Locality of the Project Area

The Project is located within the catchments of Bowmans Creek and Main Creek (which is a tributary of Glennies Creek). It is drained by a number of tributaries of Bowmans Creek. Both Bowmans Creek and Glennies Creek flow into the Hunter River, joining the Hunter River downstream of the Project Area. **Figure 3.1** shows the subcatchments within the Project Area and the broader catchment context of the Project Area.

The headwaters of Bowmans Creek are located in the Mt Royal Range and the upper catchment is deeply incised in steep bedrock terrain. The lower reaches of Bowmans Creek meander through a broad alluvial floodplain and terrace sequence that is up to 1 kilometre wide. The catchment area of Bowmans Creek within the Project Area has been reduced by the existing mining operations. Although previously disturbed by agriculture and mining activities, Bowmans Creek has sufficient contributing catchment to maintain flows under most climate conditions and has a well established channel.

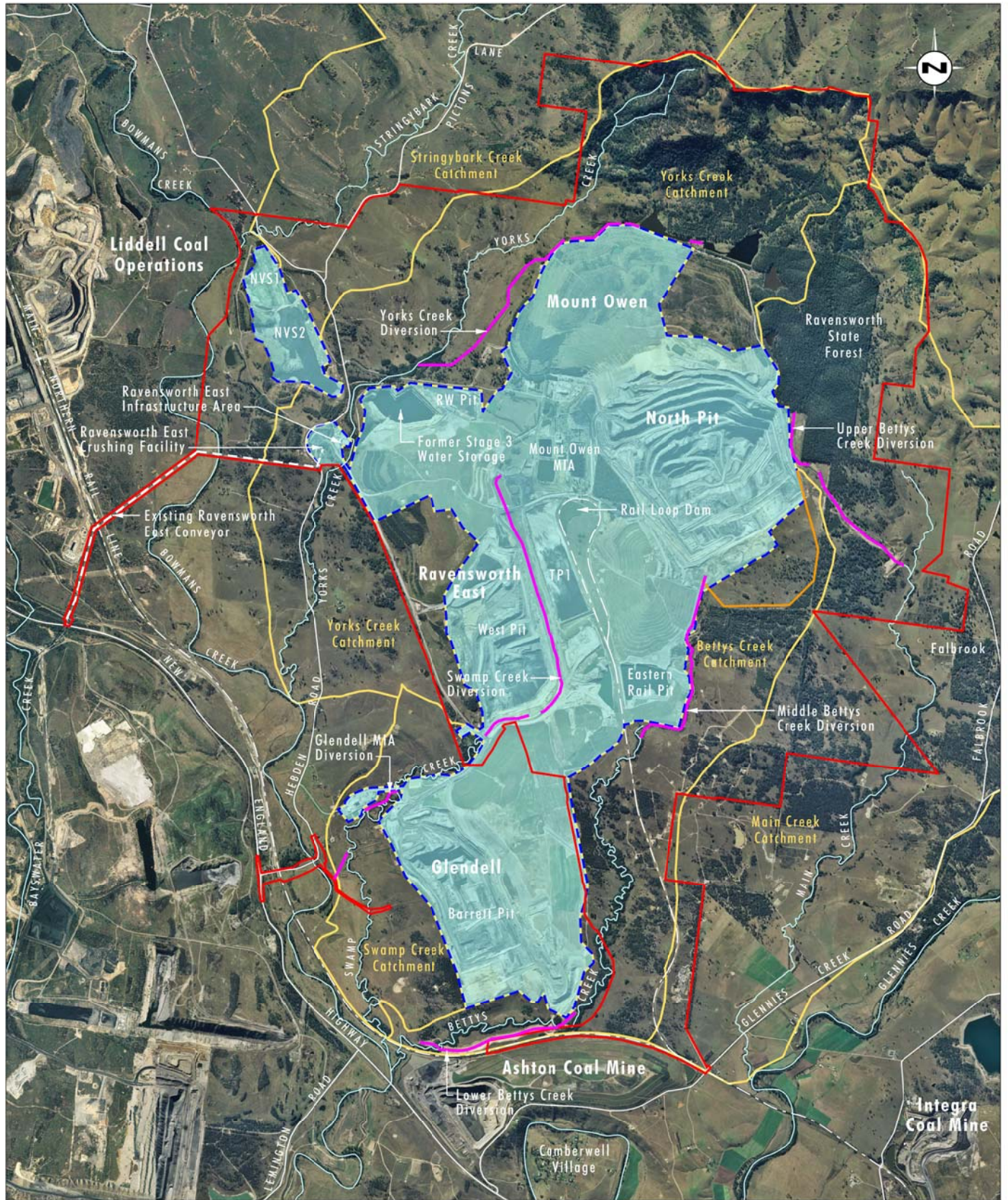


Image Source: Mount Owen (2012-2013)
Data Source: Mount Owen (2014)

0 1 2 3 km
1:60 000

Legend

- Project Area
- Approved North Pit Mining Extent
- - - Mount Owen Complex Water Management System Catchment
- Catchment Boundary
- Existing Diversion Channel

FIGURE 3.1

Project Area
Surface Water
Catchment Context

Surface water quality monitoring is currently undertaken within the Water Management System (WMS) and at various upstream and downstream locations on the creeks located near the Project Area. Water quality parameters monitored in watercourses upstream and downstream of the Project Area typically include monthly sampling of pH, electrical conductivity, total suspended solids and total dissolved solids. Existing water quality monitoring along Bowmans Creek indicates:

- pH is typically within the pH adopted trigger levels at monitoring locations both upstream and downstream of the WMS. Recent pH values are typically in the order of 8. The maximum historical pH level measured in Bowmans Creek is 8.3;
- electrical conductivity (EC) and total suspended solids (TSS) are typically below ANZECC trigger levels; and
- total dissolved solids (TDS) is typically within the trigger value.

Main Creek is a tributary of Glennies Creek and is an ephemeral creek system which ceases to flow in prolonged dry conditions. The majority of the catchment is open grasslands. The middle reaches of Main Creek have a well defined channel and mostly well-vegetated riparian zone. The lower portion of the catchment is farm land and the creek line is poorly defined. Main Creek flows in a southerly direction and joins Glennies Creek approximately 6.5 kilometres upstream of the Glennies Creek confluence with the Hunter River.

Existing water quality monitoring at two locations along Main Creek, downstream of the Mount Owen Complex, indicates:

- pH is typically below the ANZECC guideline trigger level of 8; and
- EC and TSS occasionally exceed the ANZECC guideline trigger levels.

DPI (2013b) states that water availability is one of the key constraints to agricultural development in the Upper Hunter region, due to the uncertainty around retaining access to reliable water supplies (in terms of quality and quantity) and competing demands (e.g. from mining, urban development, power generation, etc.).

Water access and water sharing strategies are defined in the *Water Management Act 2000* (WM Act). As part of the WM Act, Water Sharing Plans (WSPs) have been developed across NSW to protect the health of rivers, while at the same time securing sustainable access to water for all users. The WSPs specify maximum water extractions and allocations, and include rules for protecting the environment, extractions, managing licence holders' water accounts and water trading in the plan area. The Project is located in the plan area for the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*. The WSP applies to watercourses in the vicinity of the Project Area and to alluvial groundwaters.

The catchment of Bowmans Creek is located within the Jerrys Water Source (JWS) and the catchment of Main Creek is located within the Glennies Water Source (GWS) as defined in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009*. Within the JWS and GWS, the water requirements of holders of domestic and stock rights are estimated at 2.14 ML/day and 0.82 ML/day respectively. The share components of domestic and stock access licences authorised to extract water from these sources totals 7 ML/year for the JWS. There is a zero share component for the GWS. The share components of major utility access licences authorised to extract water from JWS is 7,700 ML/year. It is estimated that of the share components of unregulated river access licences authorised to extract water from JWS and GWS are 2,573 unit shares and 260 unit shares respectively. The share components of aquifer access licences authorised to extract water from JWS and GWS are zero unit shares in both water sources.

In addition, the Mount Owen and Ravensworth East Mines have 1,056 ML/year of high security entitlement and 861 ML/year of general security entitlement from Glennies Creek under licence.

Further information can be found in the Mount Owen Continued Operations Surface Water Impact Assessment (Umwelt 2014a).

3.2.1 Water Resources in the Project Area

3.2.1.1 Surface Flows

Bowmans Creek has four tributary catchments in, or adjacent to, the Project Area, namely Stringybark Creek, Yorks Creek, Swamp Creek, and Bettys Creek. Stringybark Creek is a 3rd order ephemeral waterway with a well defined channel, varying from confined areas with a relatively narrow width to wider open sections and is largely unaffected by the Project. Yorks Creek is a 3rd order ephemeral creek which typically has a defined channel several metres in width and approximately 1 to 1.2 metres in depth, with a relatively wide floodplain. Additionally, it is frequently dry and considered typical of 3rd and 4th order watercourses in the area. Swamp Creek is typical of 4th order watercourses in the area and is ephemeral and frequently dry with a creek channel that is narrow and well defined with wooded vegetation. Swamp Creek has been highly modified due to mining. Bettys Creek is an ephemeral creek system with flows only occurring during storm events or after prolonged periods of heavy rain; its catchment is highly modified.

As noted in **Section 3.2**, Main Creek is an ephemeral tributary of Glennies Creek.

There are no known licensed water users on waterways directly downstream of the Project Area along Yorks Creek, Swamp Creek, Bettys Creek or Main Creek; however, Mount Owen as the landholder adjacent to these creeks and drainage lines retains riparian rights to water in these creeks for domestic and stock use.

Further details regarding surface water in the Project area can be found in the Mount Owen Continued Operations Surface Water Assessment (Umwelt 2014a).

3.2.1.2 Groundwater

Two types of groundwater are found in the Project Area or its immediate catchment context. These are:

- the alluvial aquifers of:
 - Bowmans Creek and its ephemeral tributaries (Yorks, Bettys and Swamp Creek);
 - Glennies Creek and its ephemeral tributary Main Creek; and
- the hard rock aquifer associated with the coal measures.

The water quality within the hard rock aquifers can vary significantly, with the coal seam related groundwater exhibiting a water quality that is of no agricultural benefit due to high salinity. The water held in the coal measures is of poor quality being mostly brackish to saline and low yield. Coal measures in the vicinity of the Project are already partially depressurised as a result of currently approved mining activity.

There are no substantial alluvial systems likely to be impacted by the Project. Furthermore, the nearest private bores, beyond 4 kilometres, are unlikely to be significantly impacted by the Project.

Further details regarding groundwater in the study area can be found in the Mount Owen Continued Operations Groundwater Impact Assessment (SKM 2013).

3.2.1.3 Water Reliability

The *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013) states that the whole of the Upper Hunter has access to reliable water supply. This is stated to be because the area meets the criteria of having 'rainfall of 350 millimetres or more per annum in 9 out of 10 years or the area is underlain by a groundwater aquifer with a bore yield rate greater than 5 L/s and total dissolved solids of less than 1500 mg/L' (OEH and OASFS 2013).

Jerrys Plains Station (BOM Station 61086) indicates the annual average rainfall is 644.5 millimetres based on records between 1884 and 2012 (refer to **Section 3.1**).

3.3 Agricultural Resources - Significant Vegetation Communities – Regional Context

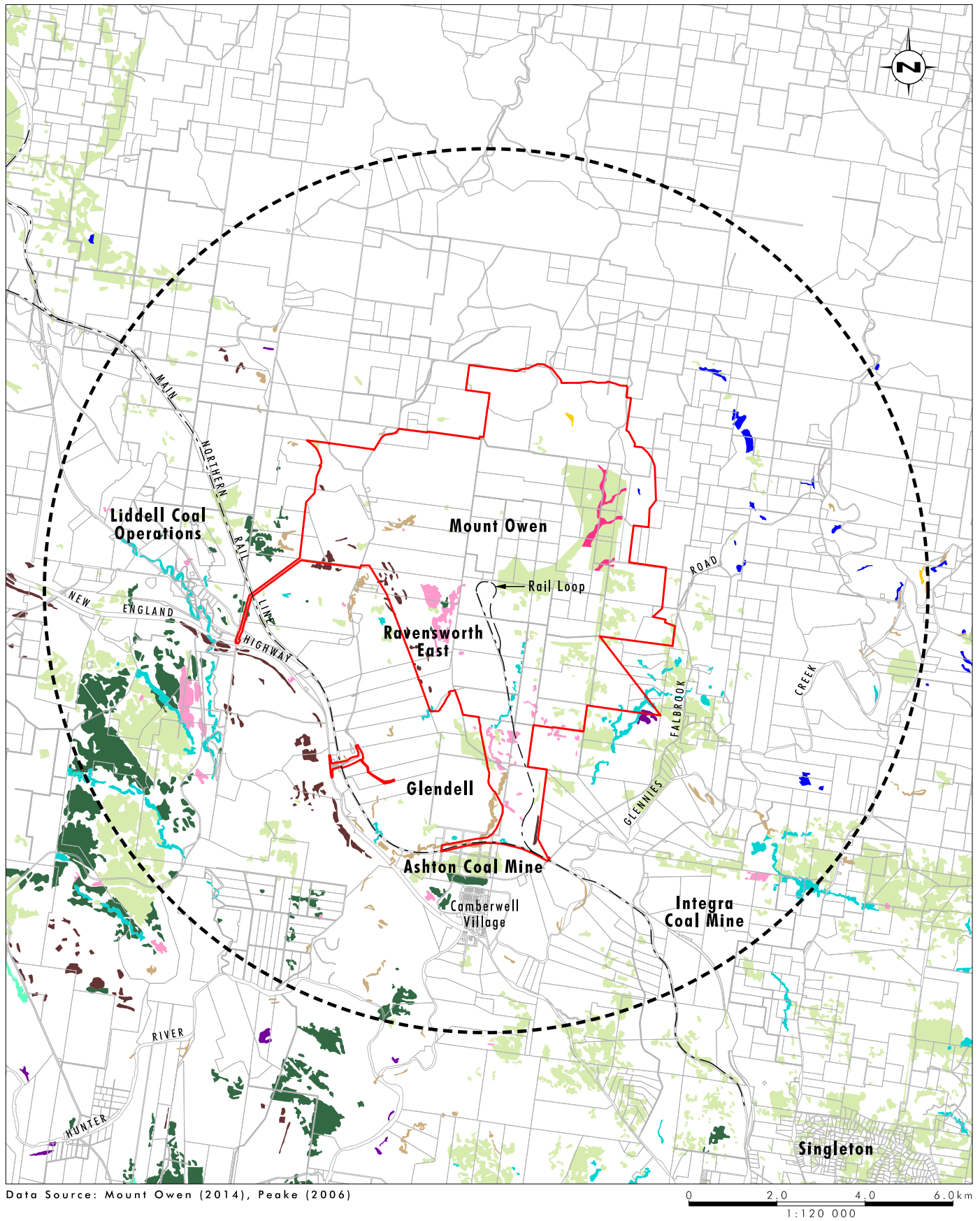
A key feature of the vegetation of the valley floor of the Upper Hunter region is the extent of clearing that has occurred since European settlement. The region has been subject to a long history of vegetation clearing for agricultural purposes (e.g. grazing and cropping) and more recently, open cut coal mining. This has led to the current condition where the woodlands and forested communities in the region have become highly fragmented. Naturally forested areas are primarily confined to the steeper land that has always been considered unsuitable for agriculture. These areas have uses other than agriculture, including forestry, conservation, tourism and military training.

Further details regarding vegetation in the Project Area and surrounding locality can be found in the Ecological Impact Assessment Mount Owen Continued Operations Project (Umwelt 2014b).

The areas surrounding the Project Area are predominantly composed of remnants of valley floor woodlands and forests (often scattered remnant trees or regrowth) and native and exotic pastures derived from the clearing of woodlands.

Peake (2006) mapped Hunter Valley floor vegetation on behalf of the Hunter Central Rivers Catchment Management Authority (HCRCA), with the vegetation community classification and mapping referred to as the Hunter Remnant Vegetation Project (HRVP). That study area covered approximately 315,000 hectares stretching from Scone in the north to Denman in the south-west and Branxton in the south-east (refer to **Figure 3.2**).

Peake (2006) delineated 36 vegetation communities in the central Hunter Valley, comprising five rainforest communities, 16 woodlands, 13 open forest communities, one heath and one (unnatural) plantation community. Six are listed as threatened ecological communities (TECs) under the *Threatened Species Conservation Act 1995* (TSC Act), while a further five communities have been nominated for listing since the report was published. Twenty-two of the 36 identified communities meet the criteria for listing as EECs under the TSC Act or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the remaining 13 naturally-occurring vegetation communities are either restricted or limited in extent (Peake 2006). The distribution of Endangered Ecological Communities (EECs) now constrains further clearing for agricultural land uses.



Legend

- Project Area
- Mount Owen Complex Locality (10km Radius from Rail Loop)
- Barrington Footslopes Complex Dry Rainforest
- Barrington Footslopes Dry Spotted Gum Forest
- Central Hunter Box - Ironbark Woodland
- Central Hunter Bullock Forest Regeneration
- Central Hunter Ironbark - Spotted Gum - Grey Box Forest
- Central Hunter Swamp Oak Forest
- Hunter Floodplain Red Gum Woodland Complex
- Hunter Lowlands Red Gum Forest
- Hunter Valley River Oak Forest
- Narrabeen Footslopes Slaty Box Woodland
- Planted areas

FIGURE 3.2
Hunter Valley
Remnant Vegetation

As shown in **Figure 3.3** vegetation communities in the Project Area have been surveyed and mapped (Umwelt 2014b) and include:

- Central Hunter Grey Box – Ironbark Woodland (EEC – TSC Act);
- Central Hunter Bulloak Forest Regeneration;
- Barrington Foothills Dry Spotted Gum Forest;
- Central Hunter Swamp Oak Forest;
- Dry Rainforest;
- Central Hunter Ironbark – Spotted Gum – Grey Box Forest (EEC – TSC Act) (also present in the proposed Cross Creek Offset Area);
- Planted Ironbark – Spotted Gum – Grey Box Forest (EEC – TSC Act);
- Derived Native Grassland;
- Kunzea Closed Shrubland;
- Hunter Lowland Red Gum Forest (EEC – TSC Act);
- Hunter Foothills Sheltered Forest; and
- Hunter Valley River Oak Forest.

3.3.1 Vegetation of the Project Area and Offset Areas

Remnant vegetation occurring in the Project Area comprises approximately 1,355 hectares of woodland, forest and riparian vegetation (the remnant), making it one of the largest remnants of native vegetation in the Hunter Valley, with Myambat Military area (2,251 hectares), Wybong Uplands (2,067 hectares) (which includes the approved Mangoola mining area), Singleton Military Area south and east (2,020 and 1,681 hectares respectively) the only remnants greater in area (Peake 2006).

Habitat and condition assessments were completed as part of the Ecological Impact Assessment (Umwelt 2014b) completed for the EIS, with results indicating that Woodland/Forest, Riparian, Shrubland and Grassland formations in the Project Area are in good condition.

The central location of the vegetation in the Mount Owen Complex Locality (including the Proposed Disturbance Area and the adjacent Ravensworth State Forest and Mount Owen Biodiversity Offset areas (refer to **Figures 1.3** and **3.3**) increases its importance due to its functionality as a fauna refuge and ‘stepping stone’ in a highly fragmented landscape. The remnant vegetation is considered to provide an important link in the generally north/south movement of highly mobile species, from other sizeable remnants in the north-west such as those of Antienne, to large remnants to the south-east and south-west of the Project Area, including remnants in Jerrys Plains.

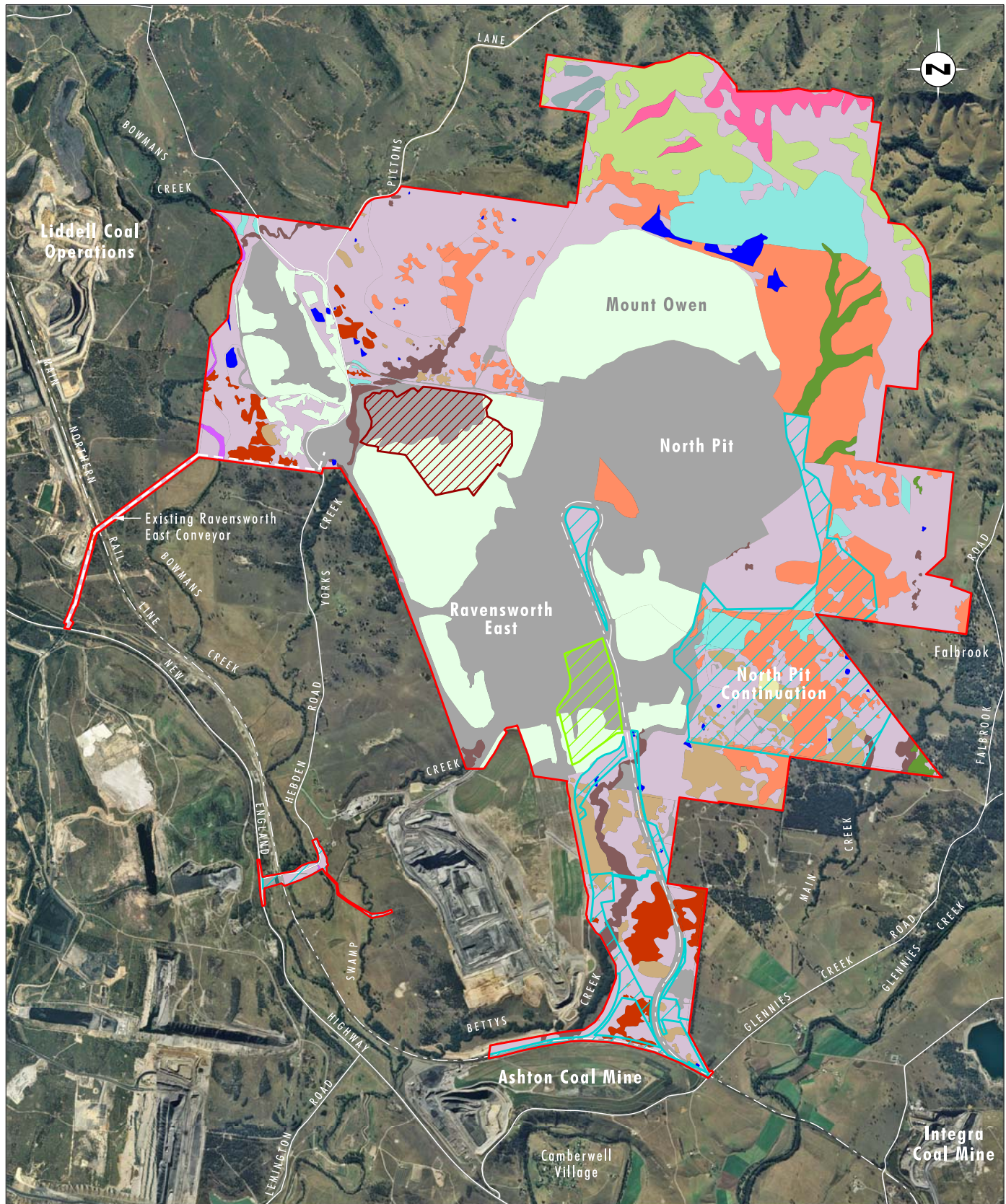


Image Source: Mount Owen (2012-2013)
Data Source: Mount Owen (2014)

0 1 2 3 km
1:60 000

Legend

- | | | |
|---|--|--|
| Project Area | Central Hunter Ironbark - Spotted Gum - Grey Box Forest | Water Body |
| Proposed Disturbance Area | Central Hunter Grey Box - Ironbark Woodland | Mine Rehabilitation |
| Bayswater North Pit | Derived Native Grassland | |
| Proposed RERR Mining Area | Dry Rainforest | |
| Disturbed Land | Hunter Lowland Red Gum Forest | |
| Barrington Footslopes Dry Spotted Gum Forest | Hunter Footslopes Sheltered Forest | |
| Central Hunter Bullock Forest Regeneration | Hunter Valley River Oak Forest | |
| Central Hunter Swamp Oak Forest | Planted Ironbark - Spotted Gum - Grey Box Forest | |
| | Kunzea Closed Shrubland | |

FIGURE 3.3

**Vegetation Communities
within the Project Area**

Further from these valley floor remnants the vegetation in the Project Area provides a central stepping stone between the conserved habitats of Mt Royal and Barrington Tops National Parks to the north and Wollemi National Park to the south. Connectivity to the east and west of the Project Area is limited due to extensive areas of cleared agricultural land and adjoining open cut mining operations.

The native vegetation in the Project Area has significant conservation value and is also the baseline from which local biodiversity corridors can be restored. Native vegetation is a valuable long term land use for the Project Area. **Figures 3.3 to 3.6** show the distribution of EECs in the Project Area and in proposed biodiversity offset areas. The extent of EECs in Esperanga offset largely precludes further clearing for agriculture and is a significant constraint to expanding or intensifying agricultural uses.

Vegetation communities of the Cross Creek Offset Area, Esperanga Offset Area and Stringybark Creek Habitat Corridor are provided in **Tables 3.2 to 3.4** below.

Table 3.2 – Vegetation Communities Present on the Cross Creek Offset Area

Vegetation Community	Legal Status	Approximate Area (ha) ²
Central Hunter Ironbark – Spotted Gum – Grey Box Forest	EEC (TSC Act ¹)	37.2
- Red Gum variant	EEC (TSC Act)	14.5
Native Grassland	-	315.3
TOTAL		367

¹Threatened Species Conservation Act 1995

² Includes approximately 12 ha of existing Crown Roads

Table 3.3 – Vegetation Communities Recorded in the Esperanga Offset Area

Vegetation Community Name	Legal status	Approximate Area (ha)
Upper Hunter White Box - Ironbark Grassy Woodland	EEC and CEEC ¹	46
Spotted Gum Open Forest Complex on Sandstone		3.2
Shrubby White Box Woodland		9.2
Red Gum Open Forest on Alluvium/Colluvium		2.7
Narrabeen Sheltered Dry Forest		59.3
Narrabeen Ironbark Woodland		91
Derived Native Grassland (White Box Woodland)	EEC and CEEC	85.1
Derived Grassland (Red Gum Open Forest on Alluvium/Colluvium)		5.9
Derived Grassland (Narrabeen Ironbark Woodland)		0.4
TOTAL		302.8

¹CEEC stands for Critically Endangered Ecological Community listed under the *Environment Protection and Biodiversity Conservation Act 1999*

*Indicates numbers have been rounded.

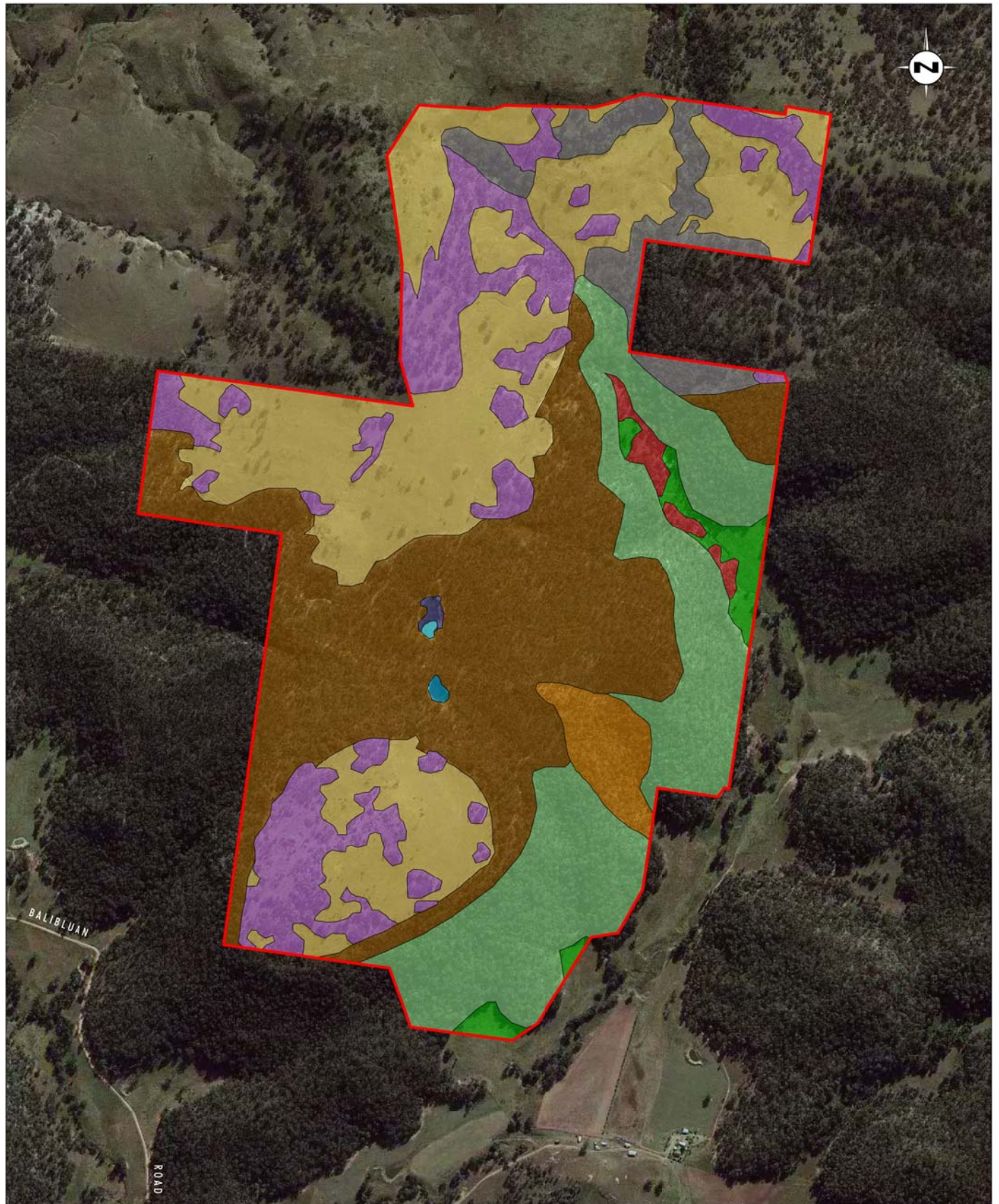


Image Source: Mount Owen (2009)
Data Source: Mount Owen (2013), Department of Lands (2009)

0 250 500 750m
1:15 000

Legend

- ▬ Esperanga Offset Area
- ▬ Derived Grassland (Narrabeen Ironbark Woodland)
- ▬ Derived Grassland (Red Gum Open Forest on Alluvium/Colluvium)
- ▬ Derived Native Grassland (White Box Woodland) (EEC - TSC Act, CEEC - EPBC Act)
- ▬ Narrabeen Ironbark Woodland
- ▬ Narrabeen Sheltered Dry Forest
- ▬ Red Gum Open Forest on Alluvium/Colluvium
- ▬ Shrubby White Box Woodland
- ▬ Spotted Gum Open Forest Complex on Sandstone
- ▬ Upper Hunter White Box - Ironbark Woodland (EEC - TSC Act, CEEC - EPBC Act)
- ▬ Water Body

FIGURE 3.4

**Vegetation Communities in the
Proposed Esperanga Offset Area**

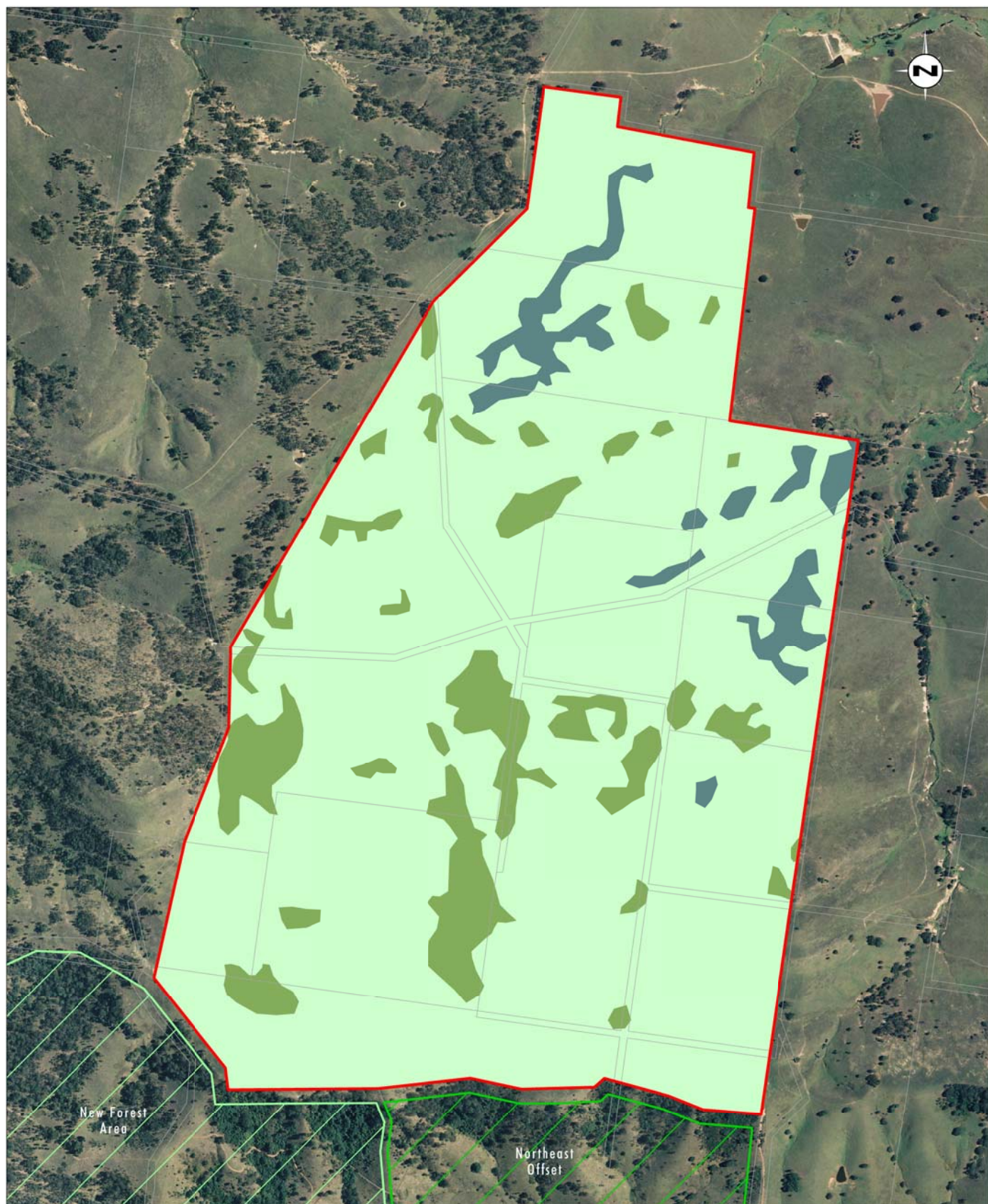


Image Source: Mount Owen (2012)
Data Source: Mount Owen (2013)

0 250 500 750m
1:15 000

Legend

- Cross Creek Offset Site
- Existing Offset Area
- Ravensworth State Forest
- Central Hunter Ironbark - Spotted Gum - Grey Box Forest (EEC - TSC Act)
- Central Hunter Ironbark - Spotted Gum - Grey Box Forest Red Gum Variant (EEC - TSC Act)
- Derived Native Grassland

FIGURE 3.5

Cross Creek Offset Area
Vegetation Communities

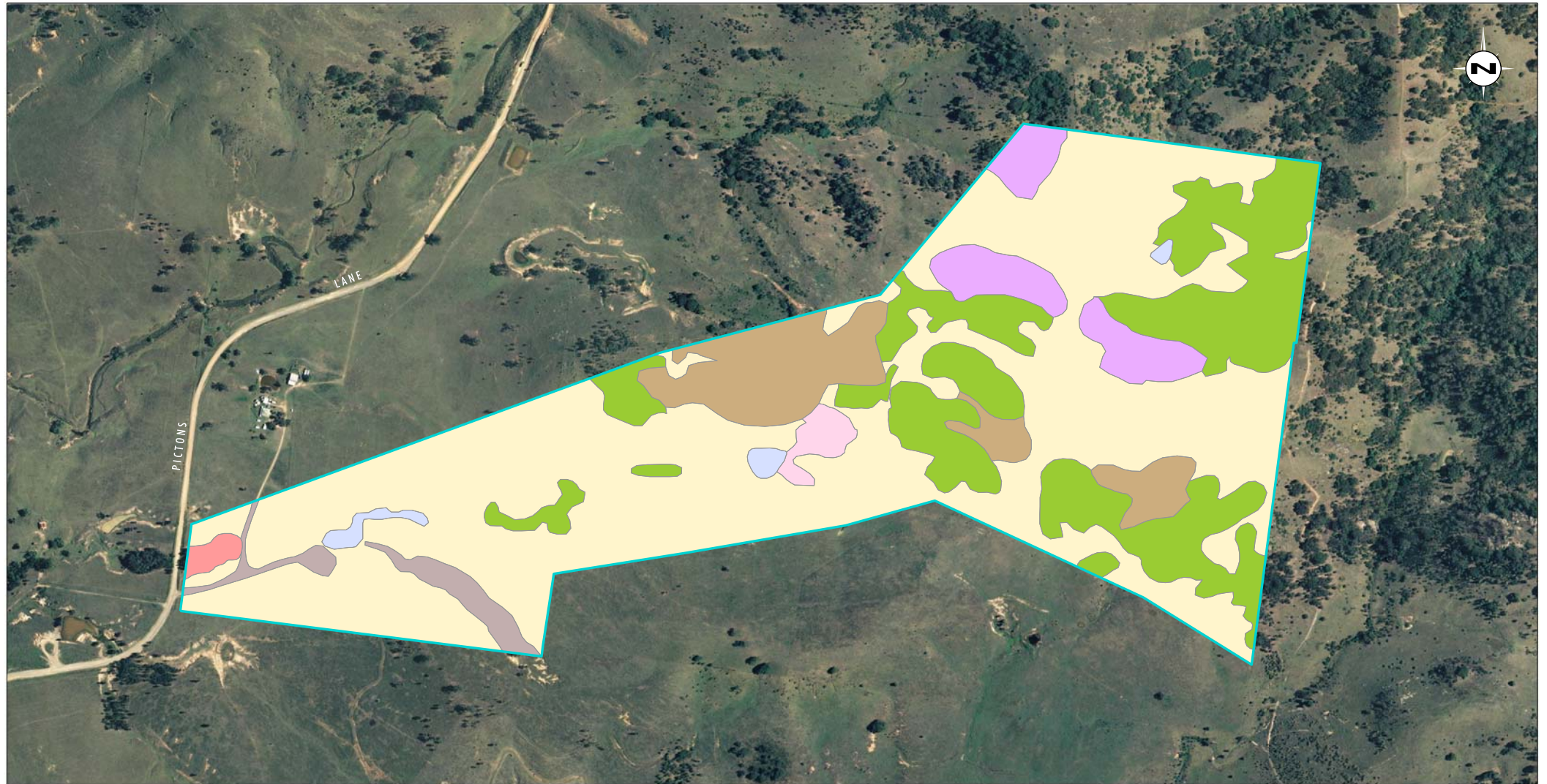


Image Source: Mount Owen (2012)

0 100 250 500 m
1:10 000

Legend

- | | |
|--|--|
| Stringybark Creek Habitat Corridor | Depauperate Dry Rainforest |
| Drainage Flat Red Gum Woodland (EEC) | Derived Native Grassland |
| Spotted Gum - Narrow-leaved Ironbark Forest (EEC) | Water Body |
| Swamp Oak Forest | Disturbed Land |
| African Olive Infestation | |

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20131129 11.11

FIGURE 3.6

Stringybark Creek Habitat
Corridor Vegetation Communities

Table 3.4 – Vegetation Communities Recorded in the Stringybark Creek Habitat Corridor

Vegetation Community Name	Legal status	Approximate Area (ha)*
Native Vegetation		
Spotted Gum – Narrow-leaved Ironbark Forest	EEC	21.6
Derived Native Grassland		58.8
Drainage Flat Red Gum Woodland	EEC	1.0
Depauperate Dry Rainforest		4.7
Swamp Oak Forest		0.5
Non-native Vegetation		
African Olive Infestation		8.0
TOTAL		94.6

*Indicates numbers have been rounded.

Further details regarding vegetation in the study area can be found in the Ecological Impact Assessment Mount Owen Continued Operations Project (Umwelt 2014b).

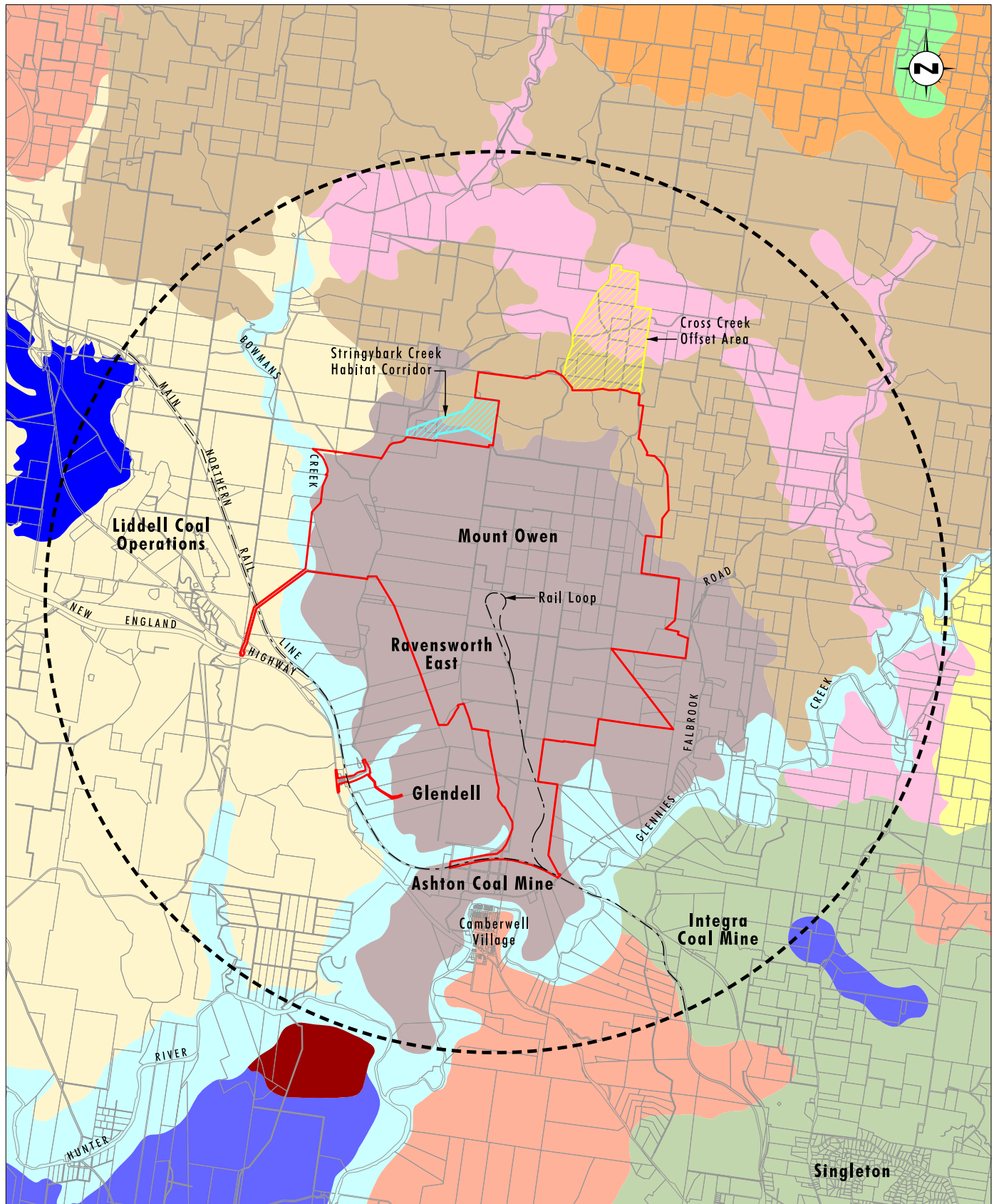
3.4 Regional Soil Landscapes

Soil landscapes are defined by distinctive associations of terrain, soil and vegetation at the landscape scale which provide an integrated picture of the physical character of the landscape.

For the Upper Hunter region, soil landscape mapping and descriptions were completed by Kovac and Lawrie (1991) at a scale of 1:250,000. These soil landscapes are detailed below (refer to **Table 3.5**). **Figure 3.7** illustrates the location of these soil landscapes as mapped by Kovac and Lawrie (1991) in a regional context, at a distance of up to 10 kilometres from the centre of the Project Area. Information regarding regional soil landscapes covering both proposed biodiversity offset areas is also included in **Table 3.5** and mapped on **Figure 3.7** (proposed Cross Creek Offset Area and Stringybark Creek Habitat Corridor) and **Figure 3.8** (proposed Esparanga Offset Area).

Key conclusions from this regional scale information regarding the landscape of the Project Area and Mount Owen Complex Locality include:

- other than the Hunter Soil Landscape which occurs on the floodplain and terraces of the Hunter River and its major tributaries (such as Bowmans Creek and Glennies Creek), the landscape is characterised by undulating to steep terrain, with erodible (susceptible to sheet and gully erosion), low fertility soils. Some higher fertility soils occur to the north of Singleton and the Glennies Creek Dam;
- soils are generally slightly to moderately acid;
- the minimum profile depth described for each soil landscape (35 to 40 centimetres) is widespread on upper to mid slopes; and
- lower slopes often have poorly drained soils with heavy clay B horizons.



Data Source: Mount Owen (2014)
Soil Landscapes: NSW Department of Environment,
Climate Change and Water (DECCW) (2010)

0 2.0 4.0 6.0 km
1:120 000

Legend

- Project Area
- Mount Owen Complex Locality
(10km Radius from Rail Loop)
- Cross Creek Offset Area
- Stringybark Creek Habitat Corridor
- Water
- Soil Landscapes:
- Rosevale
- Liddell
- Bridgelands
- Roxburgh
- Sedgefield
- Braxton
- Scrumlo
- Lethbridge
- Jerrys Plains

FIGURE 3.7

Regional Soil Landscapes

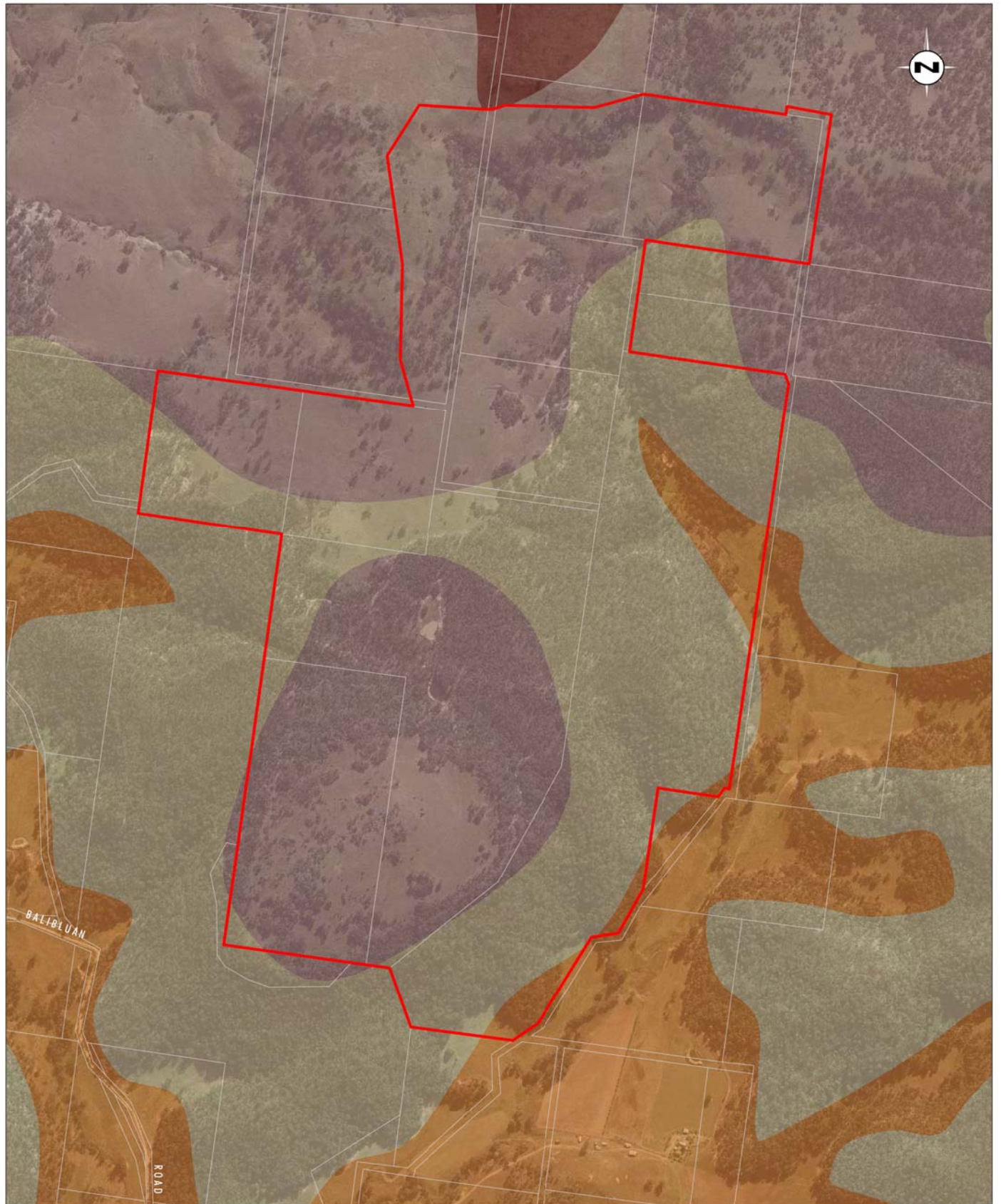


Image Source: Mount Owen (2009)
 Data Source: Mount Owen (2013), DECCW (2010), Kovacs & Lawrie (1991)
 Department of Lands (2009)

0 250 500 750m
 1:15 000

Legend

- Esparanga Offset Area
- Ant Hill
- Bow
- Sandy Hollow
- Lees Pinch

FIGURE 3.8

Esparanga Offset Area
 Soil Landscapes

Table 3.5 – Soil Landscape Characteristics

Soil Landscape	Terrain	Soil Profile Types	Other Characteristics	Hazards
Bayswater (Occurs in the Proposed Disturbance Area and the Stringybark Creek Habitat Corridor)	Covers undulating low hills south-west of Muswellbrook. The dominant soil landscape in the Project Area.	The main soils are Yellow Solodic and Yellow and Brown Podzolic soils occurring on slopes, and Alluvial Soils in drainage lines.	Profile depth 40-300 cm pH 5.5 to 7.0 Low soil fertility Poorly drained to well drained, with low to high water holding capacity.	Susceptible to moderate sheet and gully erosion on slopes. The erodibility is moderate to high and the soil salinity risk is low to high.
Rosevale (Cross Creek Offset Area and the Stringybark Creek Habitat Corridor)	Predominantly covers rolling hills to the north of Glennies Creek Dam.	The main soils are Red and Brown Podzolic Soils on the upper to lower slopes and on the steeper sections of footslopes of the Isismurra and Woolooma Formations. Yellow Soloths occur on midslopes and Euchrozems also occur on upper slopes.	Profile depth 30-110 cm pH 5.5-8.0 Low to moderate fertility Drainage varies from rapid and imperfectly drained, to well drained. Low to moderate water holding capacity.	Susceptible to minor to moderate sheet erosion on cleared areas and mass movement on steeper slopes. Low soil salinity.
Hunter (occurs in the Proposed Disturbance Area)	Occurs throughout the floodplains of the Hunter River and its tributaries.	The main soils of this landscape are all formed in alluvium.	Profile depth 40-300 cm pH 5.5-7.5 Low to moderate soil fertility Drainage varies from rapid and imperfectly drained, to moderately well drained. Low to high water holding capacity.	Susceptible to minor stream bank erosion on watercourses and minor sheet and gully erosion.
Liddell	Covers undulating low hills and undulating hills in the Liddell Power Station area.	The main soils are Yellow Soloths on the slopes with some Yellow Solodic Soils on concave slopes. There are Earthy and Siliceous Sands on mid to lower slopes where the parent material is more sandy.	Profile depth 50-110 cm pH 6.0-6.5 Low soil fertility Poorly to well drained, with low to moderate water holding capacity	The soils are susceptible to low to high topsoil erosion and have high to very high erosion hazard.

Table 3.5 – Soil Landscape Characteristics (cont.)

Soil Landscape	Terrain	Soil Profile Types	Other Characteristics	Hazards
Lethbridge	Covers rolling low hills to the north of Singleton.	The main soils are Red-Brown Earths on the steeper upper slopes with Yellow Solodic Soils in drainage lines. Red Earths and Brown Clays occur on less steep slopes.	Profile depth 70 to 100 cm pH 5.5-6.5 Low to high soil fertility Imperfectly to well drained, with moderate to high water holding capacity.	Susceptible to severe gully erosion in some drainage lines and minor to moderate sheet erosion on hillslopes. Low to high soil salinity.
Roxburgh	Covers undulating low hills and undulating hills.	Yellow Podzolic Soils occur on upper to midslopes with Red Solodic Soils on more rounded hills. Lithosols occur on crests, Brown Podzolic Soils occur on slopes on conglomerate.	Profile depth 35-140 cm pH 5.5-7.5 Low soil fertility Poorly drained to well drained, with low to moderate water holding capacity.	Susceptible to minor to moderate sheet erosion. Low to high soil salinity.
Jerrys Plains	Covers the undulating hills to the south and west of Jerrys Plains.	The main soils are Soloths on the crests to midslopes, with Solodic Soils on the lower slopes and in the drainage depressions.	Profile depth 60-300 cm pH 6.0-8.5 Low soil fertility Poorly to moderately well drained, with moderate water holding capacity.	Susceptible to severe gully erosion in some drainage lines with areas of severe salting also occur in many of the drainage lines. Susceptible to minor sheet erosion on some disturbed areas on hillslopes. Low to high soil salinity.
Sedgefield	Covers undulating low hills north of Singleton.	The main soils are Yellow Soloths on the upper midslopes with Yellow Solodic Soils on lower slopes and in drainage lines. Black Soloths may also occur in areas of seepage on the slopes.	Profile depth 60 to 100 cm pH 6.0-6.5 Low soil fertility Imperfectly drained, with low to moderate water holding capacity.	Susceptible to severe gully and sheet erosion on many slopes and in drainage lines. High soil salinity.

Table 3.5 – Soil Landscape Characteristics (cont.)

Soil Landscape	Terrain	Soil Profile Types	Other Characteristics	Hazards
Greenland (Cross Creek Offset Area)	Covers small areas of undulating low hills to the north of Singleton.	The main soils are Yellow Podzolic Soils on the lower flats with Yellow Earth-Soloth intergrades on upper slopes. Alluvial soils occur in drainage lines.	Profile depth 75-80 cm pH 6.0-6.5 Low to moderate soil fertility Drainage varies from rapid and imperfectly drained, to well drained. Low to moderate water holding capacity.	Susceptible to minor rill erosion on clear slopes and minor stream bank erosion in major drainage lines. Low to moderate soil salinity.
Ant Hill (Esparanga Offset Area)	Common in the Merriwa plateau region, often associated with basalt (or alluvium derived from basalt), on rolling low hills and hills. Distinctive white box/yellow box vegetation.	Main soils are black earths, with red and brown clays. Euchrozems on well drained slopes (limited distribution).	Profile depth 60-80 cm pH 7-9 High fertility, but may have Nitrogen and Sulfur deficiencies. Low salinity and low erodibility. Well drained and permeable	Erosion hazard is moderate to high. Shrink swell potential is high.
Lees Pinch (Esparanga Offset Area)	Mostly occurs in the south west of the Hunter Valley, but this occurrence is in the west, on rolling to steep hills and mountain country. Irregular benches and boulder littered slopes.	Main soils are shallow siliceous sands and shallow loams, with minor yellow earths and soloths at slope breaks. Sandy profiles are frequently single grained with poor structure, apedal massive.	Profile depth 30-60cm for siliceous sands, extending to 90cm for brown earths pH variable but acid Low fertility with nutrient deficiencies for Phosphorus and Nitrogen.	Moderate sheet and rill erosion where disturbed. Highly permeable and well drained (depending on slope) and moderate to high erosion hazard. High potential for structure degradation.
Sandy Hollow (Esparanga Offset Area)	Covers smooth and gentle rises and valley fills in Narrabeen Sandstone country in central Goulburn Valley and parts of Merriwa plateau.	Red and yellow solodic soils on upper and mid slopes, with yellow and brown solodic soils on lower slopes. Occasional siliceous sands.	Hardsetting surfaces and imperfect drainage Profile depth less than 70 cm pH 6.5 Low fertility and high salinity	Very high erosion hazard; moderate to high structural degradation hazard.

Source: Kovak and Lawrie 1991

3.5 Land and Soil Capability

This section considers the general Land and Soil Capability (LSC) of the region, as assessed and mapped by OEH (2012). **Section 3.6** discusses the specific slope, landform and soil characteristics of the Proposed Disturbance Area, within the Project Area. These factors contribute to the actual land and soil capability of the Project Area.

LSC is the ability of the land to sustain a range of land uses and land management practices in the long term without degradation of soil, land, air and water resources (OEH 2012, drawing on Dent and Young 1981, Emery 1986, and Sonter and Lawrie 2007). Biophysical characteristics and hazards considered in determining LSC are shown in **Table 3.6**.

Table 3.6 – LSC Classification: Biophysical Characteristics and Hazards

Soil and Landscape Characteristics	Hazards
• Soil type • Slope • Landform position • Acidity • Salinity • Drainage • Rockiness • Climate range and variability	• Water erosion, including sheet, rill and gully erosion • Wind erosion • Soil structure decline • Soil acidification • Salinity • Water logging • Shallow soils and rockiness • Mass movement

The LSC assessment scheme for NSW (OEH 2012) utilises concepts introduced in both natural resources literature and policy (such as the NSW natural resources targets (Natural Resources Commission 2005)), previous land capability assessments and mapping (Emery 1986) and in agricultural suitability classification schemes, such as Department of Agriculture 1983, SOILpak 1998, 2001 and Food and Agriculture Organisation (FAO) 1976, 1983.

The LSC assessment scheme (OEH 2012) is designed to provide regional scale information about land capability as applied to broad scale, dry-land agricultural uses.

The LSC classes identify limitations on the type and intensity of use as a result of the severity of constraints related to the physical attributes of the soil and the extent to which intensive management is required to prevent on and off site degradation under varying land uses. The LSC assessment scheme requires each tract of similar land be assessed for each of the hazards and ranked from 1 to 8 where Class 1 represents the least hazard and Class 8 the highest hazard. From this, the overall LSC Class is determined by the ranking of the most limiting hazard.

It is important to note that the classification does not necessarily reflect existing land uses; rather, it indicates the potential of the land for different agricultural purposes, while maintaining the quality of natural assets. Many parts of the Hunter region have been used beyond their LSC class for an extended period, resulting in degradation of natural and agricultural resources.

3.5.1 Land and Soil Capability of the Upper Hunter Region

Table 3.7 presents the rationale and definitions for the eight LSC classes currently used in NSW and their presence in the vicinity of the Project Area based on broad scale (1:250,000 scale) mapping undertaken for the Upper Hunter SRLUP (refer to **Figure 3.9**).

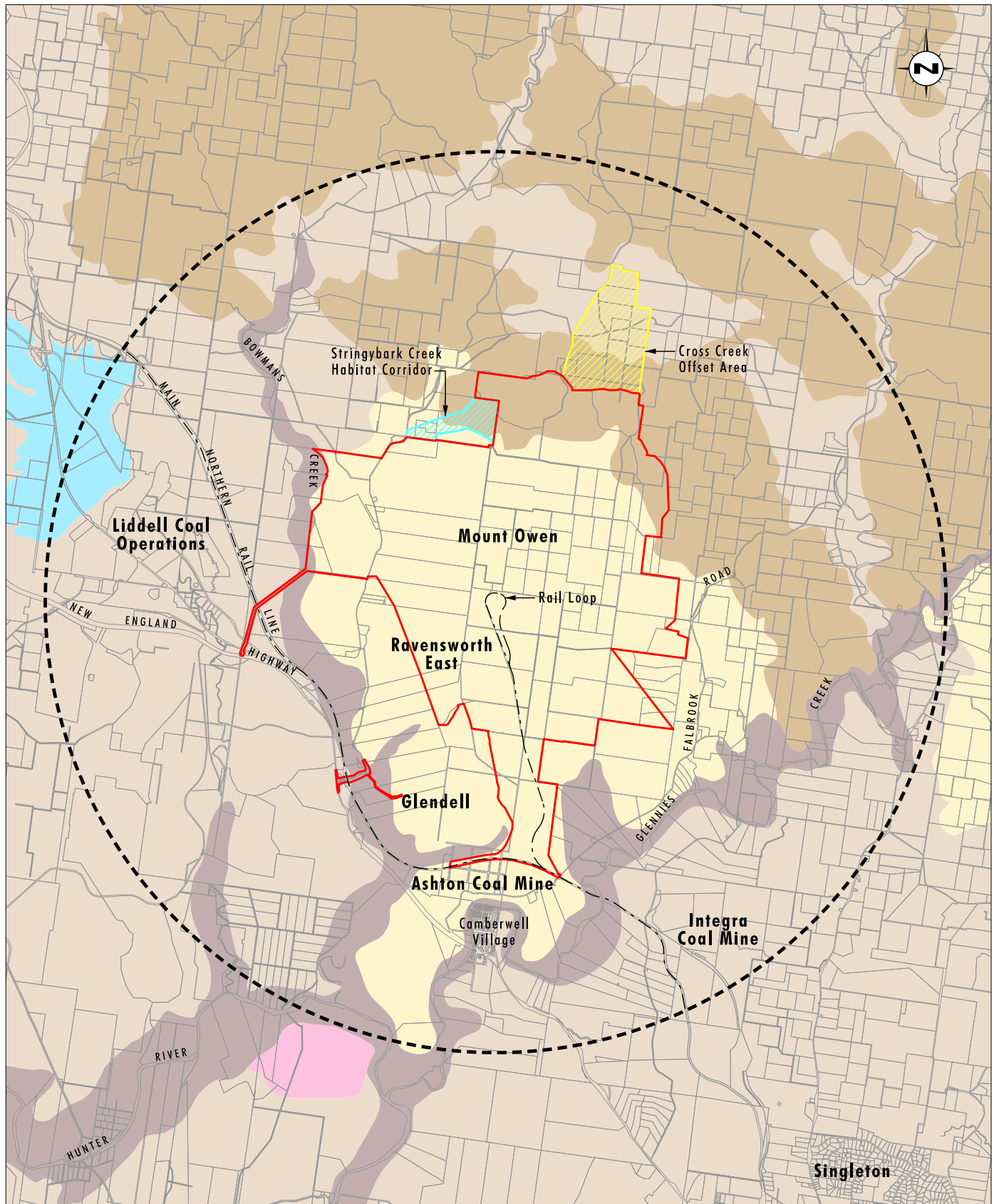
In summary:

- all eight LSC classes are mapped as occurring on or near the Project Area. However, note that there is no LSC class 1 or 2 land mapped within the Project Area and the steep LSC Class 8 land is generally located to the north of the Project Area;
- high land and soil capability areas have a limited distribution. They are associated with alluvial terraces and floodplains, where soils have a moderate clay content, good structure and low erosion hazard;
- other than river flats and terraces, the central parts of the Hunter Valley are characterised by soils which have a range of erosion and drainage limitations that make them suitable for grazing (LSC classes 4 to 6), rather than cropping; and
- small areas of good class soil can occur on slopes and floodplains. These are not necessarily mapped as separate LSC units as they occupy small areas and have limited distribution.

Additional project scale detail about the LSC of the Project Area is provided in **Sections 3.6** and **3.7**.

Table 3.7 – LSC Classes in the Singleton to Muswellbrook Area of the Hunter Valley (OEH 2012)

LSC Class	General Definition	Present in the Vicinity of the Project Area (based on regional scale mapping)
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)		
1	Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.	No Class 1 is mapped as occurring within the Mount Owen Complex Locality (refer to Figure 3.9).
2	Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	No Class 2 is mapped as occurring within the Mount Owen Complex Locality (refer to Figure 3.9).
3	High capability land: Land has moderate limitations and is capable of sustaining high impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	Land mapped as Class 3 land occurs along Bowmans Creek and Glennies Creek (refer to Figure 3.9) and is associated with the Hunter soil landscape (refer to Figure 3.7).



Data Source: Mount Owen (2014)
Land and Soil Capability: OEH (2012)

0 2.0 4.0 6.0 km
1:120 000

Legend

- Project Area
- Mount Owen Complex Locality (10km Radius from Rail Loop)
- Cross Creek Offset Area
- Stringybark Creek Habitat Corridor
- Land Capability:
 - 3 - High capability land
 - 4 - Moderate capability land
 - 5 - Moderate-low capability land
 - 6 - Low capability land
 - 7 - Very low capability land
 - Water

File Name (A4): R08/3109_849.dgn
20140926 10.49

FIGURE 3.9

Regional Land and
Soil Capability

Table 3.7 – LSC Classes in the Singleton to Muswellbrook Area of the Hunter Valley (OEH 2012) (cont.)

LSC Class	General Definition	Present in the Vicinity of the Project Area (based on regional scale mapping)
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)		
4	Moderate capability land: Land has moderate to high limitations for high impact land uses. Will restrict land management options for regular, high impact land uses such as cropping, high intensity grazing and horticulture. These limitations can only be managed by specialized management practices with a high level of knowledge, expertise, inputs, investment and technology.	Land mapped as Class 4 land occurs to the south-west of the Project Area, outside the Mount Owen Complex Locality (refer to Figure 3.9).
5	Moderate- low capability land: Land has high limitations for high impact uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long term degradation.	Land mapped as Class 5 land occurs in all directions around the Project Area (refer to Figure 3.9).
Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)		
6	Low capability land: Land has very high limitations for high impact land uses. Land use restricted to low impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environment degradation.	Land mapped as Class 6 land is the dominant LSC class within the Project Area (refer to Figure 3.9).
Land generally incapable of agricultural land use (selective forestry and nature conservation)		
7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On site and off site impacts of land management practices can be extremely severe if limitations are not managed. There should be minimal disturbance of native vegetation.	Areas of land mapped as Class 7 land are located in the northern section of the Project Area, with large areas of Class 7 occurring to the north-west, north, north-east and east of the Project Area (refer to Figure 3.9).
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	No Class 8 is mapped as occurring within the Mount Owen Complex Locality (refer to Figure 3.9).

Source: OEH 2012.

3.6 Factors influencing the land and soil capability of the Project Area

Sections 3.6 and 3.7 discuss how factors influencing the actual land and soil capability of the Proposed Disturbance Area and potential Biodiversity Offset Areas have been assessed, and the results of the detailed assessment. These sections consider slope, rock outcrop, soil types and soil fertility. **Section 3.8** evaluates the constraints associated with soils occurring in the Proposed Disturbance Area, and **Section 3.9** provides a site specific evaluation of potential Biophysical Strategic Agricultural Land in the Proposed Disturbance Area and the proposed Biodiversity Offset Areas.

3.6.1 Slope and Terrain of the Proposed Disturbance Area and Offset Areas

3.6.1.1 Method for Assessing Slope in the Proposed Disturbance Area and Offset Areas

Slope and terrain units within the Proposed Disturbance Area, have been determined from a detailed Digital Terrain Model (DTM), which was derived from LiDAR data (aerial laser scanning). The DTM is based on a contour interval of 1 metre.

The DTM enables rapid preparation of contours and calculation of slope angle and slope form. Slope forms and landforms have also been ground-truthed during the soil survey.

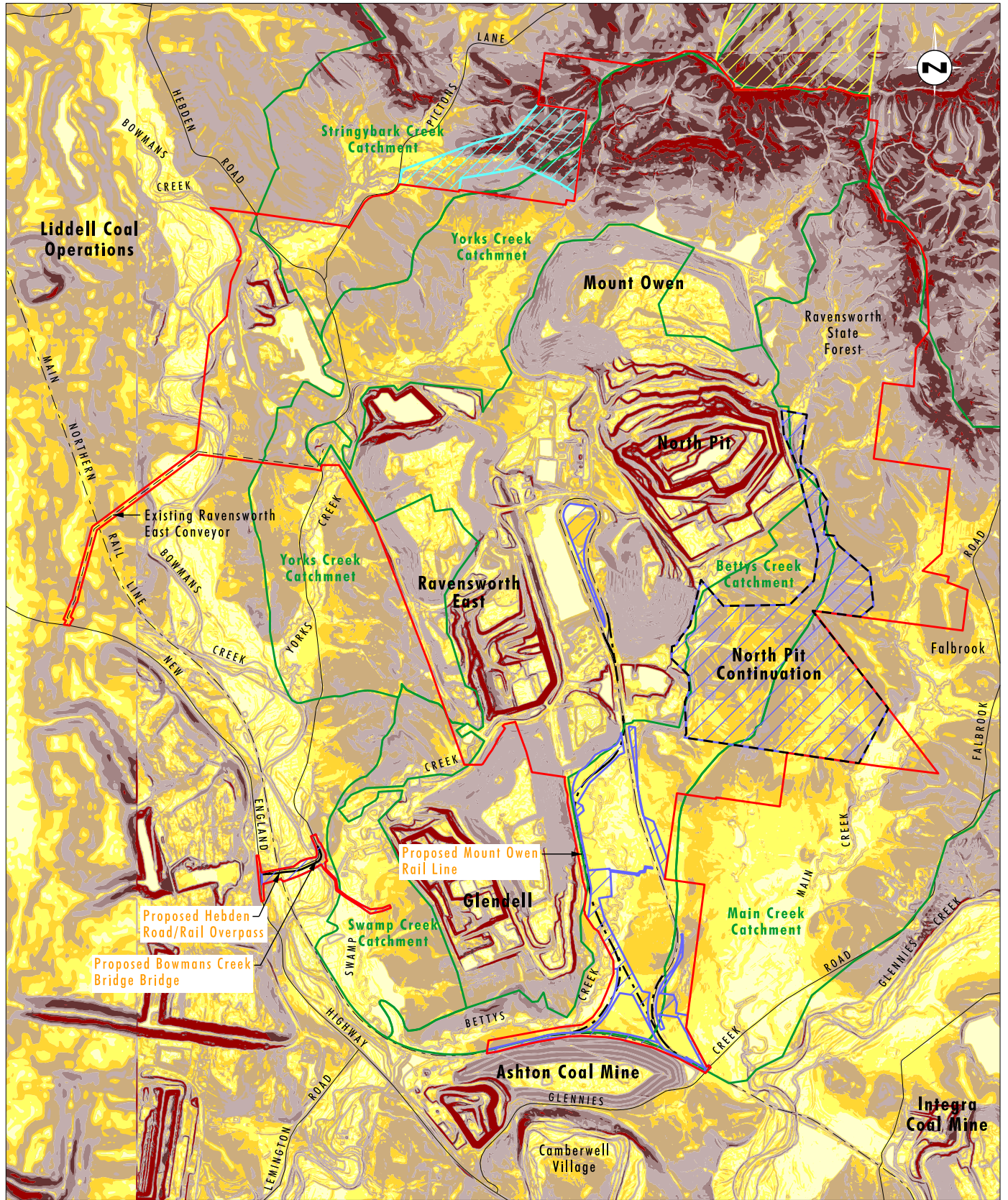
Figure 3.10 shows areas of different slope classes in the Project Area, the Proposed Disturbance Area and the Stringybark Creek Habitat Corridor. Slope classes mapped in **Figure 3.10** are aligned with the slope classes used in *NSW Land and Soil Capability Scheme (Second Approximation)* (OEH 2012) and the BSAL verification criteria (OEH and OASFS 2013).

Slope mapping, based on a DTM created from LiDAR data, has also been completed for three potential biodiversity offset areas:

- Stringybark Creek Habitat Corridor to the north-west of the Project Area (refer to **Figure 3.10**;
- Cross Creek to the north of the Project Area (refer to **Figure 3.11**); and
- Esparanga to the north-west of the Project Area, in the Upper Hunter Valley (refer to **Figure 3.12**).

3.6.1.2 Distribution of Slope Classes in the Proposed Disturbance Area and Offset Areas

Table 3.8 describes and quantifies the area occupied by each slope class within the Proposed Disturbance Area and the offset areas.



Data Source: Mount Owen (2014)

0 1 2 3 km
1:60 000

Legend

- | | | |
|---|--|---|
| Project Area | Slope Class: | > 50% |
| Proposed North Pit Continuation | < 1% | |
| Proposed Rail Upgrade Works | 1-3% | |
| Proposed Hebden Road Upgrade Works | 3-5% | |
| Proposed Disturbance Area | 5-10% | |
| Cross Creek Offset Area | 10-20% | |
| Stringybark Creek Habitat Corridor | 20-33% | |
| Catchment Boundary | 33-50% | |

File Name (A4): R08/3109_850.dgn
20141008 16.46

FIGURE 3.10
Existing Landforms and Slopes

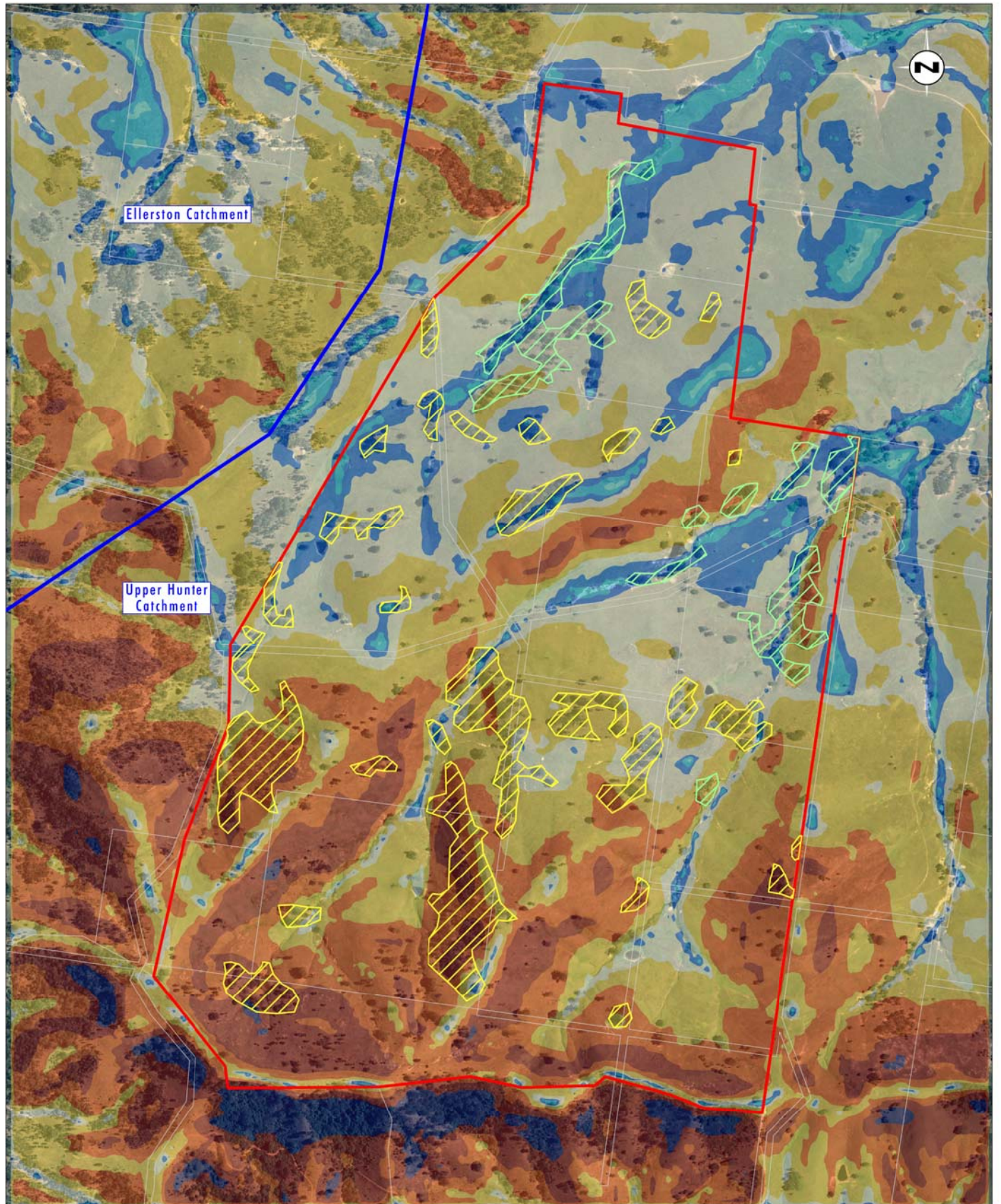


Image Source: Mount Owen (2012)
Data Source: Mount Owen (2013),
NSW Department of Environment and Conservation (2008)

0 250 500 750m
1:15 000

Legend

- | | |
|--|---|
| Cross Creek Offset Area | Slope 20- <33% |
| Subcatchment Area | Slope 33- <50% |
| Slope <1% | Slope > 50% |
| Slope 1-3% | Central Hunter Ironbark - Spotted Gum - Grey Box Forest Red Gum Variant (EEC) |
| Slope 3-5% | Central Hunter Ironbark - Spotted Gum - Grey Box Forest (EEC) |
| Slope 5-10% | |
| Slope 10-20% | |

File Name (A4): R08/3109_568.dgn
20131009 14.28

FIGURE 3.11

Cross Creek Offset Area
Slope Analysis

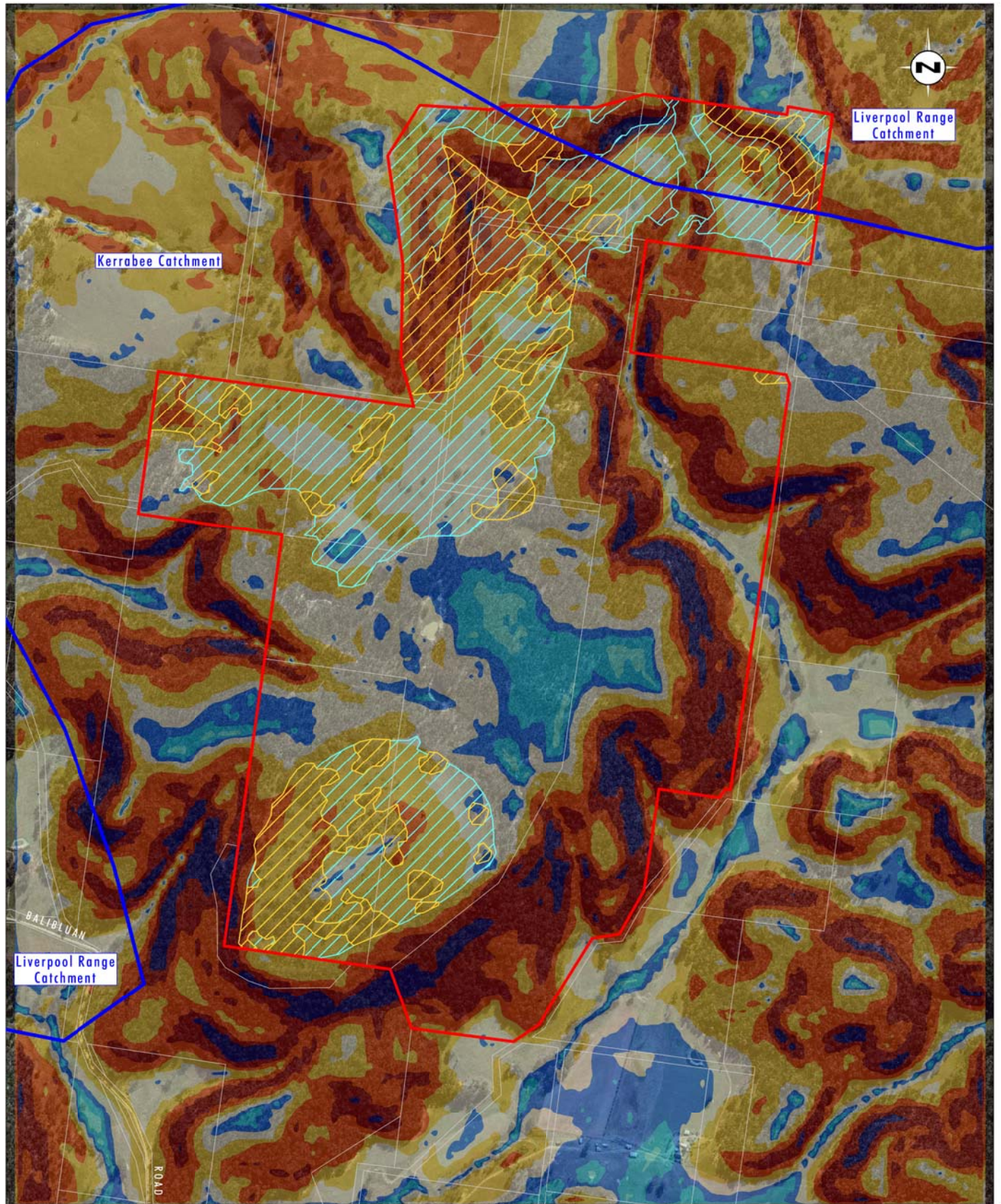


Image Source: Mount Owen (2009)
 Data Source: Mount Owen (2013),
 NSW Department of Environment and Conservation (2008),
 Department of Lands (2009)

Legend

- | | |
|---|---|
| Esperanga Offset Area | Slope 20- <33% |
| Subcatchment Area | Slope 33- <50% |
| Slope <1% | Slope > 50% |
| Slope 1-3% | Derived Native Grassland (White Box Woodland) (Component of White Box Woodland EEC and CEEC) |
| Slope 3-5% | Upper Hunter White Box - Ironbark Grassy Woodland (Component of White Box Woodland EEC and CEEC) |
| Slope 5-10% | |
| Slope 10-20% | |

File Name (A4): R08/3109_569.dgn
 20131009 14:58

FIGURE 3.12

Esperanga Offset Area
 Slope Analysis

Table 3.8 – General Locations of Slope Classes in the Proposed Disturbance Area and Offset Areas

Slope Class*	Where Are These Slopes Generally Located?	Area occupied within the Proposed Disturbance Area and Offset Areas (ha)
<1% (Class 1)	Proposed Disturbance Area: Floodplain and terraces associated with the Hunter and Liddell soil landscapes.	16.5
	Proposed Cross Creek Biodiversity Offset Area: Floodplain and terraces associated with the Greenland soil landscape.	0.3
	Proposed Esparanga Biodiversity Offset Area: Floodplain and terraces associated with the Ant Hill and Lees Pinch soil landscapes.	2.7
	Stringybark Creek Habitat Corridor: Floodplain and terraces associated with the Bayswater soil landscape.	0.1
1-3% (Class 2)	Proposed Disturbance Area: Alluvial deposits associated with the Hunter soil landscape, plus valley floors of tributary creeks in the Bayswater soil landscape and some existing mining operations areas.	102.1
	Proposed Cross Creek Biodiversity Offset Area: Floodplain and terraces associated with the Greenland soil landscape.	7.3
	Proposed Esparanga Biodiversity Offset Area: Floodplain and terraces associated with the Ant Hill and Lees Pinch soil landscapes.	11.2
	Stringybark Creek Habitat Corridor: Floodplain and terraces associated with the Bayswater soil landscape.	5.9
3-5% (Class 3)	Proposed Disturbance Area: Foothills of lower slopes in the North Pit Continuation area associated with the Bayswater soil landscape.	139.8
	Proposed Cross Creek Biodiversity Offset Area: Foothills of lower slopes associated with the Rosevale and Greenland soil landscapes.	32.4
	Proposed Esparanga Biodiversity Offset Area: Foothills of lower slopes associated with the Bow, Sandy Hollow and Lees Pinch soil landscapes.	14.4
	Stringybark Creek Habitat Corridor: Foothills of lower slopes associated with the Bayswater soil landscape.	6.1
5-10% (Class 3)	Proposed Disturbance Area: Foothills of lower slopes in the North Pit Continuation area associated with the Bayswater soil landscape.	178.3
	Proposed Cross Creek Biodiversity Offset Area: Foothills of lower slopes associated with the Rosevale and Greenland soil landscapes.	104.9

Table 3.8 – General Locations of Slope Classes in the Proposed Disturbance Area and Offset Areas (cont.)

Slope Class*	Where Are These Slopes Generally Located?	Area occupied within the Proposed Disturbance Area and Offset Areas (ha)
	Proposed Esparanga Biodiversity Offset Area: Foothills of lower slopes associated with the Bow, Sandy Hollow and Lees Pinch soil landscapes.	64.8
	Stringybark Creek Habitat Corridor: Foothills of lower slopes associated with the Bayswater and Rosevale soil landscapes.	13.5
10-20% (Classes 4 and 5)	Proposed Disturbance Area: Lower slopes in the North Pit Continuation area associated with the Bayswater soil landscape.	43.9
	Proposed Cross Creek Biodiversity Offset Area: Lower slopes associated with the Rosevale and Greenland soil landscapes.	104.9
	Proposed Esparanga Biodiversity Offset Area: Lower slopes associated with the Bow, Sandy Hollow and Lees Pinch soil landscapes.	102.0
	Stringybark Creek Habitat Corridor: Lower slopes associated with the Bayswater and Rosevale soil landscapes.	14.5
20-33% (Class 6)	Proposed Disturbance Area: Mid-slopes in the North Pit Continuation area associated with the Bayswater soil landscape.	4.0
	Proposed Cross Creek Biodiversity Offset Area: Mid-slopes associated with the Rosevale and Greenland soil landscapes.	81.6
	Proposed Esparanga Biodiversity Offset Area: Mid-slopes associated with the Bow, Sandy Hollow and Lees Pinch soil landscapes.	55.7
	Stringybark Creek Habitat Corridor: Mid-slopes associated with the Bayswater and Rosevale soil landscapes.	24.2
33-50% (Class 7)	Proposed Disturbance Area: Upper slopes in the North Pit Continuation area associated with the Bayswater soil landscape.	0.2
	Proposed Cross Creek Biodiversity Offset Area: Upper slopes associated with the Rosevale and Greenland soil landscapes.	35.1
	Proposed Esparanga Biodiversity Offset Area: Upper slopes associated with the Bow, Sandy Hollow and Lees Pinch soil landscapes.	40.3
	Stringybark Creek Habitat Corridor: Upper slopes associated with the Rosevale soil landscape.	29.8

Table 3.8 – General Locations of Slope Classes in the Proposed Disturbance Area and Offset Areas (cont.)

Slope Class*	Where Are These Slopes Generally Located?	Area occupied within the Proposed Disturbance Area and Offset Areas (ha)
>50% (Class 8)	Proposed Disturbance Area: Not Applicable.	0.2
	Proposed Cross Creek Biodiversity Offset Area: Upper slopes associated with areas of rock outcrop and the Rosevale soil landscape.	0.5
	Proposed Esparanga Biodiversity Offset Area: Upper slopes associated with areas of rock outcrop and the Bow, Sandy Hollow and Lees Pinch soil landscapes.	11.7
	Stringybark Creek Habitat Corridor: Upper slopes associate with areas of rock outcrop and the Rosevale soil landscape.	3.3

* Corresponding Land and Soil Classification Class shown in brackets

Table 3.8 indicates that the most frequently occurring slopes in the undulating Proposed Disturbance Area are in the range 3 per cent to 10 per cent. The less steep parts of this land occur on footslopes and ridge crests. Steeper slopes in the 10 per cent to 20 per cent class occur in the north-eastern part of the Proposed Disturbance Area. Slopes of less than 3 per cent, occupy about half as much of the Proposed Disturbance Area as slopes of 3 per cent to 10 per cent and are located on alluvial deposits associated with major creeks and their tributaries, as well as existing disturbed mining land. Very steep slopes are uncommon.

Slope types in the proposed Cross Creek Offset Area are approximately evenly distributed in the range 5 per cent to 33 per cent. This is steeply undulating country with relatively steep side slopes. Slopes in the 20 per cent to 33 per cent class are generally associated with low capability land. The most extensive slope types in the proposed Esparanga Offset Area are also across the 5 per cent to 33 per cent range, but Esparanga also has significant areas of very steep slopes, which are not suitable for agriculture. Slope types in the Stringybark Creek Habitat Corridor are most extensively across the 5 to 50 per cent range, with approximately 70 per cent of land ranging between 10 to 50 per cent.

3.6.2 Rock Outcrop in the Proposed Disturbance Area and Offset Areas

Rock outcrop and large amounts of rock float at the surface limit the suitability of land for cultivation and also present hazards to livestock.

The presence of rock at the surface has been determined from aerial photograph analysis and field observation.

The terrain in the north to north-east of the Proposed Disturbance Area is relatively steep, with slopes generally 10 per cent to 20 per cent and some steeper areas. Rock outcrops occur on ridgelines and hilltops. Rock outcrops occur less frequently on lower slopes (<10 per cent).

There are extensive areas of rock outcrop on the surface of the ridge crests and upper slopes in the Cross Creek Offset Area and the Stringybark Creek Habitat Corridor. Similarly, the very steep land in the south and south-eastern part of the proposed Esparanga Offset Area has extensive outcrop of sandstone.

3.7 Soils of the Proposed Disturbance Area and Offset Areas

3.7.1 Regional Scale Mapping of Land and Soil Resources in the Proposed Disturbance Area and Offset Areas

3.7.1.1 Soil Landscapes and Profile Types

Further to the information provided in **Table 3.5** about the occurrence of soil landscapes in the Project Area and Offset Areas, relevant profile types for soil landscapes previously mapped as occurring in the Proposed Disturbance Area and Offset Areas are noted in **Table 3.9**.

Table 3.9 – Soil Landscapes in the Proposed Disturbance Area and Offset Areas

Area	Soil Landscape and Northcote profile type	Area (ha)
Proposed Disturbance Area		
Hebden Road Upgrade (including realignment of Hebden Road, construction of a dual lane bridge over Bowmans Creek and rail overpass)	Hunter (Ug, Uf, Um, Dr and Db) and Liddell (Dy and Uc)	13.1
Rail Spur Upgrade	Bayswater (Dy, Gn, Dr, Dy and Db)	91.4
North Pit Continuation area	Bayswater (Dy, Gn, Dr, Dy and Db)	380.5
Total		485
Proposed Offset Areas		
Proposed Cross Creek Offset Area	Rosevale (Dr, Db, Gn and Dy) and Greenland (Dy, Gn and Uc)	367
Proposed Esparanga Offset Area	Ant Hill (Ug and Gn), Sandy Hollow (Dr, Dy, Db, Gn and Uc) and Lees Pinch (Uc, Um, Gn, Dy and Dg)	302.8
Stringybark Creek Habitat Corridor	Bayswater (Dy, Gn, Dr, Dy and Db) and Rosevale (Dr, Db, Gn and Dy)	97.5
Total		767.7

3.7.1.2 Land and Soil Capability of the Proposed Disturbance Area

LSC classes mapped as occurring within the Proposed Disturbance Area, as part of OEH's regional scale SRLUP mapping (2012), are:

- Class 3 LSC land is mapped on the terrace of Bowmans Creek, where the Hebden Road Upgrade is proposed;
- Class 5 LSC is also mapped as occurring in the proposed Hebden Road Upgrade area; and
- Class 6 LSC is mapped as occurring in both the proposed Rail Upgrade and North Pit Continuation areas.

3.7.1.3 Soil Fertility of the Proposed Disturbance Area

Soil fertility mapping at the regional scale was prepared by OEH as part of the Upper Hunter SRLUP. Soils in the Proposed Disturbance Area are mapped as having low fertility in the Rail Spur Upgrade and North Pit Continuation areas, and low to moderately high fertility in the Hebden Road Upgrade area (refer to **Figure 3.13**). The site specific soil survey and sampling program provides additional information with which to evaluate the fertility of the soils in the Project Area.

3.7.2 Soil Sampling Program

A program of field observations and sampling of soils in the Proposed Disturbance Area was conducted to verify the results of regional scale soil mapping (Kovac and Lawrie 1991, OEH 2012, DP&I 2012), as outlined in **Section 3.7.1**. The soil sampling program included field based descriptions of soil materials and laboratory testing of A and B horizon materials from selected profiles/soil types.

The fieldwork for the soil survey was undertaken in September 2012, July 2013 and June 2014. The objectives of this survey were to:

- describe, classify and map the soil types within the Proposed Disturbance Area;
- to assess the LSC to determine the potential agricultural value of the Proposed Disturbance Area;
- to verify the mapping of BSAL identified in the *Strategic Regional Land Use Plan for the Upper Hunter* (DP&I 2012) within the Proposed Disturbance Area in the vicinity of Hebden Road; and
- to analyse the suitability of the soils for use in rehabilitation.

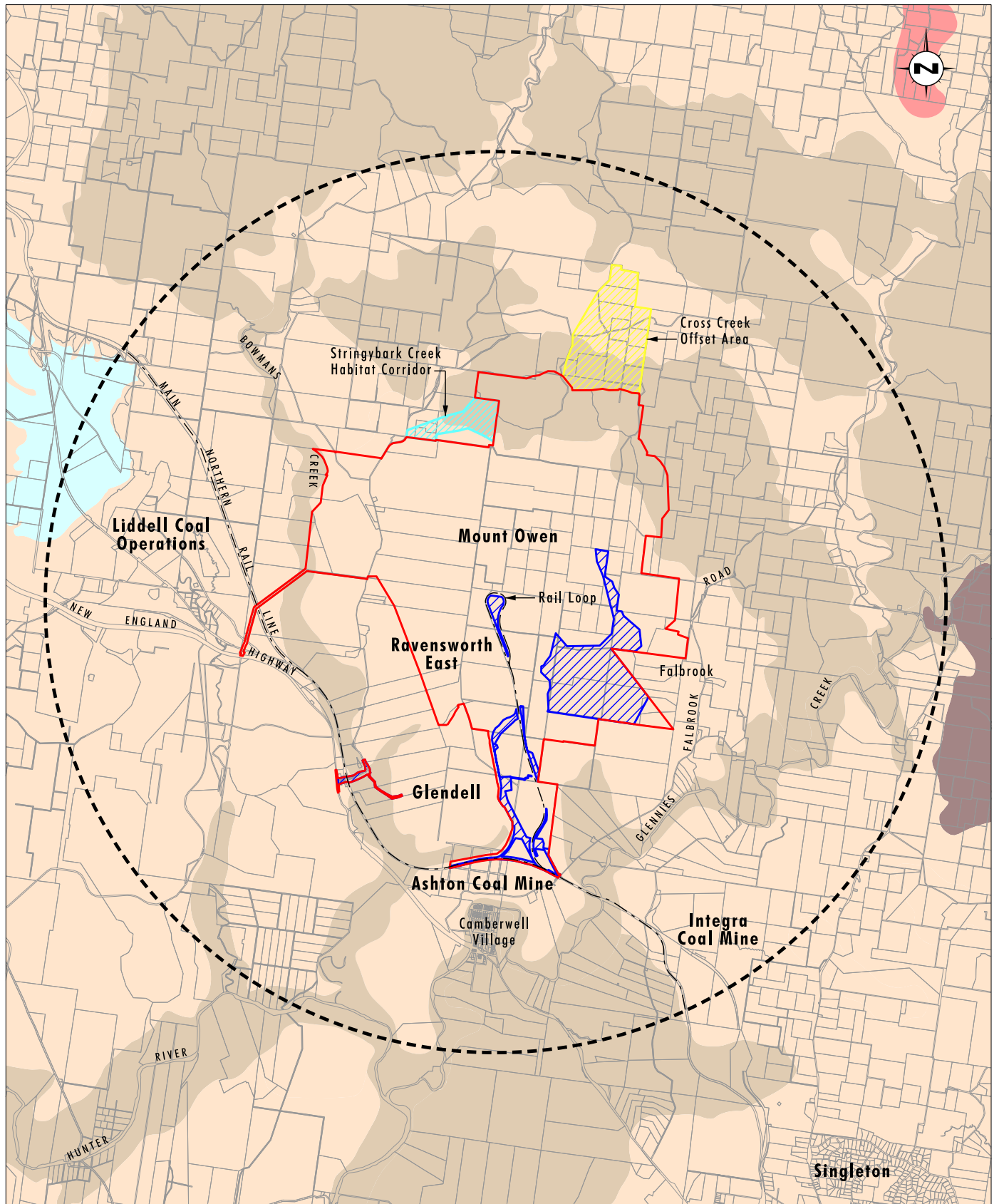
As required by the Agriculture Impact Statement guidelines and interim soil verification guidelines, the survey and assessment has been conducted by qualified Umwelt soil scientists, including peer review by Mr Peter Fogarty, an experienced soil scientist who is certified Grade 3 by the Australian Soil Science Society.

Further details about the soil survey and verification process are provided in **Appendix A**.

3.7.2.1 Rationale and Strategy

Requirements for soil sampling and testing are set out in the *Strategic Regional Land Use Policy: Guideline for Agricultural Impact Statements* (DP&I 2012a) and the *Agricultural Impact Statement: Technical Notes – A companion to the Agricultural Impact Statement guideline* (DPI 2013a). Specifically, to provide consistent and reliable data, the soil sampling and descriptions must be conducted in accordance with the following references:

Aspect	Requirements Set Out in Reference
Soil sampling and survey	McKenzie, N.J., Grundy, M.J., Webster, R., Ringrose-Voase, A.J. (2008). <i>Guidelines for Surveying Soil and Land Resources</i> , 2nd ed. CSIRO Publishing, Victoria, Australia.
Soil classification	Isbell, R.F. (2002). <i>The Australian Soil Classification</i> . CSIRO Australia, Collingwood, VIC
Soil physical measurements	McKenzie, N., Coughlan, K., & Resswell, H. (2002). <i>Soil physical measurement and interpretation for land evaluation</i> . Collingwood, Australia: CSIRO Publishing.



Data Source: Mount Owen (2014), OEH (2012), Department of Lands (2009)

0 2.0 4.0 6.0 km
1:120 000

Legend

- | | |
|--|--|
| Project Area | Low |
| Mount Owen Complex Locality (10km Radius from Rail Loop) | Moderate |
| Proposed Disturbance Area | Moderately Low |
| Cross Creek Offset Area | Moderately High |
| Stringybark Creek Habitat Corridor | Water |

File Name (A4): R08/3109_852.dgn
20140926 11.16

FIGURE 3.13
Regional Soil Fertility

Aspect	Requirements Set Out in Reference
Soil chemical measurements	Rayment, G. E., and Lyons, D. J. (2011). <i>Soil Chemical Methods: Australasia</i> .
Land and soil capability	OEH 2012
BSAL verification	OEH and OASFS 2013

These references have informed each step of land and soil analysis for the Project.

The method for sampling, assessing and mapping soil characteristics included the following steps:

- desk top assessment of soils and other information from the regional scale mapping references (refer to **Section 3.4.1**);
- preparation of detailed slope and terrain map using LiDAR data (refer to **Section 3.3.4**);
- mapping of known constraints to agricultural use, such as presence of EECs, conservation area, high conservation value Aboriginal sites or existing mine operations;
- development of a survey design to sample soils in the Proposed Disturbance Area associated with different landform elements. The survey design meets the requirement for sampling at a minimum of 1:25,000 scale. Sampling locations are shown in **Figures 3.14 to 3.16** and sampling statistics are summarised in **Table 3.10**; and
- samples of soil materials from the A horizon and B horizon of representative profiles were collected for analysis by the NATA Accredited Scone Soil Laboratory (Soil Conservation Service).

Table 3.10 – Soil sampling observations and density in the Proposed Disturbance Area

Proposed Disturbance Area	Area (ha)	Soil Landscape, Land and Soil Capability (LSC) Class (Desktop)	Shallow Shovel Pit Sites	Number of Soil Auger Sites	Number of Laboratory Analysis Sites (includes samples from auger sites and shallow shovel pits)	Number of Mapping Observation Sites
Hebden Road Upgrade	13.1	Hunter, Liddell LSC Class 3	2 12, 13	1 Site 14 (K)	3 Sites 12 to 14 (K)	3
Proposed rail line	91.4	Bayswater LSC Class 4 and 5	4 8, 9, 10, 11	3 Sites 15 (I) - 17 (G)	5 Sites 8-11, 17 (G)	3
North Pit Continuation	380.5	Bayswater LSC Class 4 to 7	7 1-7	10 Sites 18 (A) - 27	13 Sites 1-7, 22 (F) - 27	4
TOTAL	485	-	13	12	19	9

Field data collection for soil profiles used the standard Soil and Land Information System (SALIS) recording sheets and recorded the following information (refer to **Table 3.11**).

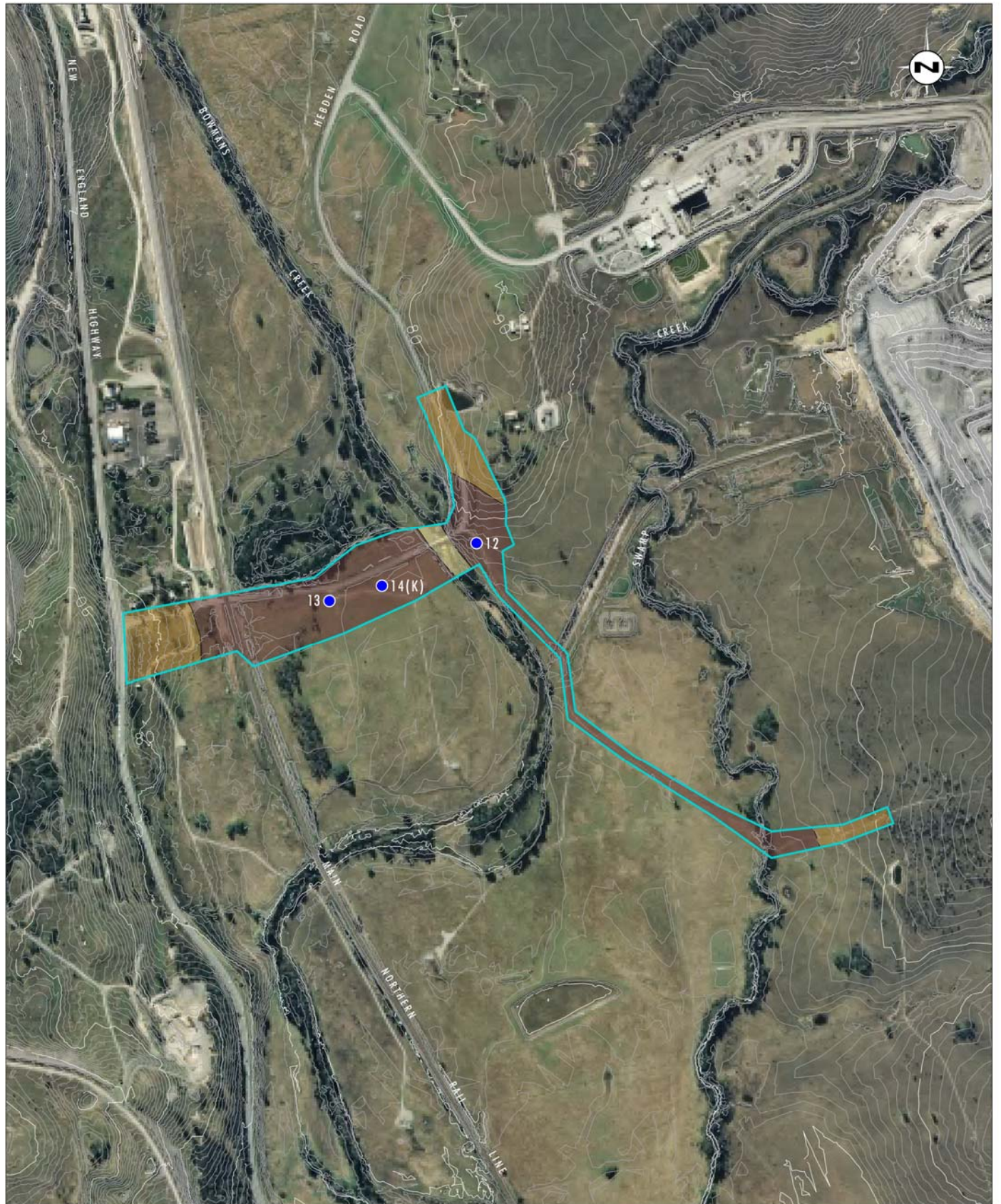


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 100 250 500m
1:10 000

Legend

- Proposed Disturbance Area
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

File Name (A4): R08/3109_853.dgn
20140805 13.23

FIGURE 3.14

Proposed Hebden Road
Upgrade Works Area - Soil Types

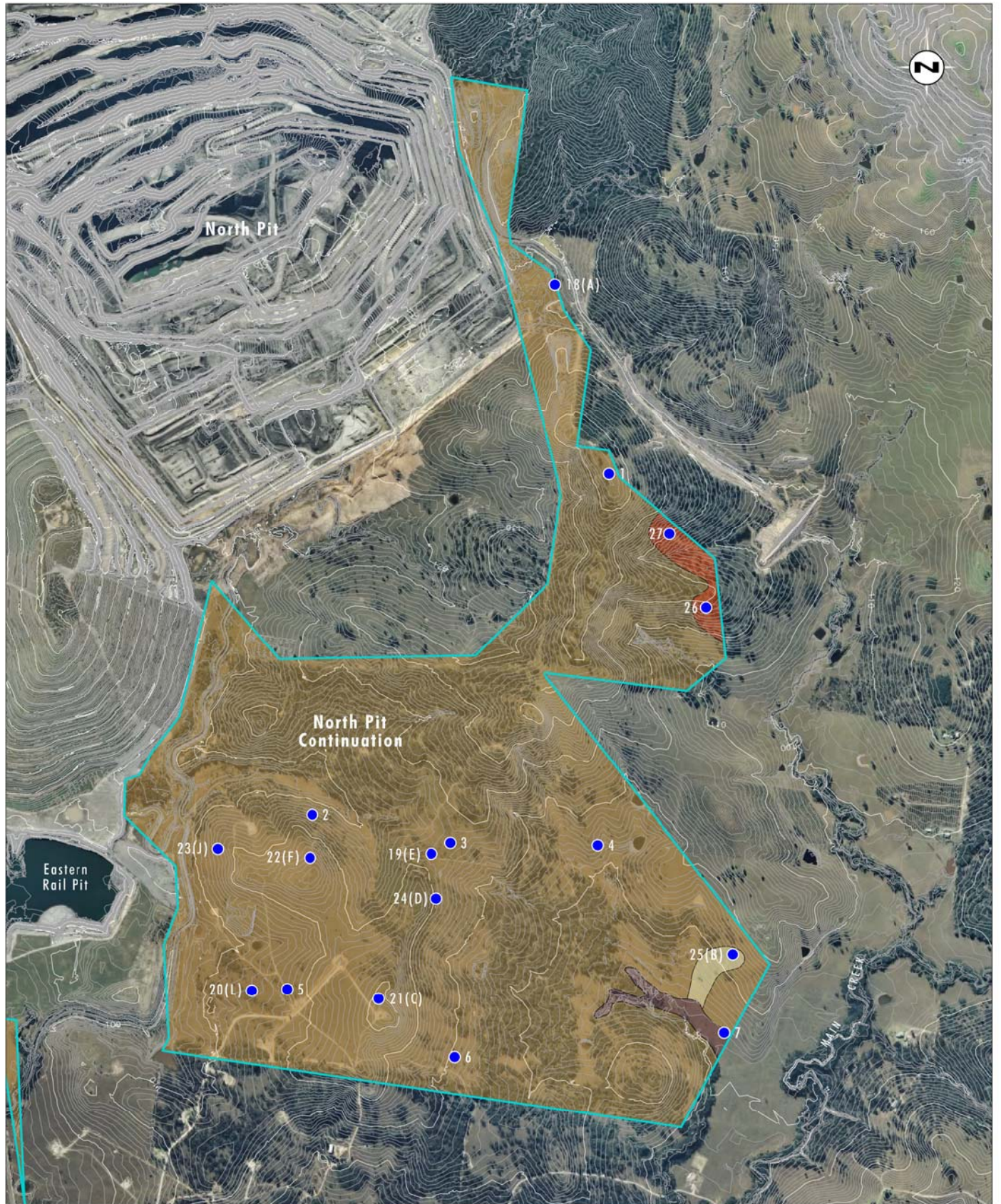


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.25 0.5 1.0 km
1:20 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

File Name (A4): R08/3109_797.dgn
20140805 13.28

FIGURE 3.15

Proposed North Pit
Continuation Area - Soil Types

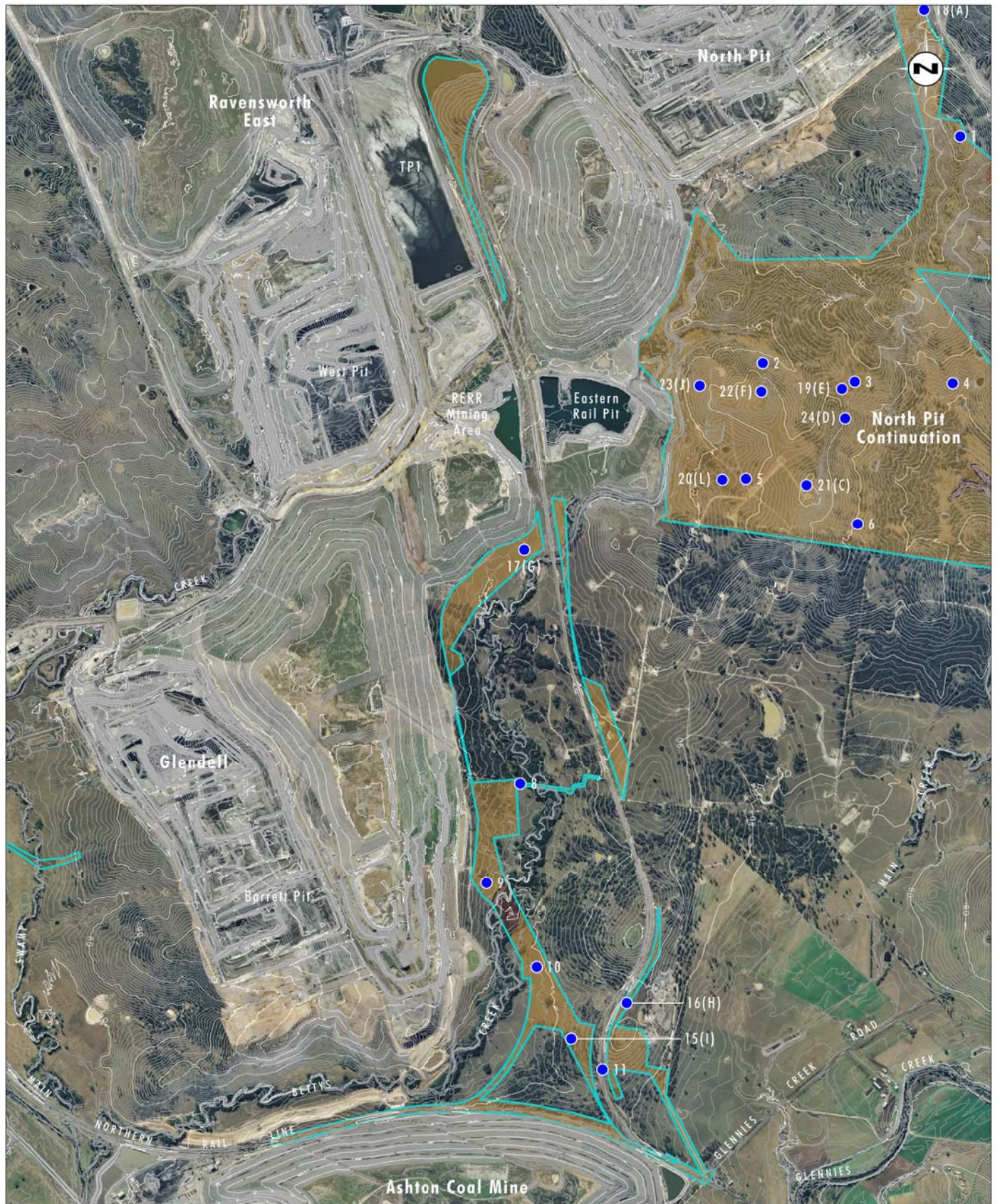


Image Source: Mount Owen (2013)
 Data Source: Mount Owen (2014)
 Note: Contour Interval 1m

0 0.5 1.0 1.5 km
 1:30 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Stratic Rudosol
- Soil Sampling Site

File Name (A4): R08/3109_796.dgn
 20140805 13.32

FIGURE 3.16

Proposed Rail Upgrade
 Works Area - Soil Types

Table 3.11 – Soil Profile Description Parameters

Descriptor	Application
Horizon depth	Weathering characteristics, soil development, fertility
Field colour	Permeability, aeration, susceptibility to dispersion/erosion
Mottles – presence, colour	Permeability, aeration
Field texture – A and B horizon	Erodability, hydraulic conductivity, permeability, water holding capacity, root penetration
Horizon boundary distinctness	Erosional/depositional status, textural grade, identification of Australian Soil Classification
Consistence force	Structural stability, dispersion, ped formation
Structural pedality grade	Soil structure, root penetration, permeability, aeration
Ped type and size	Soil structure, root penetration, permeability, aeration
Gravel – presence, quantity, size	Water holding capacity, erosional/depositional character, permeability, root penetration
Field pH – A and B horizon	Identification of Australian Soil Classification
Roots – presence, depth	Effective rooting depth

Nineteen topsoil (0 to 10 centimetres) and 17 subsoil (20 to 30 centimetres) samples were analysed. Parameters for which analysis was conducted are shown in **Table 3.12**. The parameters tested in this analysis were discussed with Department of Primary Industries (DPI) officers prior to the tests being conducted. Full soil test results are included in Appendix AA of **Appendix 1**.

Table 3.12 – Laboratory Analysis Tests

Laboratory Analysis Tests	
A Horizon (0-10 cm) – Sites 1 to 13	B Horizon (10-20 cm) – Sites 1 to 11 and 13
EC (dS/m)	EC (dS/m)
PH (water and CaCl ₂)	PH (water and CaCl ₂)
Cation Exchange Capacity (me/100g)	
Exchangeable Sodium, Potassium, Calcium, Magnesium, Aluminium (me/100g)	
Available Phosphorus (mg/kg)	
Emerson Aggregate Test	Emerson Aggregate Test
Texture	Texture
A Horizon (0-10 cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 25 (B), 26 and 27	B Horizon (approx 20-30 cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 26 and 27
All tests as above plus:	All tests as above plus:
Organic Carbon (Walkley Black)	Cation Exchange Capacity and Exchangeable Cations (me/100g)
Particle Size Analysis	-
Total Nitrogen	-

3.7.3 Project Scale Soil Mapping and Information

3.7.3.1 Profile Types and Soil Characteristics

Detailed descriptions of the soil types occurring in the Proposed Disturbance Area are included in **Appendix 1**. Four different soil types were identified within the Proposed Disturbance Area (refer to **Figures 3.14 to 3.16**).

Rudosols were the most common soil type in the Hebden Road Upgrade section of the Proposed Disturbance Area and in the south-eastern part of the North Pit Continuation, associated with the tributaries of Main Creek. Sodosols were the dominant soil type in the Rail Upgrade and remaining sections of the North Pit Continuation (refer to **Table 3.13**). There is also an area of Kurosols along the eastern edge of the North Pit Continuation area.

Table 3.13 – Overview of Soil Types in the Proposed Disturbance Area

Soil Type		Soil Landscape	Land Area	
			Hectares	Percentage (%)
1	Stratic Rudosol	Hunter	15.8	3.3
2	Clastic Rudosol	Hunter, Bayswater	2.7	0.6
3	Brown Sodosol	Bayswater	461.8	95.2
3	Brown Kurosol	Bayswater	4.7	1.0
Total			485	100

Representative soil profiles for each soil type are briefly described below.

Stratic Rudosol – LSC Class 4

This soil occurs on recently deposited alluvial landforms, along the floodplain and low terraces of Bowmans Creek. (refer to **Plate 3.1**). It has limited profile development from the surface to the subsoil.

A1 horizon: Brown whole coloured fine sandy loam with weak structure and moderately weak consistence; rapidly drained; 2-5mm crumb peds; few fine roots present; pH 6.5. Diffuse boundary at 15 cm.

B1 horizon: brown whole coloured fine sandy loam; weak structure with moderately weak consistence; 5-10 mm subangular blocky peds; pH 6.5; rapidly drained, no roots, gradual boundary.

B2 horizon: Brown whole coloured fine sandy loam; weak structure; 5-10 mm subangular blocky peds with moderately weak consistence; pH 6.5; no roots.

Clastic Rudosol – LSC Class 7

This soil type occupies a relatively small area. The sols are young depositional materials associated with Bowmans Creek and tributaries of Main Creek. The principal profile feature is a gravel layer between the light textured A1 horizon (to 20-25 cm) and heavy clay B horizon. Refer to **Plate 3.2**.

A1 horizon: Brown loam; moderate structure; 2-5 mm subangular blocky peds with moderately firm consistence; pH 6.0; no gravel, no mottles; rapidly drained; abrupt boundary.

A2 horizon: Brown fine sandy loam; moderate structure; 2-5 mm subangular blocky peds with moderately firm consistence; slightly acid (pH 5.5); 20-50% sub rounded gravel, 6-20 mm; no mottles; gradual boundary.

Gravel layer: brown medium clay; slightly acid pH 5.5; rapidly drained with 90% sub rounded gravel (20-60 mm); gradual boundary.

B horizon: Grey heavy clay; massive structure; pH 5.5; very slow drainage; less than 2% gravel; distinct orange mottles; no roots.

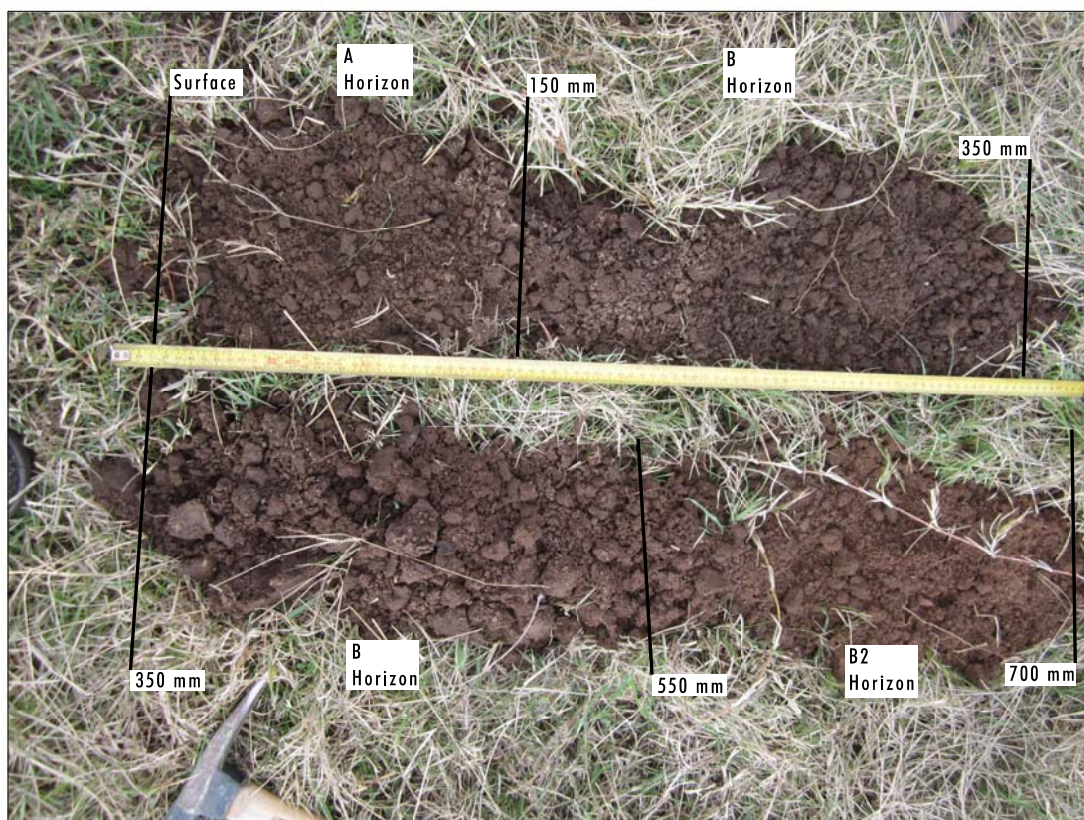


PLATE 3.1
Soil Forming Materials in the Stratic Rudosol Soil at Site 14 (K)
(Refer to Figure 3.13)

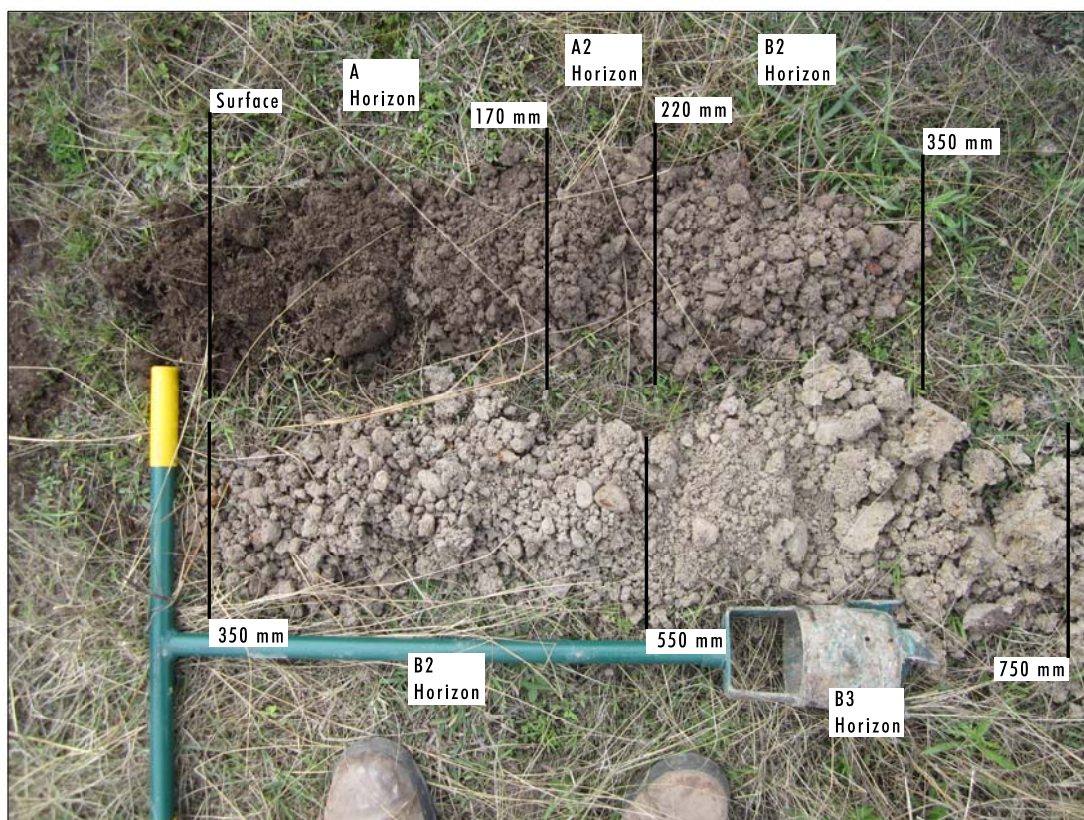


PLATE 3.2
Soil Forming Materials in the Clastic Rudosol Soil at Site 25 (B)
(Refer to Figure 3.14)

Brown Sodosol – LSC Class 4-7

This soil type covers most of the Proposed Disturbance Area off the alluvial terraces. The soils have strong texture contrast profiles, with light textured topsoils (A1 and A2 horizon to 20 cm) overlying poorly drained, strongly structured subsoils which are dispersible. Refer to **Plate 3.3**.

A1 horizon: Brown loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5); rapidly drained; no gravel; no mottles; sharp boundary; common fine roots present.

A2 horizon: Grey silty clay loam; weak structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5), rapidly drained; no mottles; sharp boundary, common fine roots.

B2 horizon: Brown medium clay; strong structure; 20-50 mm sub-angular blocky peds with moderately strong consistence; slightly acid pH (5.5); very slow drainage; no gravel; 10-20% faint orange mottles; few fine roots.

B3 horizon: Brown medium clay; strong structure; 10-20 mm sub-angular blocky peds with moderately strong consistence; slightly acid pH (5.5); very slow drainage; no gravel; 20-50% distinct orange mottles; no roots.

Brown Kurosol – LSC Class 4-5

This soil type occupies a relatively small area and is associated with the undulating Bayswater Soil Landscape. These soils have reasonably well drained sandy loam to clay loam topsoils with a strong texture contrast at 0.05 to 0.25 metres to a poorly drained, strongly structured sodic clay B horizon which is also strongly acidic. Refer to **Plate 3.4**.

A1 horizon: Brown sandy loam; weak structure; 1-2 mm sub-angular blocky peds with moderately weak consistence; moderately acid pH (5.0); rapidly drained; no gravel; no mottles; abrupt boundary; common fine and medium roots present.

A2 horizon: Pale fine sand; moderate structure; 10-20 mm sub-angular blocky peds with moderately firm consistence; rapidly drained; no gravel; no mottles; abrupt boundary, few fine and medium roots present.

B1 horizon: Brown heavy clay; moderate structure: 20-50mm sub angular blocky peds with firm consistence; strongly acid pH (4.5); very slow drainage; no gravel; 2-10% distinct orange mottles; few fine and medium roots.

B2 horizon: It is noted that the profile continued deeper, but was too dry to sample.

3.7.3.2 Soil Hazards and Constraints

The *NSW Land and Soil Capability Assessment Scheme (Second Approximation)* (OEH 2012) considers a range of biophysical soil hazards. The most limiting hazard determines the overall LSC ranking of the soil. Details of the assessment of soil profiles in the Proposed Disturbance Area are included in **Appendix 1**.

3.7.3.3 Verified Land and Soil Capability

Table 3.14 summarises the LSC of sites in the Proposed Disturbance Area, applying the hazards and descriptors described by OEH 2012. The limiting factor for each soil is shaded in the table.

Table 3.14 – LSC of sites in the Proposed Disturbance Area

Site No.	Soil type	Hazard Criteria								
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	Overall class
1	Sodosol	2	2	3	4	1	2	6	1	6
2	Sodosol	3	2	6	4	1	3	7	1	7
3	Sodosol	2	2	6	4	1	3	3	1	6

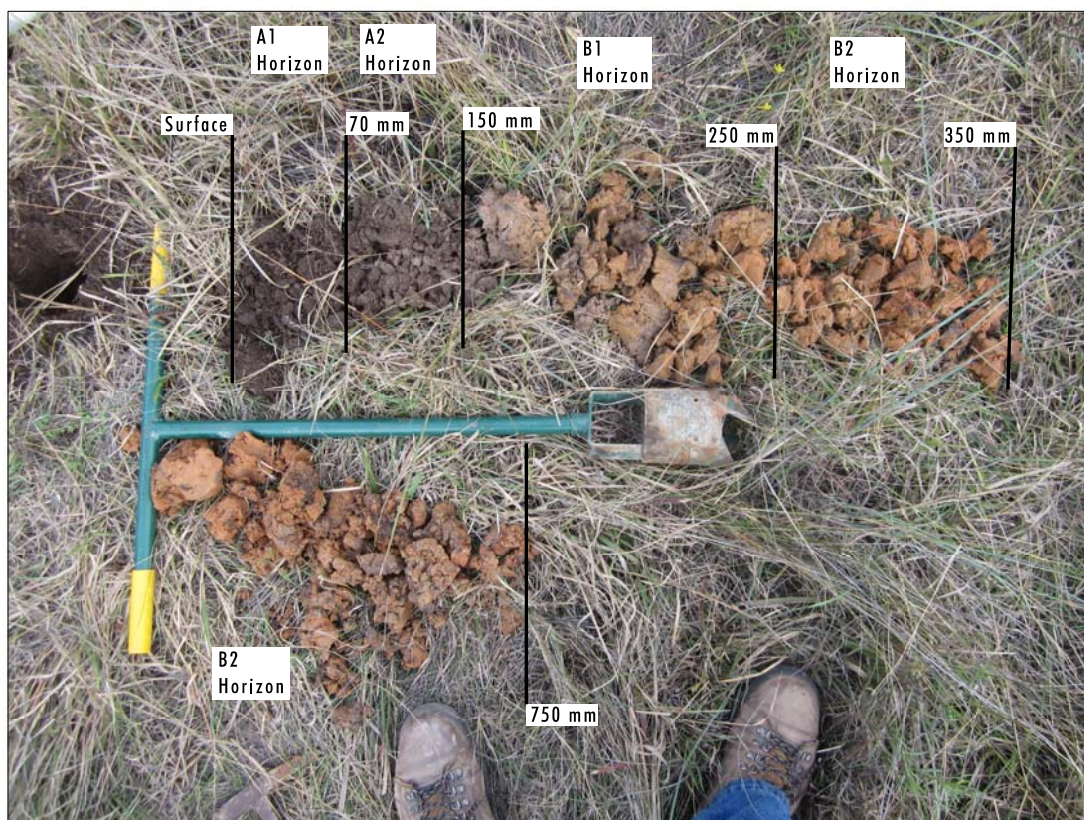


PLATE 3.3
Soil Forming Materials in the Brown Sodosol Soil at Site 24 (D)
(Refer to Figure 3.9)

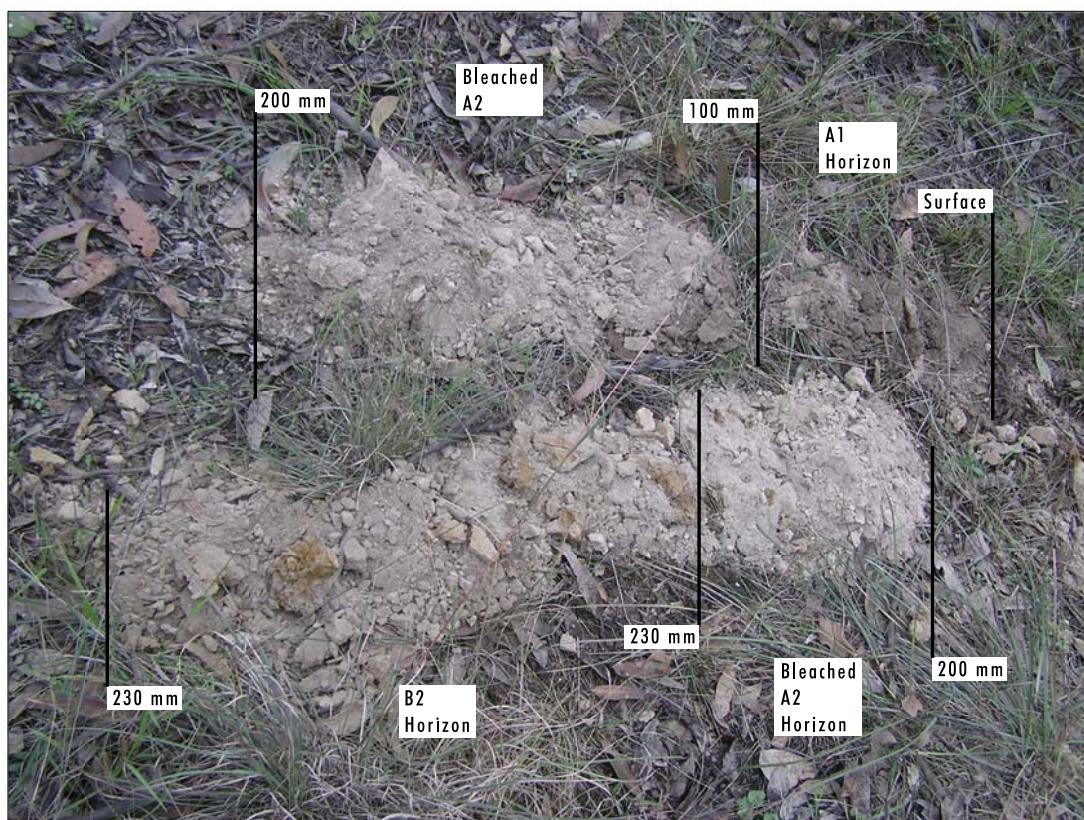


PLATE 3.4
Soil Forming Materials in the Brown Kurosol Soil at Site 26

Table 3.14 – LSC of sites in the Proposed Disturbance Area

Site No.	Soil type	Hazard Criteria								
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	Overall class
4	Sodosol	2	3	3	4	1	3	3	1	4
5	Sodosol	3	2	6	4	1	3	3	1	6
6	Sodosol	3	2	6	4	1	3	3	1	6
7	Rudosol	2	3	3	4	1	1	3	1	4
8	Sodosol	2	2	6	4	1	3	2	1	6
9	Sodosol	1	2	7	4	1	3	2	1	7
10	Sodosol	1	3	7	4	1	3	3	1	7
11	Sodosol	1	2	6	4	1	3	3	1	6
12	Rudosol	2	2	3	4	1	1	7	1	7
13	Rudosol	1	3	3	4	1	1	1	1	4
14 (K)	Rudosol	1	3	3	4	1	1	3	1	4
15 (I)	Sodosol	2	2	6	4	1	3	3	1	6
16 (H)	Sodosol	2	2	6	4	1	3	3	1	6
17 (G)	Sodosol	2	2	6	4	1	3	3	1	6
18 (A)	Sodosol	2	2	3	4	1	3	3	1	4
19 (E)	Sodosol	2	2	3	4	1	3	3	1	4
20 (L)	Sodosol	2	2	6	4	1	3	3	1	6
21 (C)	Sodosol	2	2	6	4	1	3	3	1	6
22 (F)	Sodosol	2	5	3	4	1	2	3	1	5
23 (J)	Sodosol	2	4	3	5	1	4	3	1	5
24 (D)	Sodosol	2	2	3	4	1	3	3	1	4
25 (B)	Rudosol	2	2	3	4	1	2	7	1	7
26	Kurosol	3	2	3	5	2	4	3	1	5
27	Kurosol	4	2	3	4	2	4	4	1	4

The most common limiting constraint for these sites is soil structure decline, followed by acidity and shallow soil depth. The fine sandy soil materials on the terrace of Bowmans Creek are susceptible to wind erosion when dry.

Based on this analysis, the Proposed Disturbance Area contains LSC Classes 4 to 7 which represent moderate through to very low capability land (refer to **Figures 3.17 to 3.19**).



Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 100 250 500m
1:10 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/3109_854.dgn
20140805 13.35

FIGURE 3.17

Proposed Hebden Road Upgrade Works Area
Land and Soil Capability

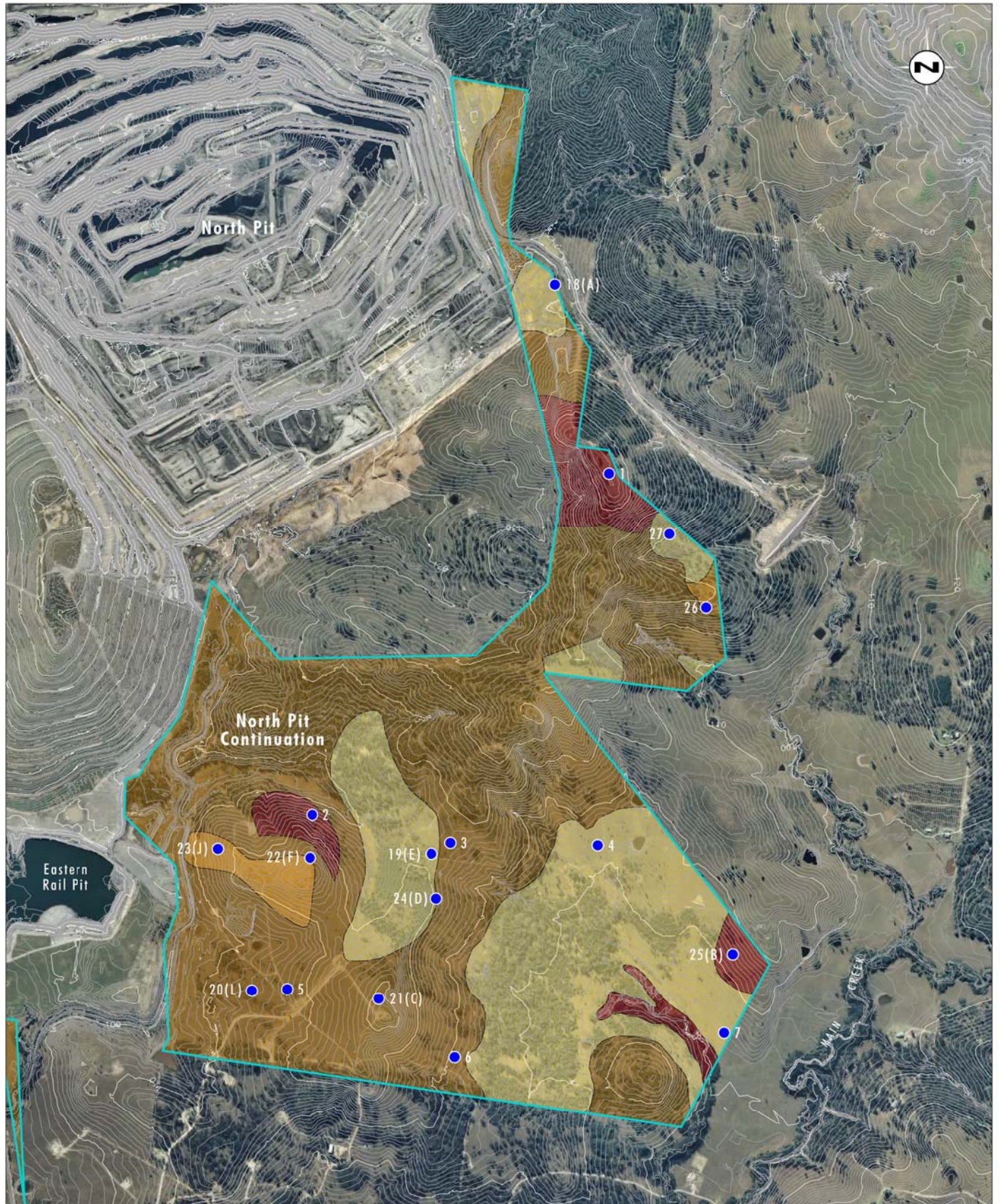


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.25 0.5 1.0 km
1:20 000

Legend

- Proposed Disturbance Area
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/3109_798.dgn
20140805 13.37

FIGURE 3.18

Proposed North Pit Continuation Area
Land and Soil Capability

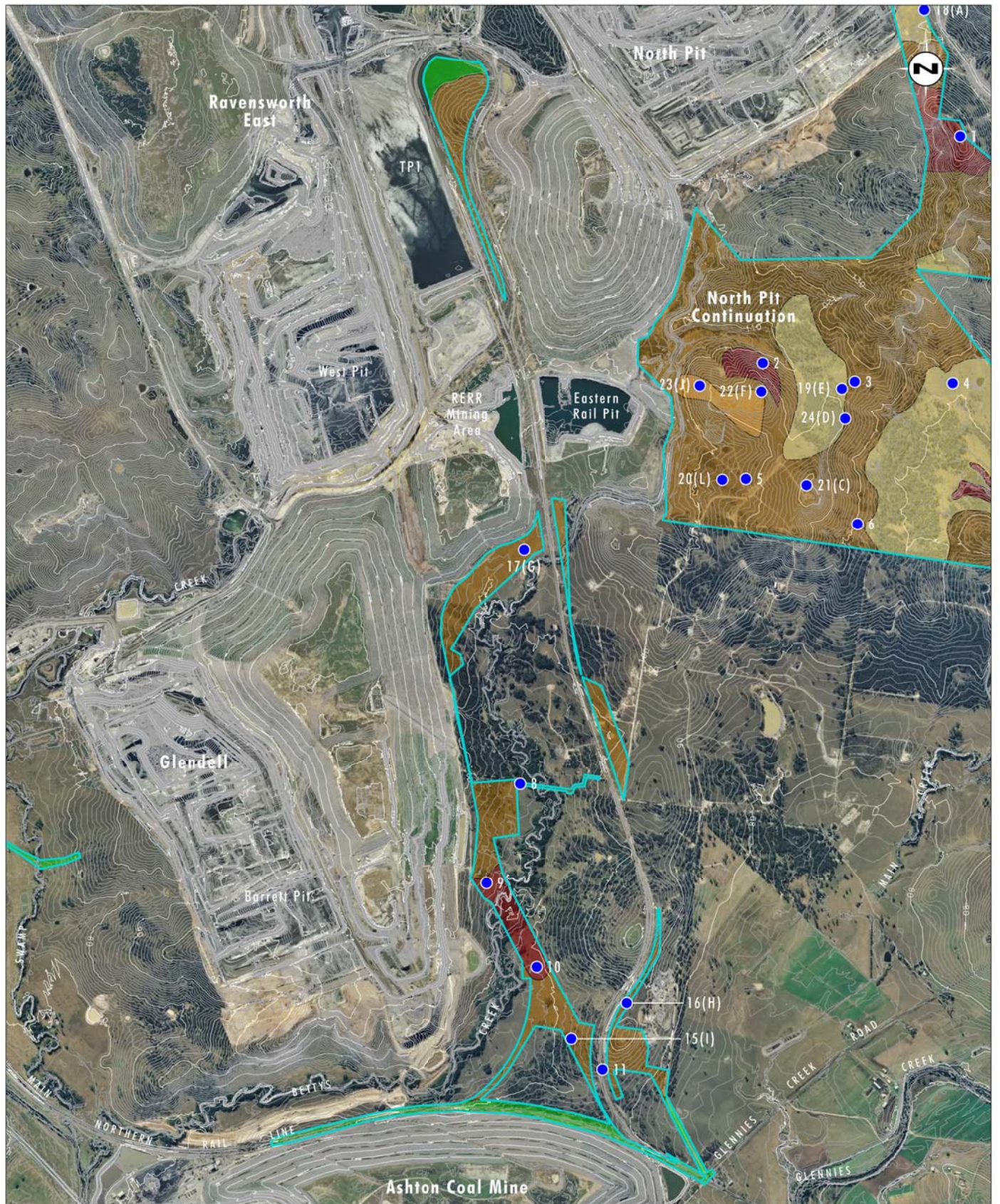


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.5 1.0 1.5 km
1:30 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/3109_799.dgn
20140805 13.40

FIGURE 3.19

Proposed Rail Upgrade Works Area
Land and Soil Capability

There is widespread potential for soil acidification across the Proposed Disturbance Area due to soils with low buffering capacity and low surface pH. These characteristics are associated with LSC Class 4 and 5 land. These limitations could be managed with the use of acid tolerant perennial pastures and/or the use of lime, but ongoing specialist management practices or inputs are required to overcome constraints and maintain sustainable productivity.

There is widespread risk of soil structure decline across many of the Sodosol soils of the Proposed Disturbance Area. The majority of sites recorded moderate surface soil sodicity which would require maintenance of surface soil vegetation cover to prevent erosion and inputs of gypsum to effectively manage the sodium levels. The subsoils were also strongly sodic and prone to dispersion adding to the limitations of these soils. These constraints are associated with LSC Class 6 land, which can be used for limited land uses such as grazing, forestry and nature conservation.

Class 7 land only occupies limited areas of the Proposed Disturbance Area where there are localised soil depth issues, including a gravel layer inhibiting rooting depth, and two sites (9 and 10) with very high surface Exchangeable Sodium Percentage (ESP) levels that may have been affected by previous land management activities that has caused the topsoil to have been lost through sheet erosion.

3.7.3.4 Verified Soil Fertility in the Proposed Disturbance Area

Each soil type was assessed on the basis of soil fertility factors as classified by the Australian Soil Classification (ASC). The Stratic Rudosol soils associated with the Bowman's Creek floodplain and terraces are classified as moderately low fertility and yet are mapped at a regional scale as probable BSAL. Soil testing undertaken in the field and the laboratory at Sites 13 and 14 show the typical indicators of inherent soil fertility, including Cation Exchange Capacity (CEC), Particle Size Analysis/Texture, and Organic Carbon, reinforce the ASC classification. Cation Exchange Capacity is moderately low (10-11 meq/100 g), Particle size Analysis identifies a relatively low clay percentage (13 per cent) in a fine loamy sand and Organic Carbon (Walkley Black) is moderate (2.89 per cent). The surface pH (Ca Cl₂) is 5.6–5.8 and in combination with a low buffering capacity and mean annual rainfall between 550 and 700 millimetres indicates a potential acidification risk which is identified as LSC Class 4.

The Clastic Rudosols are classified as low fertility under the ASC. This is also reinforced by laboratory testing of Sites 12 and 25 which measured a low CEC (7.2-7.4 meq/100 g), a low clay percentage (10 per cent) and a moderately low Organic Carbon (1.91 per cent). The surface pH (measured in Calcium Chloride (CaCl₂) solution) is 4.9-5.0 and the buffering capacity of the soil is low, indicating a potential soil acidification risk. Further these soils are constrained by a 30 centimetres thick gravel layer within the root zone which effectively limits the depth of the soil and placing these soils in LSC Class 7.

The Brown Sodosols and Kurosols are classified as moderately low fertility under the ASC. The sites tested with the Proposed Disturbance Area had CECs ranging from low (2.8 meq/100 g) to high (35.6 meq/100 g) where the high values had high sodium levels and low Calcium to Magnesium ratios associated with them. Surface pH (measured in Calcium Chloride (CaCl₂) solution) was generally below 5, surface soils had low clay percentages, low buffering capacity and moderately low Organic Carbon levels. LSC Classes ranged from 4 to 7 with the constraints relating to potential acidification and soil structural limitations.

The fertility classes and LSC classification fail to meet the criteria for BSAL across the Proposed Disturbance Area (refer to **Section 3.8.2**).

3.7.4 Soil Resources of the Proposed Offset Areas

Soil sampling was not carried out in the proposed offset areas, but desktop analysis of characteristics was conducted, supplemented by a site visit and surface soil inspection. The proposed Offset Areas have the following soil characteristics. These soil resources will not be modified by the proposed Project.

Soils

As discussed in **Table 3.5**, soil landscapes mapped as occurring within the Cross Creek Offset Area are Rosevale and Greenland (refer to **Figure 3.7**); while soil landscapes mapped as occurring within the Esparanga Offset Area are Ant Hill, Bow, Sandy Hollow and Lees Pinch (refer to **Figure 3.8**). Soil landscapes mapped as occurring within the Stringybark Creek Habitat Corridor are Bayswater and Rosevale (refer to **Figure 3.7**). Details on the soil characteristics within the proposed offset areas are provided in **Table 3.5**.

Soil Fertility

Soils in the Cross Creek Offset Area and Stringybark Creek Habitat Corridor are mapped at a scale of 1:250,000 by OEH 2012 as having moderately low to moderately high soil fertility, while soils in the Esparanga Offset Area are mapped as having low to moderately high soil fertility (refer to **Figures 3.13** and **3.20**).

LSC Classes

LSC classes mapped as occurring within the Cross Creek Offset Area, Esparanga Offset Area and the Stringybark Creek Habitat Corridor, as part of OEH mapping for the Upper Hunter SRLUP 2012 (refer to **Figures 3.9** and **3.21**), are:

- Class 3 LSC land is mapped in a small section on the northern boundary of the Esparanga Offset Area;
- Class 5 LSC land is mapped in the northern section of Cross Creek Offset Area and on the south-eastern section of the Esparanga Offset Area;
- Class 6 LSC land is mapped as occurring throughout the Esparanga Offset Area and in the south-western section of the Stringybark Creek Habitat Corridor; and
- Class 7 LSC land is mapped as occurring in the southern section of Cross Creek Offset Area and throughout the Esparanga Offset Area and in the north-eastern section of the Stringybark Creek Habitat Corridor.

3.8 Strategic Agricultural Land

The Upper Hunter SRLUP identifies agricultural land that is considered to be of strategic significance because of its land capability, productivity or other economic and social value to the region. This land may be BSAL, based on its land and soil characteristics, or it may be CIC land, based on specific production and economic values, such as viticulture, horses and associated rural tourism.

BSAL and CIC land is mapped at the regional scale in the Upper Hunter SRLUP (DP&I 2012). The OEH protocol (2012) requires that BSAL lands are verified at the project scale, to ensure that decisions about agricultural land use are based on sound information and that land is used for the purposes for which it is best suited.

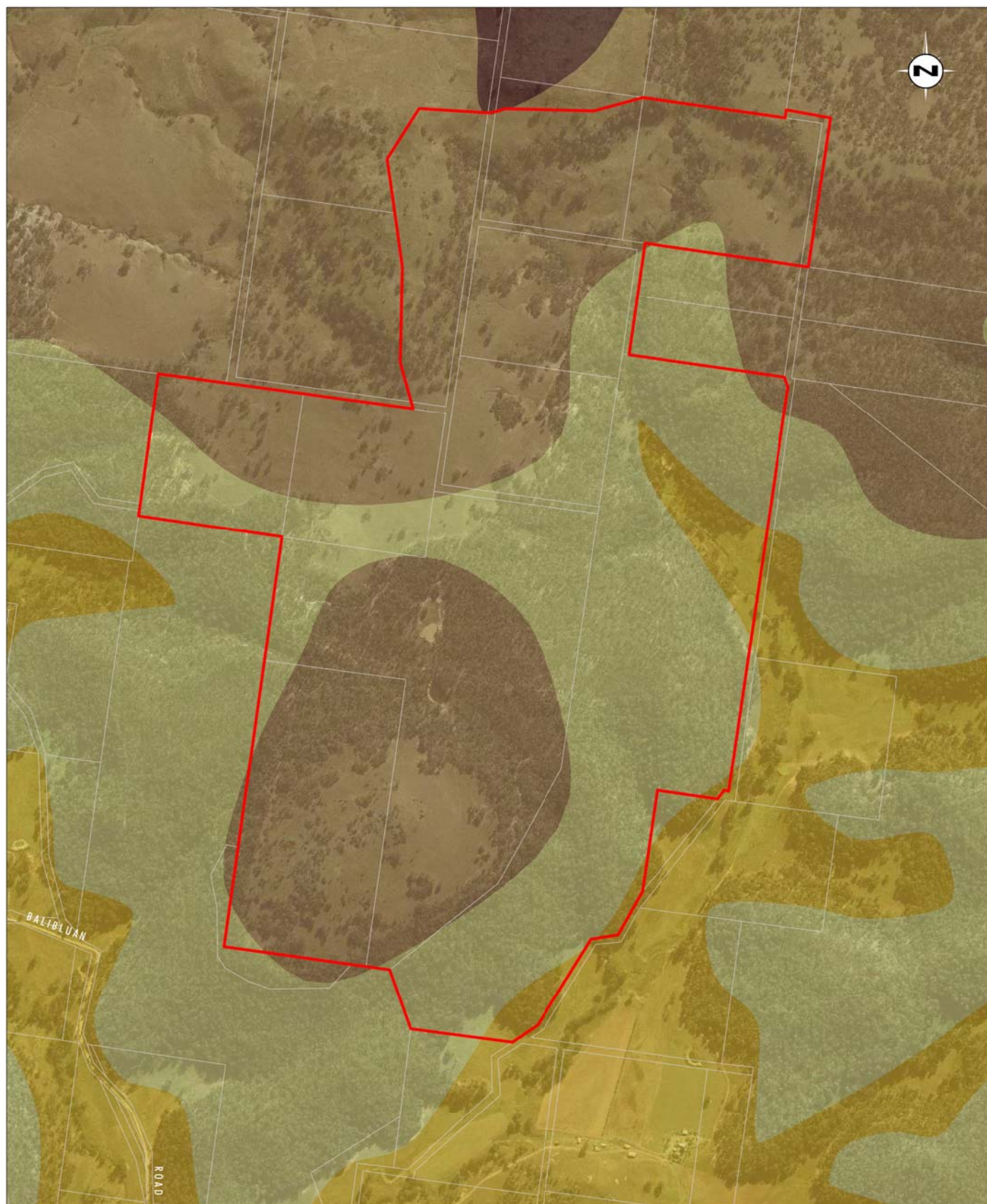


Image Source: Mount Owen (2009)
Data Source: Mount Owen (2013), OEH - Upper Hunter SRLUP Mapping (2012),
Department of Lands (2009)

0 250 500 750m
1:15 000

Legend

- Esperanga Offset Area
- Low
- Moderate Low
- Moderate High
- High

FIGURE 3.20

Esperanga Offset Area
Soil Fertility

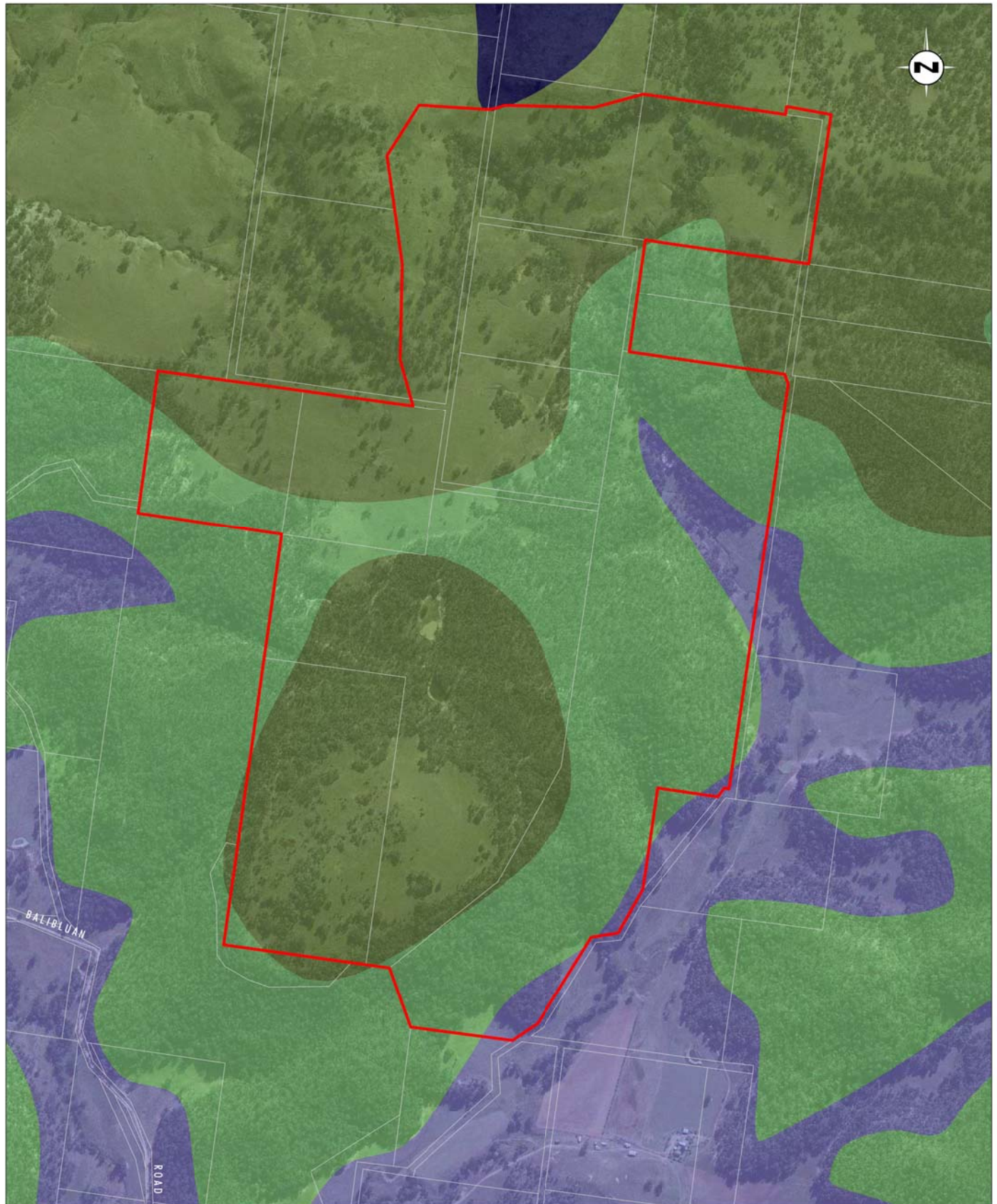


Image Source: Mount Owen (2009)
 Data Source: Mount Owen (2013), OEH - Upper Hunter SRLUP Mapping (2012),
 Department of Lands (2009)

0 250 500 750m
 1:15 000

Legend

- Esparanga Offset Area
- Class 3
- Class 5
- Class 6
- Class 7

FIGURE 3.21

Esparanga Offset Area
 Land and Soil Capability

3.8.1 Critical Industry Clusters

Within the locality of the Project, the strategic mapping undertaken for the Upper Hunter SRLUP indicates there are no CICs within proximity of the Project Area (refer to **Figure 3.22**). The nearest area of CIC is located more than 10 kilometres south-west of the southern-most section of the Project Area.

3.8.2 Verification of Biophysical Strategic Agricultural Land

Within the locality of the Project Area, the strategic mapping undertaken for the Upper Hunter SRLUP (DP&I 2012) indicates potential BSAL along the floodplains and terraces associated with the Bowmans Creek, Glennies Creek and Hunter River drainage lines (refer to **Figure 3.22**).

The BSAL, as mapped in the Upper Hunter SRLUP, is associated with the Hunter soil landscape (refer to **Table 3.5**).

In the Project Area, BSAL has been mapped at the regional scale in the area to be affected by construction of a new road crossing over Bowmans Creek. This section of the Proposed Disturbance Area totals 13.1 hectares.

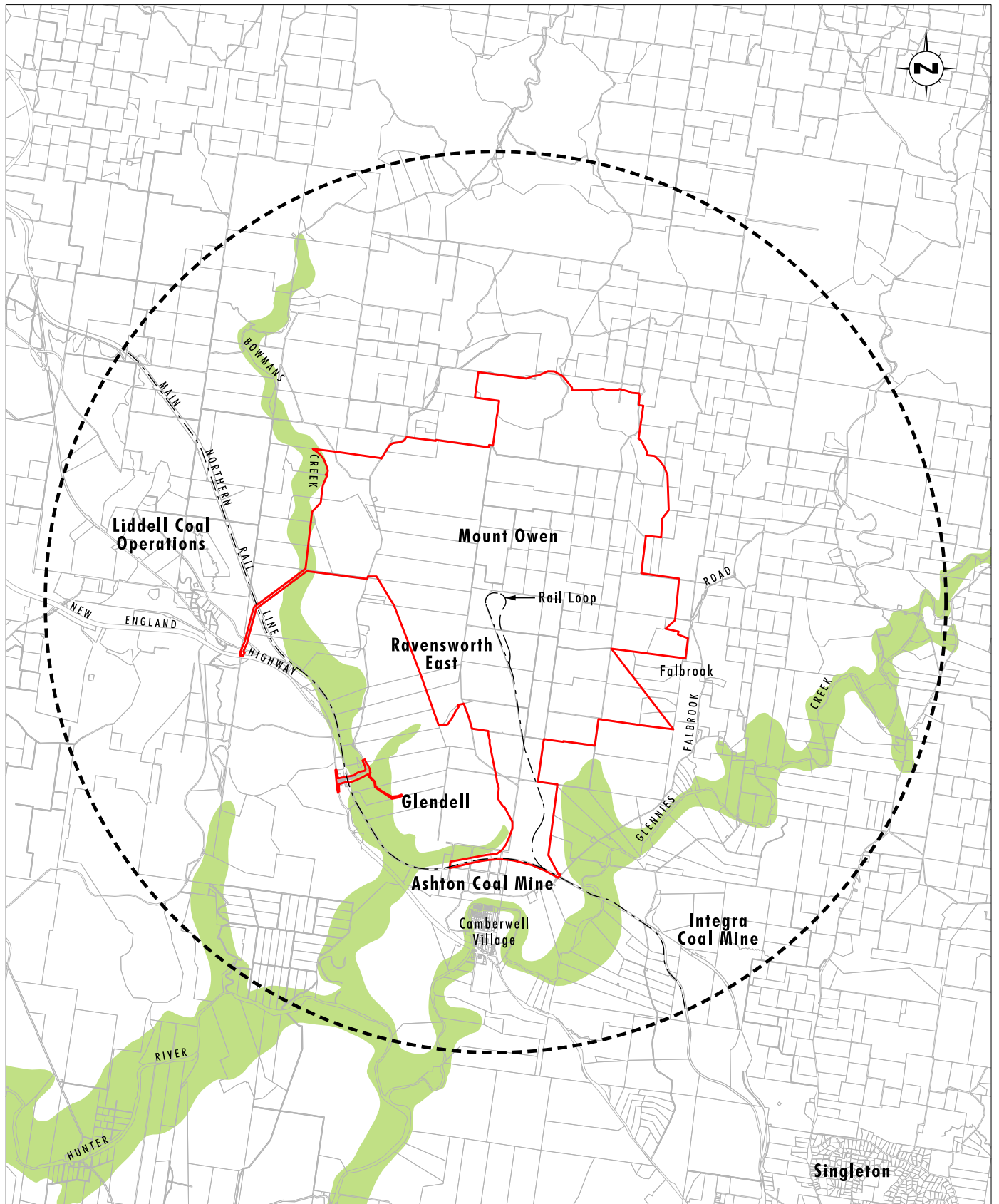
Verification of the BSAL mapping was conducted across the entire Proposed Disturbance Area in accordance with both the criteria outlined in the SRLUP for the Upper Hunter, **Table 3.15** and **Table 3.16** (BSAL Criteria SRLUP 2012) and the Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land (OEH and OASFS 2013) (**Table 3.17**).

Detailed soil survey and sampling of the offset areas to verify their LSC class and BSAL status has not been undertaken in this assessment. None of the land in the Offset Areas is mapped at the regional scale with an LSC class better than LSC Class 4 and no BSAL land has been mapped in either of the Offset Areas. Detailed desktop mapping of terrain in the Offset Areas, aerial photograph analysis and reconnaissance site inspection indicate that these are appropriate assessments of the quality of agricultural land in the proposed Offset Areas.

The Project will not change the agricultural resources of the Offset Areas. While these areas are proposed to be managed for conservation, the soils and water resources present in the area will not be disturbed.

Table 3.15 – Biophysical Strategic Agricultural Land Criteria - Upper Hunter SRLUP

Criteria
Soil fertility land that falls under soil fertility classes 'high' or 'moderately high' under the Draft Inherent General Fertility of NSW (OEH), and
Land capability land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH), and



Data Source: Mount Owen (2014), OEH (2011)
 Note: Absence of critical industry clusters is due to their not being mapped as occurring within the locality.

0 2.0 4.0 6.0 km
 1:120 000

Legend

- Project Area
- Mount Owen Complex Locality (10km Radius from Rail Loop)
- Biophysical Strategic Agricultural Land (BSAL)

FIGURE 3.22

Potential Biophysical Strategic
 Agricultural Land and Critical Industry
 Clusters - Upper Hunter SRLUP Mapping

Table 3.15 – Biophysical Strategic Agricultural Land Criteria - Upper Hunter SRLUP (cont.)

Criteria
Access to water - reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or - properties within 150 m of 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 L/s and total dissolved solids of less than 1,500 mg/L.
OR
Soil Fertility land that falls under soil fertility classes 'moderate' under the Draft Inherent General Fertility of NSW (OEH), and
Land Capability land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH), and
Access to water - reliable water of suitable quality, characterised by having rainfall of 350 mm or more per annum (9 out of 10 years); or - properties within 150 m of 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 5L/s and total dissolved solids of less than 1,500 mg/L.

The minimum requirement for reliable rainfall was met across the Project Area (see **Section 3.1** for details) where mean annual rainfall is greater than 600 millimetres (BoM), therefore the LSC Class and the soil fertility were assessed for each soil type identified within the Proposed Disturbance Area. The results are shown in **Table 3.16**.

Table 3.16 – Applied BSAL Criteria- SRLUP Upper Hunter

Soil Type	LSC Class	Fertility*	BSAL	BSAL Limitation
Stratic Rudosol	4	Moderately low	No	LSC Class and fertility
Clastic Rudosol	7	Low	No	LSC Class and fertility
Brown Sodosol	4 to 7	Moderately low	No	LSC Class and fertility
Brown Kurosol	4 to 5	Moderately low	No	LSC Class and fertility

* Fertility correlated with ASC classes (OEH 2012).

The fertility classes and land and soil capability classification failed to meet the criteria for BSAL across the Proposed Disturbance Area (see **Section 3.7.3.4**). No verified BSAL exists in the Proposed Disturbance Area, including the small area on Bowmans Creek mapped as such in the regional scale mapping by OEH (2012).

The *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (DP&I 2012) applies a 12 step verification process (refer to **Table 3.17**). The site must meet all 12 criteria, including being greater than 20 hectares in area to be assessed as BSAL. That is, if any of the conditions are not met, the site is rejected as BSAL and the remaining conditions are not assessed.

Table 3.17 – Twelve Step Process for BSAL Site Assessment

Step Number	Criteria	BSAL Definition
	Reliable water supply	Reliable water of suitable quality, characterised by having rainfall of 350 millimetres or more per annum (9 out of 10 years)
1	Slope	Slope less than or equal to 10%
2	Rock outcrop	Less than 30% rock outcrop
3	Unattached rock fragments	Less than or equal to 20% of site has unattached rock fragments > 60 millimetres diameter
4	Gilgais	Less than or equal to 50% of the site has gilgais >500 metres deep
5	Slope	Slope <5% (If yes, go to 6, if no go to 7b)
6	Rock outcrop	Nil rock outcrop (if yes, go to 7a, if no go to 7b)
7a	Fertility	Soil has moderate fertility
7b	Fertility	Soil has moderately high or high fertility
8	Soil depth	Effective rooting depth to a physical barrier > 750 millimetres
9	Drainage	Drainage better than poor
10	pH	pH range from 4.5 to 8 in calcium chloride in upper 600 millimetres
11	Salinity	Salinity less than or equal to 4 dS/m*
12	Effective rooting depth	Depth to chemical barrier >750 millimetres
13	Minimum area	Area greater than or equal to 20 hectares.

* ds/m = decisiemens per metre

All soil types across the Proposed Disturbance Area failed to meet the criteria for BSAL based on soil fertility being low to moderately low (refer to **Section 3.7.3.4** and Appendix AA of **Appendix 1**).

Both assessments determined that there is no BSAL within the Proposed Disturbance Area.

4.0 Agricultural Land Uses and Production

In this section:

- Land ownership.
- Historical rural uses and enterprises of the Project Area and locality.
- Current agricultural enterprises and production in the locality.
- Current agricultural enterprises and production on the Project Area.
- Current rural community character and values.

4.1 Land Ownership in the Project Area and Mount Owen Complex Locality

Land ownership in the Project Area and surrounding locality is shown on **Figure 4.1**.

4.1.1 Land Tenure in the Mount Owen Complex Locality

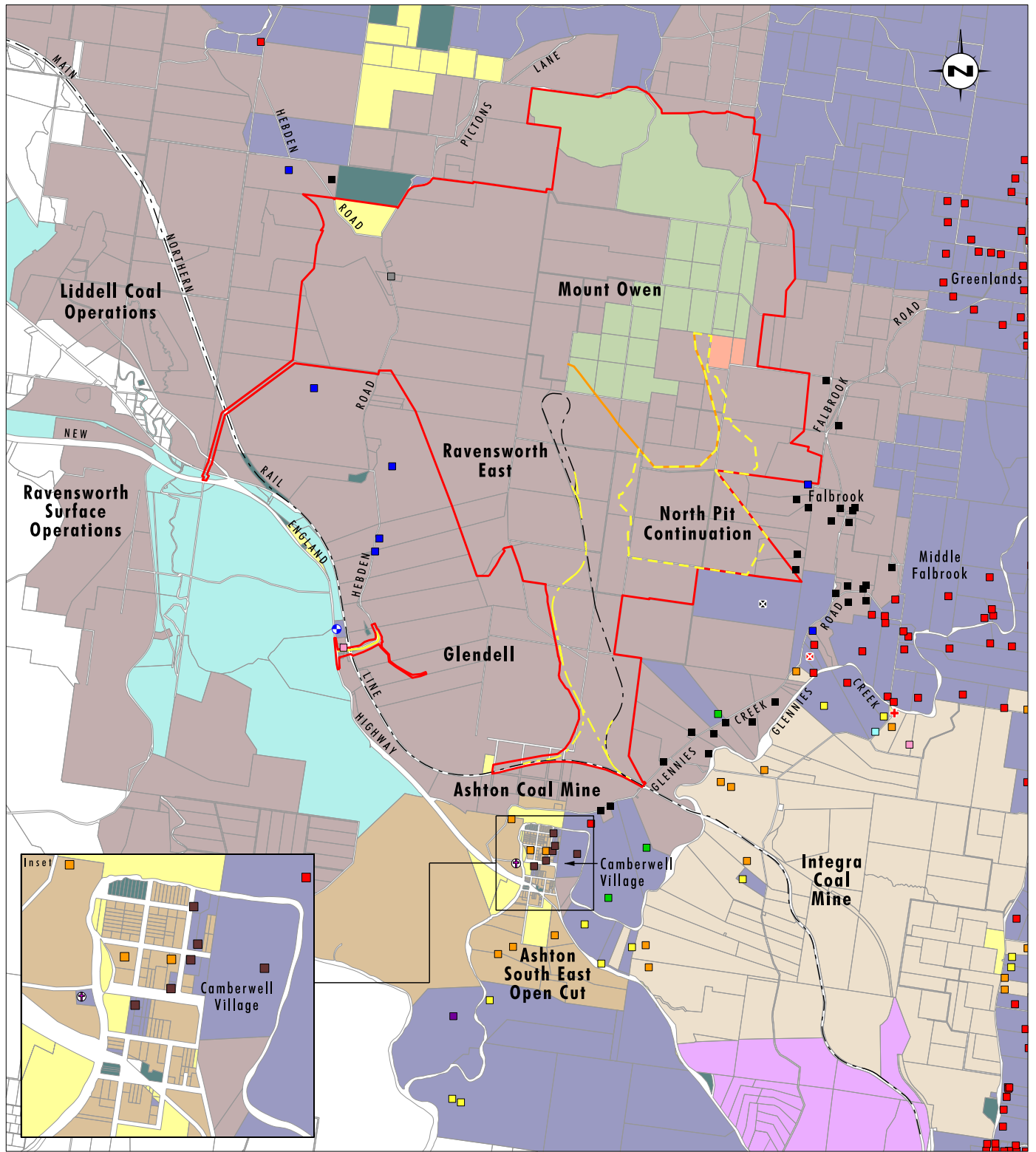
In the locality of the Project, the main land owners are:

- Glencore (Mount Owen Complex, Liddell and Ravensworth Surface Operations). As shown on **Figure 4.2**, part of this land is currently managed as agricultural land by the Glencore pastoral enterprise, Colinta;
- Integra Coal;
- Ashton Coal;
- Macquarie Generation;
- private rural land holdings, such as in the Middle Falbrook and Greenlands areas, in the catchment of Glennies Creek; and
- private rural residential and rural village blocks (such as at Camberwell and along Glennies Creek).

An area of Crown land and/or land owned by other Government authorities is located to the north of the Project Area and the Mount Owen Complex.

4.1.2 Project Area

The Proposed Disturbance Area is wholly located on land owned by Mount Owen (refer to **Figure 4.1**). Within the Project Area boundary there is also a remnant of the Ravensworth State Forest and an area of new State Forest which has been rehabilitated and revegetated as part of the 2004 Mount Owen Mine Conditions of Consent (refer to **Figure 4.2**). Land owned by NSW State Forests extends into the current mining area, which is mined with consent of the owner. Other small parcels of land are Crown land that is either vacant or part of a Travelling Stock Route.



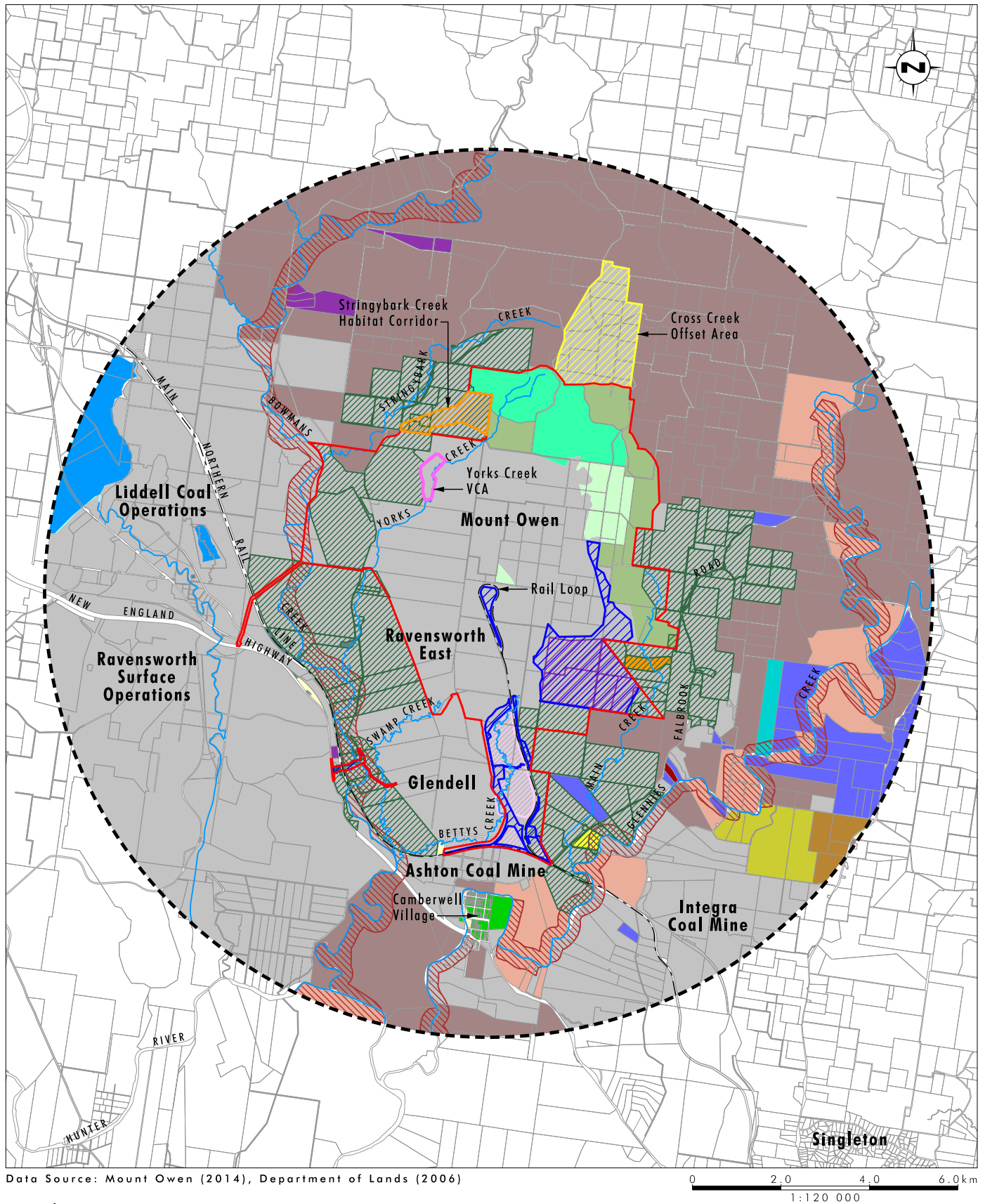
Data Source: Mount Owen (2014),
Department of Lands (2009)

Legend

- | | | |
|--|--|--|
| Project Area | State Forest | ■ Mine Owned Residence - Vacant |
| Approved North Pit Mining Extent | ⊕ Church | Community Hall |
| Proposed North Pit Continuation | ⊕ Daracon Site Office | Former Hebdon Public School |
| Proposed Rail Upgrade Works | + Glennies Creek Fire Brigade | |
| Proposed Hebdon Road Upgrade Works | x Private No Dwelling | |
| Ashton Coal | x Subject to Acquisition Rights - Glencore No Dwelling | |
| Crown Land | Currently Subject to Acquisition Rights - Dairy | |
| Crown Land TSR | SEOC Acquisition - Noise Trigger | |
| Government Authority | ■ Private Residence | |
| Integra Coal | Private Residence - Currently Subject to Acquisition Rights - Glencore | |
| Macquarie Generation | Private Residence - Currently Subject to Acquisition Rights - Other Mines | |
| Glencore | ■ Mine Owned Residence - Glencore | |
| Private | ■ Mine Owned Residence - Other Mine | |
| Rixs Creek Mine | ■ Mine Owned Residence - Derelict | |

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FIGURE 4.1
Land Ownership



Legend

- | | | |
|---|--|---|
| Project Area | Drainage Line | Regenerating Forest |
| Proposed Disturbance Area | Colinta Feedlot | Mining Operations |
| Yorks Creek VCA | Grazing - Native Pastures, Some Improved Pastures | Quarry/Industrial |
| Cross Creek Offset Area | Rural Residential/Horse Breeding | Rural Residential |
| Stringybark Creek Habitat Corridor | Integra Coal Operations Biodiversity Offset Areas | Vacant |
| Land with Potential for Irrigation/Cropping | Mixed, Grazing and Irrigation/Cropping/Improved Pasture | Village/Small Holdings |
| Colinta Agriculture (Cattle Grazing) | Olive Grove - Glencore | Water |
| Colinta Agriculture (Ungrazed) | Regenerating Forest (Ravensworth State Forest) | Government Authority |
| Bettys Creek Habitat Management Area | Ravensworth State Forest | Crown Land |
| Mount Owen Locality (10km Radius from Rail Loop) | Current Mount Owen Biodiversity Offset Area | |

FIGURE 4.2
Land Use

Part of the Project Area is currently managed by the Glencore pastoral group, known as Colinta (refer to **Figure 4.2**). The land currently managed by Colinta in the Project Area is part of land owned by Glencore and managed for agriculture in the locality and broader region, totalling 4,350 hectares.

There is no privately owned rural land within the boundary of the Project Area.

4.2 History of Agricultural Enterprises in the Upper Hunter Region, Mount Owen Complex Locality and the Project Area

Changing agricultural focus and rural settlement patterns are a key characteristic of the history of the area, responding to changes in short to medium term environmental conditions and to changes in economic, social and policy frameworks, often at a scale well beyond the Project Area and Mount Owen Complex Locality.

Notwithstanding these changes, the general agricultural land use of the Project Area and its locality is cattle grazing. The broader Upper Hunter Region has higher quality soils and a more diverse agricultural sector.

4.2.1 Land Use History of the region and the Mount Owen Complex Locality

European settlers occupied the floor of the Hunter Valley from the early nineteenth century, taking up land as far north as Singleton by October 1821. Early reports described the suitability of the land for pastoral pursuits resulting in the establishment of large scale pastoral holdings. By the mid-nineteenth century European settlement had expanded rapidly, with a total of 372,141 acres taken up in the Hunter Valley between 1822 and 1826.

Since European settlement of the Hunter Valley, in the locality of the Project, a number of agricultural industries have been important and subsequently declined. Since the early nineteenth century, land in the vicinity of the Project Area has been used for sheep and wool, cereal crops, dairying, fodder crops, dryland grazing, forestry and small areas of vineyard. Changes in land use have responded to changes in environmental, regulatory and economic conditions at the time. A brief history of regional land use, scoping the extent of change over time is presented below.

Historical records indicate cultivation began early in European settlement of the area, with crops including wheat, maize, barley and tobacco. Wheat crops grown in the Hunter Valley were prone to the disease 'rust', which struck severely in 1857. Disease together with the relatively dry conditions in the Upper Hunter made wheat a precarious crop and as a result its production declined. The decline in wheat cultivation saw an increase in barley production, mainly for stock feed but as the dairy industry began to grow, lucerne crops became a more viable option.

Dairy farming became an important land use after sheep/wool production began to wane and by the early twentieth century, dairy farms of up to 500 acres in size were present in the Upper Hunter. The growing importance of the dairying industry in the early twentieth century coincided with the 'development of the mechanical separation of milk and refrigeration causing a re-shaping of the pattern of farming' in the Singleton and Muswellbrook Local Government Areas (LGAs), due to the increased demand for dairy products in Australia and overseas (Turner 1995:19).

Dairying increased after the World War I as soldiers were given small holdings and government assistance to establish small agricultural businesses, such as dairy farms (Heritage Office & DUAP 1996a:49). A gradual decline of the dairying industry began in the second half of the twentieth century, with the number of dairy farms almost halving between 1970 to 1976 from 9,061 to 4,626 (Dunne 2012:75-81). The decline is described as being the result of changing policies, Britain joining the European Economic Community (resulting in Australia losing its main dairy export market), and the reallocation of milk quotas and the eventual deregulation of the industry (following the replacement of the Milk Board with the Dairy Industry Authority). Between 1970 and 1976 the number of dairy farms almost halved from 9,061 to 4,626.

With the decline of dairy farming, viticulture began to grow in importance in the region. Commercial wine growing in the area developed following the establishment of Soldier Settlement viticultural farms in the 1920s; however, the boom of grape growing in the Hunter Valley did not occur until the 1970s.

The development of coal resources began on a limited scale in the early 1900s. Rapid expansion took place in the 1950s with the establishment of large open-cut mines to supply power stations and increasingly to meet export demand. Today coal mining employs approximately 36 per cent of workers in the Singleton LGA (refer to **Section 4.3.2**).

4.2.1.1 Mount Owen Complex Locality

The pastoral industry was the earliest established industry within the locality of the Project Area. In 1823, John Howe was granted permission to graze his stock at Patrick's Plains, agisting 1,000 sheep and 1,200 cattle.

The earliest land taken up in the locality of the Project Area was that of Dr James Bowman (surgeon and pastoralist) at Ravensworth in 1824. Other early settlers are identified in **Table 4.1**. Bowman and Glennie are both recognised in the region by names of significant creeks. In the 1820s, Dr James Bowman ran 2,000 merino sheep and 200 head of cattle on his Ravensworth Estate.

During the 19th century, the area of Ravensworth Estate was central to local and regional wool production. However, there was a shift from wool production in the later nineteenth century to mixed farming; with dairying and to a lesser degree grazing becoming more important in the twentieth century. The move away from wool production was further encouraged by parasitic infections in sheep in the late nineteenth century.

Table 4.1 – Early Settlers in the Region

Name	Description	Location
Dr James Bowman	Ravensworth Estate - an 1824 land grant of 11,000 acres	West of the Project Area
George Bowman (unrelated to James Bowman)	Archerfield, Singleton on a 1824 grant of 1,130 acres	South of the Hunter River (south of the Project Area)
Robert Lethbridge	Granted 1,200 acres of land on 10 July 1837	East side of Glennies Creek (east of the Project Area)
James Glennie	Land originally promised to Glennie by Sir Thomas Brisbane on 24 June 1824. The 1828 census lists (Glennie) as a Farmer of Dulwich at Patrick Plains with 2,080 acres of land and 21 assigned convicts	East side of Glennies Creek (east of the Project Area)

Table 4.1 – Early Settlers in the Region (cont.)

Name	Description	Location
John Gaggin	Gaggin had lost this Hunter property by 1832	West side of Glennies Creek (immediately to the east of the Project Area)
William Simms Bell	Granted 700 acres of land near Lemington by Sir Thomas Brisbane on 14 July 1825	South of the Hunter River (south of the Project Area)
Robert Dawson	Grant of 1,280 acres from Governor Bourke in March 1836 in recompense for the grant he had sought unsuccessfully from Sir Ralph Darling in 1828. Named 'Goorangula'	Goorangoola Creek (north-east of the Project Area)

Information sourced from Gray nd, Nexus 2008, Flowers nd and www.jenwilletts.com

Further details regarding land use history in the Project Area and Mount Owen Complex Locality can be found in the Historic Heritage Assessment Mount Owen Continued Operations Project (Umwelt 2014c).

4.2.1.2 Ravensworth Village Area

The Ravensworth Village area (the area south of Hebden Road) was originally part of James Bowman's Ravensworth Estate. Ravensworth Village was not set out as a surveyed Government town, but grew around the needs of workers on the railway and Ravensworth Estate. Prior to 1876, those living in the area would have been employees of Ravensworth Estate or railway employees. There were various landowners of the Ravensworth Village area until its purchase by William Wolfgang in 1908. Apart from one Lot, which was subdivided and sold in 1927, the majority of the land was retained by the Wolfgang family until the 1950s.

4.2.2 Land Use History of the Project Area

The Project Area is located within the Parishes of Vane and Goorangoola.

The 1923 Parish Map of Vane shows most of the lands within the Project Area as being owned by the Russell family with the occasional block marked as belonging to Mackay. Several Settlement Purchase Area (SPA) blocks are also indicated on the 1923 Parish Map of Vane. The 1923 Parish Map of Liddell shows the eastern portion of the Project Area as being part of Bowman's Ravensworth Estate. The 1917 Parish Map of Goorangoola shows a number of smaller blocks as still being owned by William and Eliza Russell as well as a number of other individuals including Duncan Mackay.

This tenure history is consistent with the tenure and land use history of the broader locality, with broad acre pastoral enterprises being fragmented for soldier settlement after the First World War.

The Ravensworth State Forest occupies part of the Project Area. The forest was declared as a timber reserve in 1866 and gazetted as State Forest in 1916. The State Forest was extensively logged and grazed until the 1990s, so was until then part of the agricultural land use pattern of the area. With the commencement of coal mining in 1993, part of the original State Forest was included in the mining area. The adjoining New Forest area (refer to **Figure 4.2**), previously grazed and forested land, was purchased by the mine at that time as

part of the biodiversity and state forest offset process, and has been managed for conservation since then.

4.3 Current Agricultural Enterprises in the Locality and the Region

This section describes the rural land use context of the Singleton and Muswellbrook LGAs of the Upper Hunter region and of the specific Mount Owen Complex Locality (i.e. in a 10 kilometre radius from the centre of the Project Area).

Due to the locality of the Project being close to the border of the Singleton and Muswellbrook LGAs, the AIS has examined agricultural land use and production data for both LGAs; with some comparison to the wider Upper Hunter region, within which both LGAs are located. The Upper Hunter region encompasses Dungog; Gloucester; Muswellbrook; Singleton and the Upper Hunter LGAs. The region has a long history of settlement and features multiple towns and villages which have traditionally functioned as rural or transport service centres. The pattern and demography of rural towns and villages has been gradually changing since the mid-twentieth century, in response to factors such as changes in technology, social conditions and wealth.

With a variety of landscapes and climates, the Upper Hunter region supports a diverse range of agricultural industries. Similarly, Singleton and Muswellbrook LGAs have a long history of agricultural land use; particularly in regard to cropping and grazing.

HCRCMA reviewed regional land use for the Upper Hunter during the preparation of the *2013 Catchment Action Plan*. The CMA reviewed the Australian Bureau of Statistics (ABS) land use data released in 2012. For the Upper Hunter, the analysis identified the areas used for diverse rural and industry purposes, as shown in **Table 4.2**.

Table 4.2 – Areas of Land Use Types, Upper Hunter (HCRCMA 2013)

Upper Hunter Land use summary LAND USE	AREA (HA)
Conservation Area	43,431
Cropping	37,863
Grazing	668,477
Horticulture	5,175
Intensive Animal Production	2,861
Mining & Quarrying	55,360
Power Generation	441
River & Drainage System	14,243
Special Category	1,735
Transport & Other Corridors	8,095
Tree & Shrub Cover	124,361
Urban	12,756
Wetland	302

There are a diverse range of agricultural enterprises within the Singleton and Muswellbrook LGAs, including:

- Livestock production is the most widespread agricultural enterprise in both LGAs, including:
 - cattle production (i.e. meat, dairying and breeding stock);
 - poultry production for meat and eggs (i.e. chickens, ducks, turkeys and other poultry);
 - sheep production (i.e. wool, meat and breeding stock);
 - pig production (i.e. meat and breeding stock); and
 - other livestock production (e.g. buffaloes, deer, goats and horses).
- Crop production (including horticulture) is the next most important agricultural enterprise in both LGAs, including:
 - hay and silage production, including:
 - pasture, cereal and other crops;
 - broadacre crop production, including:
 - cereal crops for grain and seed (i.e. wheat, oats, barley, maize, and other crops);
 - non-cereal crops;
 - nurseries (i.e. cut flowers or cultivated turf);
 - vegetable production, including:
 - for human consumption (i.e. capsicums, cauliflower, lettuce, melons, mushrooms, potatoes, pumpkins, sweet corn, and other vegetables);
 - fruit and nuts production, including:
 - citrus fruit (i.e. oranges, lemons and limes, mandarins, grapefruit, and other citrus fruit);
 - stone fruit (i.e. apricot, nectarines, olives, peaches, and plums);
 - pome fruit (i.e. apples);
 - nuts (i.e. almonds, macadamias, and pecans); and
 - viticulture for wine and table grape production.

In Singleton LGA, agriculture is an extensive land use, with 32 per cent of land dedicated to farm holdings; of which 84 per cent and 4 per cent are dedicated to grazing and cropping (including horticulture) respectively (refer to **Table 4.3**, which shows the area occupied by various agricultural land uses for 2006 and 2011). Agriculture is also a dominant land use (by area) within Muswellbrook LGA, with 31 per cent of land dedicated to farm holdings, of which 78 per cent and 7 per cent are dedicated to grazing and cropping (including horticulture) respectively (refer to **Table 4.3**). The importance of grazing and cropping agricultural enterprises is reflected in the data for the Upper Hunter region as a whole, with 86 per cent and 4 per cent of farm holdings dedicated to grazing and cropping (including horticulture) respectively (DPI 2013b).

Table 4.3 – Land Use by Area for Agriculture in the Singleton and Muswellbrook LGAs, 2006 and 2011 data

Land Use by Area	Census Year		Change
	2006	2011	
Singleton			
Total LGA Area (ha)	488,425	488,425	No Change
Total Area of Farm Holdings (ha)	156,484	156,171	-343
Number of Farms	551	536	-15
Farm Holdings as Percentage of LGA Total Area (%)	32	32	No Change
Grazed/Crop Land as Percentage of LGA Total Area (%)	29	29	No Change
Combined Crop and Grazing Area (ha)	139,561	142,839	+3,278
Grazing Lands (ha)	132,631	133,686	+1,055
Crop Lands, including horticulture (ha)	6,930	9,153	2,223
Muswellbrook LGA			
Total LGA Area (ha)	340,200	340,200	No Change
Total Area of Farm Holdings (ha)	121,872	105,548	-16,324
Number of Farms	314	264	-50
Farm Holdings as Percentage of LGA Total Area (%)	36	31	-5
Grazed/Crop Land as Percentage of LGA Total Area (%)	30	28	-2
Combined Crop and Grazing Area (ha)	103,599	94,829	8,770
Grazing Lands (ha)	95,446	88,175	7,271
Crop Lands, including horticulture (ha)	8,153	6,654	1,499

Source: ABS, 2012a and DPI, 2013b

While agricultural enterprises account for a high spatial proportion of land use within both LGAs, ABS (2012a) indicates a decline in the number of farms (refer to **Table 4.3**). This is reflected in the ABS regional profile for Singleton LGA, which indicates a decline in the number of businesses in the agriculture, forestry and fishing industries between 2004 and 2007; reducing from 633 to 597 (ABS 2010).

DPI (2013b) indicates that, in 2006, the Singleton and Muswellbrook LGAs accounted for approximately 35 per cent of the total number of farms in the Upper Hunter region. This is despite only accounting for approximately 22 per cent of the total area farmed in the Upper Hunter region. This is reflected in the average farm sizes in Singleton and Muswellbrook LGAs, at approximately 284 hectares and 388 hectares respectively, where the average farm size in the Upper Hunter region is approximately 492 hectares (DPI 2013b). The smaller farm sizes are associated with intensive flood plain and terrace agriculture (e.g. historically to support dairying) and historical land tenure such as soldier settlement schemes.

4.3.1 Regional Agricultural Production Statistics

Data collected by Australian Bureau of Statistics (ABS) (2011a and 2011b) indicate that in the Singleton and Muswellbrook LGAs, agriculture only accounts for approximately 3 per cent and 5 per cent of employment respectively.

Table 4.4 provides a summary of the estimated value of agricultural products (excluding horses) for LGAs included within the Upper Hunter region (DPI 2013b).

Table 4.4 – Estimated Value of Agricultural Products (Excluding Horses) for Muswellbrook and Singleton LGAs, the Upper Hunter Region and NSW

Local Government Area	Estimated Value of Agricultural Products (excl. horses) (\$ million)
Muswellbrook	74
Singleton	81
Upper Hunter Region	461
NSW	19,677

Source: DPI (2013b) Note that DPI presents the value of the stud horse industry separately to other agricultural products.

Muswellbrook and Singleton LGAs account for approximately 16 per cent and 18 per cent of the estimated value of agricultural products (excluding horses) in the Upper Hunter region respectively. Together, Muswellbrook and Singleton LGAs account for approximately 34 per cent of the total estimated value of agricultural products in the Upper Hunter region and 1 per cent of the total estimated value of agricultural products in NSW.

DPI 2013b also provides an indication of the value of the equine industry in the Upper Hunter, based on ABS 2006 data. In 2006, there were 2,630 stud horses in Muswellbrook LGA and 932 in Singleton LGA, with 6,617 in the Upper Hunter LGA and 10,658 in the Upper Hunter Region. DPI (2013b) refers to estimates from HTB (2010) that the Hunter overall produces 70 per cent of the stud horses in Australia and 80 per cent to 90 per cent of the export value. HTB (2010) also states that the value of bloodstock on Hunter Valley farms is around \$2.5 billion. Based on the ABS horse numbers from 2006, this means stud horses in the region have an average value of \$234,556. (DPI 2013b) There are no stud horse enterprises in the Mount Owen Complex Locality.

4.3.1.1 Ten Year Agricultural Production Data

Table 4.5 shows the amount, in tonnes, of various agricultural products for the region, for the periods 2000-2001 and 2010-2011. **Table 4.5** shows the value of production of these agricultural commodities over the same 10 year period.

As shown in **Table 4.6**, in 2010-11 the total gross value of agricultural production in Singleton and Muswellbrook LGAs were approximately \$50.7 million and \$38.0 million respectively (ABS 2012). In Singleton LGA this was an increase of approximately \$13.6 million and \$16.2 million from the total gross value of agricultural production in 2000-01 and 2005-06 respectively. In Muswellbrook LGA this was an increase of approximately \$4.4 million and \$4.0 million from the total gross value of agricultural production in 2000-01 and 2005-06 respectively.

Livestock slaughtering and milk production have consistently been the biggest contributors to the total value of agricultural production in the Singleton and Muswellbrook LGAs. In 2010-11 the gross values of livestock slaughtering and milk production accounted for approximately 87 per cent and 84 per cent of the total value of agricultural production in Singleton and Muswellbrook LGAs respectively (refer to **Table 4.6**).

In Singleton LGA, this was an increase of approximately \$17.23 million and \$0.38 million from 2005-06 for livestock slaughtering and milk production respectively. In Muswellbrook LGA, this was an increase of approximately \$3.95 million and \$3.52 million for livestock slaughtering and milk production respectively. It is noteworthy that the gross values of livestock slaughtering and milk production have increased despite a decline in livestock and dairy cattle numbers since 2000-01 (refer to **Tables 4.5** and **4.6**).

In the 10 years between 2000-01 and 2010-11, production of agricultural commodities in Singleton and Muswellbrook LGAs has experienced a decline; this is excluding hen egg production, fruit and nut production and, in Muswellbrook LGA, the total number of meat poultry (refer to **Table 4.5**). It is important to note that despite a decline in livestock numbers and milk production, the gross value of livestock slaughtering and milk production in both LGAs have increased since 2000-01.

Table 4.5 – Production Statistics for the Periods 2000-2001 and 2010-2011* for Singleton and Muswellbrook LGAs[#]

Agricultural Commodities	2000-2001	2010-2011	Change
Singleton LGA			
Hay and Silage – Total Production (t) ¹	29,874	30,336	N/A ²
Broadacre Crops – Total Production (t) ³	689	55	-634
Vegetables for human consumption - Total Production (t) ⁴	3,865	950	-2,915
Fruit and Nuts - Total Production (t) ⁵	215	234	19
Grapevines - Total Production (t) ⁶	4,808	3,139	-1,669
Hen egg production for human consumption (dozens)	0	591	591
Total Meat Poultry (no.)	885,292	728,136	-157,156
Dairy cattle - Total (no.)	14,410	7,722	-6,688
Meat cattle - Total (no.)	50,036	49,113	-923
Sheep - Total (no.)	2,066	664	-1,402
Pigs - Total (no.)	191	125	-66
Goats (no.)	Data Not Available	347	Data Not Available
Horses - Stud (no.)	Data Not Available	735	Data Not Available
Horses - Other (no.)	Data Not Available	1,017	Data Not Available
All other livestock (no.)	Data Not Available	2,846	Data Not Available
Muswellbrook LGA			
Hay and Silage – Total Production (t) ¹	28,220	26,402	N/A*
Broadacre Crops – Total Production (t) ²	894	835	-59
Vegetables for human consumption - Total Production (t) ³	812	35	-777
Fruit and Nuts - Total Production (t) ⁴	<1	560	559
Grapevines - Total Production (t) ⁵	11,337	2,819	-8,518
Hen egg production for human consumption (dozens)	1,596	9,452	7,856
Total Meat Poultry (no.)	130	2,885	2,755
Dairy cattle - Total (no.)	12,840	10,546	-2,294
Meat cattle - Total (no.)	41,205	34,500	-6,705
Sheep - Total (no.)	10,130	2,957	-7,173

Table 4.5 – Production Statistics for the Periods 2000-2001 and 2010-2011* for Singleton and Muswellbrook LGAs[#] (cont.)

Agricultural Commodities	2000-2001	2010-2011	Change
Muswellbrook LGA			
Pigs - Total (no.)	60	16	-44
Goats (no.)	Data Not Available	128	Data Not Available
Horses - Stud (no.)	Data Not Available	3,546	Data Not Available
Horses - Other (no.)	Data Not Available	516	Data Not Available
All other livestock (no.)	Data Not Available	4	Data Not Available

Source: ABS 2008 and 2012a.

* The ASGC dataset for 2010-11 has been used in order to provide a comparison to the 2000-01 dataset.

[#] Data has been obtained from ABS (2008) and ABS (2012a). This data is based on estimates for a range of commodity items. As such, production numbers are estimates. Furthermore, data categories may not necessarily align between years; it has been noted where data has been perceived to not align.

1 Includes pasture, cereal and other crops cut for hay pasture and cereal cut for silage.

2 The 2000-2001 dataset does not provide data on silage production and as such a comparison/change cannot be drawn.

3 Includes cereal crops for grain or seed; and wheat, oats and barley for grain.

4 Includes carrots, capsicums, cauliflowers, herbs, lettuce, melons, mushrooms, onions, peas, potatoes, pumpkins, sweet corn and tomatoes.

5 Includes citrus fruit, stone fruit, pome fruit, nuts and other orchard fruit.

6 Includes for wine, table and/or other grape production.

Table 4.6 – Value of Agricultural Production Data for Singleton and Muswellbrook LGAs based on 2000-01, 2005-06 and 2010-11 Census Data

Value of Agricultural Commodities produced	2000-01		2005-06		2010-2011*	
	Value (\$m)	% of total agriculture	Value (\$m)	% of total agriculture	Value (\$m)	% of total agriculture
Singleton LGA						
Cereal Crops	0.15	0.4	0.12	0.4	0.00	0.0
Other Broadacre Crops	0.04	0.1	0.01	0.0	0.00	0.0
Nurseries & Cut Flowers	0.82	2.2	0.16	0.5	0.20	0.4
Crops for Hay	2.84	7.6	2.07	6.0	3.40	6.7
Vegetables	1.99	5.4	2.11	6.1	1.80	3.6
Citrus Fruit	0.02	0.1	0.10	0.3	0.10	0.2
Grapes (wine and table)	2.05	5.5	3.28	9.5	1.00	2.0
Other Fruit	0.31	0.8	0.10	0.3	0.10	0.2
Nuts	0.00	0.0	0.00	0.0	0.00	0.0
Wool	0.00	0.0	0.06	0.2	0.00	0.0
Milk	11.47	30.9	13.22	38.3	13.60	26.8
Eggs	0.00	0.0	0.00	0.0	0.00	0.0
Livestock Slaughterings	17.41	46.9	13.27	38.5	30.50	60.2
Total Agricultural Commodities	37.10	100	34.50	100	50.70	100
Muswellbrook LGA						
Cereal Crops	0.17	0.5	0.09	0.3	0.20	0.5
Other Broadacre Crops	0.00	0.0	0.03	0.1	0.10	0.3
Nurseries & Cut Flowers	0.11	0.3	0.11	0.3	0.10	0.3
Crops for Hay	2.11	6.3	3.96	11.6	3.80	10.0
Vegetables	0.39	1.2	0.10	0.3	0.00	0.0
Citrus Fruit	0.16	0.0	0.00	0.0	0.00	0.0
Grapes (wine and table)	7.66	22.9	4.23	12.4	0.90	2.4
Other Fruit	0.00	0.0	0.48	1.4	0.80	2.1

Table 4.6 – Value of Agricultural Production Data for Singleton and Muswellbrook LGAs based on 2000-01, 2005-06 and 2010-11 Census Data (cont.)

Value of Agricultural Commodities produced	2000-01		2005-06		2010-2011*	
	Value (\$m)	% of total agriculture	Value (\$m)	% of total agriculture	Value (\$m)	% of total agriculture
Nuts	0.48	1.4	0.66	1.9	0.30	0.8
Wool	0.25	0.7	0.06	0.2	0.00	0.0
Milk	12.24	36.6	13.08	38.4	16.60	43.7
Eggs	0.00	0.0	0.00	0.0	0.00	0.0
Livestock Slaughterings	10.07	30.1	11.25	33.0	15.20	40.0
Total Agricultural Commodities	33.63	100	\$34.04	100	38.00	100

Source: DPI, n.d. and ABS, 2012b.

* Values of agricultural commodities produced in 2010-11 were taken from Value of Agricultural Commodities Produced, Australia, 2010-11 (ABS, 2012b) with rounding to the nearest one-hundred thousand. Therefore, in 2010-11 while some commodities are indicated as having a value \$0.0 million, values may have been rounded down.

4.3.2 Agricultural Communities

A significant proportion of the total LGA areas of Singleton (32 per cent) and Muswellbrook (31 per cent) are dedicated to farm holdings (predominantly grazing and cropping). However, while farm holdings account for a significant proportion of the total LGA areas of Singleton and Muswellbrook, only 3 per cent and 5 per cent of the working population are employed in the agricultural industry respectively.

DPI (2013b) notes the shortage of skilled farm workers as one of the challenges faced by most agricultural industries in the Upper Hunter region, which is stated to be due to the availability of alternative employment opportunities. As an example, mining accounts for 36 per cent and 38 per cent of employment in Singleton and Muswellbrook LGAs respectively (ABS, 2011a and 2011b). As noted in **Section 4.3.3**, the strength of mining employment relative to agricultural employment was also noted by local farmers in the vicinity of the Mount Owen Complex.

As discussed in **Section 4.3.1**, farm sizes in Singleton and Muswellbrook LGAs are, on average, smaller in size than the average farm size for the Upper Hunter region. This is reflected in farm numbers, with more than one-third of the total number of farms in the Upper Hunter region found in Singleton and Muswellbrook LGAs (DPI 2013b).

Along with the Upper Hunter and Cessnock LGAs, Singleton and Muswellbrook LGAs support a cluster of internationally renowned viticultural and equine breeding industries, in addition to their associated support industries (DPI 2013b). DPI (2013b) states that while ABS data does not identify the region encompassing Singleton and Muswellbrook LGAs as producing a large percentage of NSW's wine grapes and stud horses, this is due to the industries in the region concentrating on quality as opposed to bulk volume.

As discussed in more detail in **Section 4.3.4**, supporting infrastructure for agricultural industries in Singleton and Muswellbrook LGAs is well established and includes equipment supplies, advisory services, livestock markets (i.e. abattoirs, sale yards), produce markets and more.

4.3.2.1 Local Farming Communities

There are 174 residences located within the Mount Owen Complex Locality (10 kilometres radius of the Project). These include:

- 34 (19.5 per cent) owned by Glencore.
- 14 (8 per cent) owned by other mining operations.
- 10 (5.7 per cent) currently subject to Acquisition rights with other mining operations.
- 4 (2.3 per cent) currently subject to Acquisition rights from both Glencore and other mining operations.
- The remainder (64.5 per cent) are privately owned.

The occupiers of these residences make up the local community.

This local community is changing. Key changes over the last decade include:

- increasing proportion of recent arrivals, either as rural residential (small farm holdings) owners, who derive most of their income from non-farm activities or as lifestyle migrants to the area;

- increasing number of people who are renting (e.g. people renting residences owned by mining operations or others);
- changes to the age structure of occupiers of residences (different changes for long term residents and recent arrivals); and
- changes to the primary occupation of people living in the community, with increases in mining and mining services employment.

Table 4.7 provides examples of changes already occurring in the Mount Owen Complex Locality, based on ABS statistics for the Camberwell and Bridgman Statistical areas, which include the Project Area.

Table 4.7 – Social trends in communities in the locality of the Project

Indicator	Camberwell Statistical Area		Bridgman Statistical Area	
	2006	2011	2006	2011
Median individual income (weekly)	\$422	\$677	\$515	\$612
Median household income (weekly)	\$1,153	\$1,607	\$1,607	\$1,402
Top industry employment	Mining 26%	Mining 19%	Mining 19%	Mining 25%
Construction industry employment	11%	0%	6%	13%
Wholesale trade industry employment	11%	0%	6%	13%
Occupation (managers)	24%	13%	9%	15%
Occupation (technicians and trades)	11%	21%	24%	17%
Population	378	181	477	396
Lone person household	16%	25%	5%	8%
Dwellings owned under mortgage	32%	11%	43%	34%
Dwellings being rented	39%	64%	12%	26%

More detail on the demographic character of the locality of the Project Area and changes in recent years is presented in the Social Impact and Opportunities Assessment in Appendix 5 of the EIS.

Rural communities are defined not just by locality or by economic production, but by the links between people and local institutions, such as schools, community organisations, sporting clubs, bushfire brigades, SES, pony clubs, hall committees, sharing farm equipment and labour and other local activities that bring people together.

Changes to the social structure and connection of the community which have been noted by residents during consultation for the Project are summarised in **Section 4.3.3**.

4.3.3 Local Production Details and Issues from Consultation

Local details about agricultural production and land management, based on consultation with land owners (see **Section 2.3.4** for details of land holders consulted), are summarised in **Table 4.8**. This information is based on a small number of irrigated properties on Glennies Creek, but does provide an indication of some important production values and linkages in the locality.

A significant portion of the floodplain/terrace land in the locality of Mount Owen Complex is within the Project Area and is owned by Glencore and currently managed by Colinta (see **Section 4.4** for details of management and production).

Table 4.8 – Issues from Landholder/Manager Consultation

Issue	Details
Property size	Rural residential properties are less than about 10 hectares. Grazing and fodder producing farms have areas of 30-90 hectares and may have no other agistment land. Properties are on the terrace of Glennies Creek (LSC Class 2-3 land) have irrigation licences.
Period of residence/farming	Farmers in the locality are multi generation land owners. Some were previously dairy producers, but ceased due to various factors such as deregulation, labour sourcing problems and general family health. Ageing land holders – some leaving industry because of age.
Current operations	Irrigated hay and silage, as well as turning off vealers or yearlings from a cow/calf herd. Stock are cross bred Hereford/charolais. Livestock are sold through the Singleton sale yards (vealers) and to abattoirs in Singleton, Scone or Wingham for yearlings. Pasture fertilised every year; other soil improvement also applied each year, in each case by the farmer.
Irrigation licences	Properties on the terrace of Glennies Creek have irrigation licences which are used to irrigate oats and/or lucerne crops. Concern that general security water licences (farming properties) are cut off when the dam levels are low (below 50%), but power generation, mining and town drinking water supply have high security licences in the Hunter Regulated River System. (note Glennies Creek irrigation is in the Hunter Unregulated system).
Production	Lucerne hay in small bales is produced and sold to the horse industry (e.g. horses kept on small holdings); forage sorghum and oats is grown for the cattle industry. Occasional production of wrapped round bale silage, but more difficult to sell because of handling issues. Number of small properties with horses has increased in recent years – so good market for lucerne hay for horse feed. Pastures improved with rye grass, red and white clover. Replacement heifers are not bred on these properties.
Off farm income	Some rural households have limited off farm income (not working in other industries). Some land holders earn income from rental of houses. This has been a buoyant market in recent years because of the number of people employed in the coal industry looking for accommodation.
Supplies and services	General farm and rural supplies are purchased in Singleton. A local trucking company is used to deliver stock to market. Agronomy advice not purchased. Use abattoir and sale yards in Singleton.

Table 4.8 – Issues from Landholder/Manager Consultation (cont.)

Issue	Details
Farm labour	Reported to be difficult to source labour because of competition of high wages elsewhere. Also lack of farming skills as people are trained for employment in other industries.
Farming community	A loss of community was reported. The landholders noted that as properties are bought surrounding the mine, long standing farmers leave and are replaced by rental residents who do not have the same history and commitment to the local area (to the community or to the land). A flow on impact is loss of volunteers for community activities/services such as bush fire brigade, hall committee.
Management of offset areas	Concern about management of offset and surrounding lands and lack of control of pests (including wild dogs and kangaroos), fire, weeds (such as green cestrum and 'oak' trees). Difficulties in retrieving straying cattle from offset areas because of dense vegetation (unsafe for mustering).
Other environmental issues	Concern about noise, dust, lights and blasting (vibration) associated with various mines in the locality. General concern that proximity to mining decreases the value of the land.

4.3.4 Supporting Infrastructure for agriculture

Within the Mount Owen Complex Locality, the primary agricultural infrastructure is the road network, which connects rural communities and landholders to markets, services and suppliers. This ranges from the New England Highway to small unsealed roads servicing the agricultural and residential land surrounding the mining operations.

The main agricultural service centre is Singleton which provides rural supply outlets, agronomic services and a livestock selling centre. The rural supply outlets and livestock selling facilities are well patronised by grazing operations in the Mount Owen Complex Locality. The relatively low intensity of most of the agriculture means there is low reliance on commercial agronomic or livestock advice other than that provided by the rural resellers.

The locality is downstream of the Glennies Creek Dam and is part of the Hunter Regulated River system. There is no specific support infrastructure relating to the irrigation industry within the locality, however each irrigator has their own pumping and water use monitoring system, as well as water delivery systems.

More broadly, supporting infrastructure for the agricultural industries in the Hunter Valley is well established. There are milk processing factories, abattoirs and regional saleyards as well as retailers of agricultural equipment and providers of specialist services such as agronomic advice or management services. A brief overview of regional infrastructure and services for agriculture is provided below:

- Abattoirs located in Singleton, Scone and Kurri Kurri process up to 1,300 head of cattle per day, for both the export and domestic markets. Cattle are sourced from around the eastern seaboard, including into Queensland. Cattle are supplied from both on-property sales and from sale yards. Employment is significant with up to approximately 600 full time employees.

- Regional sale yards are located at Scone, Singleton and Maitland. Anecdotally, numbers of cattle sold at Singleton and Maitland have declined by about one third to a half over the past 10 to 15 years. While some of this is linked to the expansion of mining in the region which has removed significant areas of potential grazing land from agricultural production, declining yard numbers are typical across the State as producers use other forums for selling stock.
- Milk processing is undertaken at Hexham.
- Wine grapes are either processed directly on the vineyard or sold on to other wineries in the region including around the Cessnock/Pokolbin district. The grape growing industry is well supported by a vine management industry that undertakes contract pruning, fertilising and spraying.

These specialised ancillary agricultural industries are in turn supported by regional businesses supplying equipment and services.

The region is close to major transport links and population centres including Sydney and Newcastle.

4.3.5 Value of Agricultural Enterprises in the Locality of the Project

The value of individual agricultural enterprises varies with many different levels of skill, resources, types of inputs and outputs and the goals and aspirations of owners. Gross margin analysis has been used to provide a general potential value of the agricultural production of the two main enterprises in the locality, dryland cattle grazing and irrigated lucerne. Within the past 10 years there were three dairies located along Glennies Creek however these no longer operate due to a combination of factors including deregulation and difficulties sourcing labour.

4.3.5.1 Dryland Cattle Grazing - Locality

Cattle grazing enterprises in the Mount Owen Complex Locality are largely centered on cow/calf operations with the calves weaned and sold prior to winter as vealers or weaners are held on property to grow out to yearlings depending on market conditions and feed availability.

DPI information (NSW DPI 2006) regarding carrying capacities of the land in the Hunter Valley indicates that on soils with moderate Phosphorus levels and regular biannual applications of fertiliser, 1.8 to 2.3 hectares per breeding cow is required, depending on the age of cattle turned off. A 40 cow herd is considered the minimum size for a viable commercial enterprise. This indicates that the property size needs to be between 72 and 92 hectares. Lower capability land with low soil Phosphorus levels and limited fertiliser applications supports only native pasture and much larger properties (around 400 hectares) are required as a minimum to run a viable enterprise. It is unlikely that higher value beef breeding operations can be carried out on low capability land, limiting the profitability of agriculture particularly on steeper country.

Gross margin analysis of weaner, vealer and yearling enterprises provides a relative comparison between different types of beef production. Used in conjunction with a risk assessment to determine the effect of changes in costs, returns, weight gains and weaning percentages for example, gross margins are a useful tool for assessing the potential value of agriculture on a per hectare basis. NSW Department of Industry and Investment produce a Farm Enterprise Budget Series (NSWI&I 2012) with gross margin analysis for the type of dryland beef enterprises conducted in the Mount Owen Complex Locality.

In today's prices these indicate that producing yearlings is the most profitable enterprise with returns of \$164.62 per hectare achievable. Within the locality of the Project approximately a third of the land has been identified as supporting grazing enterprises. This equates to about 10,300 hectares of dryland beef production, potentially valued at \$1.73 M per annum.

4.3.5.2 Irrigated Lucerne Hay Production – Mount Owen Complex Locality

There is an irrigation industry along the regulated Glennies Creek to the east of the Project and to a much lesser extent along the unregulated Bowmans Creek to the west of the Project. The irrigation is used for a mix of lucerne, fodder crop and improved pasture conserved as hay, silage or fed off directly to livestock.

With access to the unregulated water source of Glennies Creek, any alluvial soils along the creek have the potential to produce high value crops. Gross margin analysis (NSWI&I 2012b) indicates that returns of \$1,032 per hectare are achievable. With approximately 1,000 to 2,000 hectares of suitable land and assuming available irrigation allocations, this activity could be worth \$1 Million to \$2 Million per annum.

Most agricultural holdings, particularly along Glennies Creek are small (<100 hectares), with larger enterprises occurring to the north of the Project where more extensive dryland grazing is undertaken.

4.4 Current Agricultural Land Use of the Project Area and Offset Areas

The Project Area is used for three main purposes:

- Coal production and transport;
- State forest (conservation management, not timber production); and
- Cattle grazing on surrounding land owned by Glencore (4,350 hectares).

A small area within the surrounding area of the existing Mount Owen operations is also used as an olive grove.

The Proposed Disturbance Area is entirely owned and managed by Mount Owen. It is divided into a number of discreet areas each of which has a different mix of agricultural and non-agricultural land uses.

- Hebden Road Upgrade – This is an area of approximately 13.1 hectares, of which approximately 2 hectares is occupied by the Main Northern Railway and 11 hectares is currently under management by Colinta. The agricultural land uses are restricted to beef cattle grazing on semi-improved pastures. A lack of irrigation entitlements from the unregulated Bowmans Creek is limiting current production.
- Rail Upgrade – This area of approximately 91.4 hectares is not currently used for agriculture due to the proximity of existing rail infrastructure and mining activity. It has not been used for agriculture for at least 15 years. The area is being naturally regenerated to native vegetation with supplementary planting in strategic areas. It is within the currently approved Bettys Creek Habitat Management Area (HMA).

- North Pit Continuation area – This area covers a total area of approximately 381 hectares. The majority of this area is not currently being used for agriculture and is naturally regenerating to native vegetation. Approximately 10 per cent of the area is being used for dryland beef production currently managed by Colinta.

4.4.1 Proposed Biodiversity Offset Areas

In addition to the direct Proposed Disturbance Area, the Project will set aside three parcels of land as biodiversity offsets:

- Cross Creek Offset Area – Approximately 367 hectares of currently cleared land to the north of the Project bordering existing mine owned biodiversity offset and regeneration land. The land ranges from steep where it borders the existing mine lease to flat. It has until recently been grazed as a dryland beef production enterprise.
- Esparanga Offset Area – Approximately 302.8 hectares of land located in the Manobalai locality of the Hunter Valley, maintained by Glencore and utilised for cattle grazing, although large portions of the property comprise native vegetation cover.
- Stringybark Creek Habitat Corridor – Approximately 97.5 hectares of land located to the north-west of the Project Area, and the New Forest Area (Ravensworth State Forest) (refer to **Figure 4.2**). The land ranges from steep along its eastern border with the Project Area to very low gradient in the west. It has until recently been grazed by Colinta (refer to **Figure 4.2**).

4.4.2 Colinta – Grazing Management in Existing Mine Owned Land

Land surrounding the Mount Owen Complex is owned by Glencore and currently managed for agricultural purposes by Colinta. Colinta are the largest agricultural land managers in the locality, managing approximately 4,350 hectares of Glencore owned land surrounding Mount Owen, Ravensworth East and Glendell mines.

Colinta currently operate a commercial Charolais cow/calf operation where the weaners are relocated to other Glencore owned property near Ulan to grow out. Colinta also run a Charolais bull breeding enterprise including a recently instigated annual on-property bull sale.

Colinta also currently manage pastoral activities on land owned by Glencore around the Bulga Mine Complex and at the Ulan Coal Mine.

Table 4.8 summarises the farming practices and production of the Mount Owen Colinta management, based on information from interviews with the land manager.

Table 4.8 – Pastoral Land Management by Colinta

Agricultural Resource and Production	Details
LSC Class	Land currently managed by Colinta includes Class 3-4 LSC on the floodplain and terraces of Bowmans Creek and Glennies Creek. A larger area of land in LSC Classes 5 -7 is managed in hillslopes in the subcatchments draining to Bowmans Creek and Glennies Creek. Colinta has acquired water irrigation licences for Glennies Creek as creek frontage properties are acquired for the mine. Bowmans Creek area is considered to have good soil but there is no water allocation so the area is just used for grazing.

Table 4.8 – Pastoral Land Management by Colinta (cont.)

Agricultural Resource and Production	Details
Water supply	The water source is Glennies Creek Regulated stream. Water quality and quantity are good. Irrigation is used for watering about 100 ha of improved pasture including lucerne, ryegrass and chicory. Pasture is either fed off directly or ensiled by contractors for use in the feedlot. Use a combination of travelling irrigators, moveable pipes and hard hose (self rewinding) systems.
Pasture management	Fertiliser is used on the irrigated country regularly and on the other country when it is able to be afforded. Pastures are a mix of natural and improved species. Pasture improvement (cultivation) was being undertaken but has been constrained by other environmental requirements making it too hard to co-ordinate.
Stock numbers	Colinta currently run Charolais cattle with 200 stud cows and 1,000 commercial breeders on the land they manage, including Mount Owen owned land.
Management and markets	Weaners are turned off into a small feedlot or onto irrigated pasture prior to being sent to the Colinta operation at Ulan where young cattle are grown out on irrigated pasture and crop for various markets. Colinta sells approximately 50 stud Charolais bulls that are also fed in the feedlot or on irrigated pastures along Glennies Creek. This year (2013) a bull sale was held on farm for the first time (see below). Prior to that, bulls were put in other Charolais sales but the number of multi-vendor sales has reduced. Colinta Holdings also breed bulls for their own use. Sales of Colinta bulls at the Singleton sale in July 2013 were reported by the Australian Charolais Society and The Land (1 August 2013). Thirty six Charolais bulls sold for an average of \$2,107 with the top price being \$3,000. Eight Angus cross bulls sold for an average of \$1,500. Two pens (26 head) of commercial heifers were also sold, at an average of \$663/head.
Employment	Colinta employs 1 fulltime and 3 part time staff in this area. Weed control is done by contractors. The olive grove to the east of the Proposed Disturbance Area is leased to other land managers.
Sources of agricultural supplies	Rural supplies and agricultural advice come locally from Singleton.
Other land management issues	Colinta reported concerns about kangaroo numbers on the grazed lands, attributing them to adjacent offset lands. Colinta see themselves as good rural neighbours, responding promptly to any stock issues.

4.4.2.1 Feedlot

Colinta currently uses a small feedlot on its property on the banks of Glennies Creek (refer to **Plate 4.1**), which is used for short periods as part of the preparation of bulls and heifers for market. The feedlot has a capacity of approximately 150 head of cattle. It was formerly a dairy and the feedlot reuses pens and sheds that were part of the dairy. Operation of the feedlot will not be affected by the Project.



PLATE 4.1
View of the Colinta Feedlot on the banks of Glennies Creek facing south

5.0 Assessment of Impacts

In this section - potential impacts on:

- Agricultural resources in the Proposed Disturbance Area.
- Agricultural land uses in the Proposed Disturbance Area.
- Agricultural resources in the locality.
- Agricultural uses and enterprises in the locality.
- Rural communities in the locality.
- Access to water for agriculture.
- Socio-economic impacts on rural communities in the locality including agricultural support industries, visual amenity/landscape values, employment, critical mass thresholds.
- Significance of impacts.

Mining activities can result in changes to land resources that are temporary, long term or permanent. Temporary losses include short term impacts such as construction access tracks or storage areas, which can be readily rehabilitated. Permanent mining impacts on land resources include final voids and significant changes to landform, local drainage and surface and groundwater processes, such that pre mining land and soil capability cannot be restored.

Land that is disturbed by open cut mining activity is gradually rehabilitated as the extraction area moves forward. Best practice landform reshaping, surface water management and soil rehabilitation has been demonstrated to be able to restore resources suitable for grazing, with careful ongoing management of physical, chemical and biological properties of the soil. With best practice, impacts on the land and soil resources of Class 4 to 7 lands can be considered to be long term, but not permanent. Post-mining resources will be different but equivalent to the pre mining resources.

As identified in the preliminary risk assessment (refer to **Section 2.3.3**) potential impacts on agricultural resources and agricultural enterprises include:

- direct permanent loss of existing agricultural land and resources including soils, which are within the mine footprint (Proposed Disturbance Area) and will not be rehabilitated for agricultural uses post mining;
- direct temporary loss of existing agricultural land and resources, which are within the mine footprint (Proposed Disturbance Area), but will be rehabilitated or restored for agricultural use post mining;
- permanent change in land use resulting in the loss of land currently used for agriculture because it is within the proposed biodiversity offset area for the Project. The agricultural resources of this land are not changed by the Project, but tenure, access to and use of the land is changed;

- indirect impacts on agricultural land and enterprises outside the Project Area (in the locality) (loss of value or diversity of potential uses) because of environmental impacts such as noise, dust or water access/water quality, which may affect the feasibility of the land use. In general where acquisition is required to create a suitable noise or dust buffer around mine operations, the resources and use of the land will not change, but tenure and community structure may be affected;
- indirect impacts on existing agricultural uses due to changes to access to rural infrastructure, such as sale yards, processing plants or transport;
- indirect impacts on agricultural land uses in the locality because of changes to management of pests and weeds, or changes to fencing and farm neighbour practices;
- indirect impacts on nearby rural communities caused by changes in employment patterns, land tenure, visual amenity and landscape values; and
- indirect cumulative impacts on communities and agricultural resources resulting from changes in land use and resources across the wider Hunter Valley environment.

This section considers the impacts of the Project on agricultural resources and uses within the Proposed Disturbance Area (refer to **Sections 5.1** and **5.3**) and offset areas (**Sections 5.2** and **5.3**). It also considers impacts of the Project on agricultural resources and uses/enterprises in the locality (i.e. a 10 kilometre radius from the centre of the Project Area) (refer to **Sections 5.4** and **5.5**). The potential impacts of the Project on agricultural support services (refer to **Section 5.6**) and the amenity, lifestyle and connectedness of rural communities are also considered (refer to **Section 5.7**).

5.1 Impacts on Agricultural Resources of the Proposed Disturbance Area

The Project will have direct and long term or permanent impacts on the majority of agricultural soil and land resources within the Proposed Disturbance Area. The total area of agricultural soil and land resources permanently affected by the Project will be 458.1 hectares, which is approximately 94 per cent of the total 485 hectares of the Proposed Disturbance Area (refer to **Section 5.3** for discussion of impacts on agricultural uses). Within the Proposed Disturbance Area, 25.5 hectares has been affected by previously approved infrastructure including roads and rail lines. A very small area of approximately 1.5 hectares of resources will not be permanently impacted but may be temporarily impacted during the construction phase of the Hebden Road Upgrade.

The agricultural resources of the Proposed Disturbance Area, which will be directly impacted by the Project, are entirely in the ownership of Mount Owen. The majority of the land (453.4 hectares) is currently managed as temporarily revegetating land while a small amount (approximately 25 hectares) is currently managed for dryland cattle grazing by Colinta, on behalf of Glencore.

Table 5.1 summarises the impact of the Project on the land and soil capability and land use of the Proposed Disturbance Area. The table shows the area of current LSC Classes in the Proposed Disturbance Area, the post mining LSC classes and pre and post mining agricultural land uses.

The Project will have a direct impact on LSC Class 4 to 7 land. The impacts on specific agricultural resources are discussed in **Sections 5.1.1** to **5.1.4**. Overall loss of currently used agricultural land in the Proposed Disturbance Area is approximately 23.3 hectares.

Table 5.1 - Change in Agricultural Resources and Land Use – Proposed Disturbance Area¹

Project Site	LSC Class (verified)	Area (ha)	Existing Landuse	LSC Class Post Development (indicative)	Area (ha)	Landuse post development	Area of land Lost (-) or Gained (+) to agriculture (ha)	Permanent or Temporary Change
Hebden Road Upgrade	4	4.0	Dryland grazing	4	1.0	Dryland grazing	-3.0	Permanent
	6	1.3	Dryland grazing	6	0.3	Dryland grazing	-1.0	Permanent
	7 (Bowmans Creek channel)	0.5	Dryland grazing	7	0.2	Dryland grazing	-0.3	Permanent
	Infrastructure	7.3	Road Infrastructure	Infrastructure	8.8	Road Infrastructure	N/A	Permanent
	Total change in agricultural land use: -4.3 (74 %)							Permanent
Rail Spur Upgrade	6	64.3	Non-agricultural land and temporary biodiversity	N/A	64.3	Native vegetation - woodland	No change in current agricultural land use	
	7	8.7	Non-agricultural land and temporary biodiversity	N/A	8.7	Native vegetation - woodland	No change in current agricultural land use	
	Infrastructure	18.4	Rail Infrastructure	N/A	18.4	Native vegetation - woodland	No change in current agricultural land use	
North Pit Continuation area	4	13	Dryland grazing	4 to 5 (estimated)	13	Open grassland (potentially suitable for agriculture) with patches of native woodland	-13 (note this area has potential to be used for grazing)	Long term or Permanent
	7	6	Dryland grazing	7 (estimated)	6	Native vegetation - woodland	-6	Permanent
	4 to 7	361.5	Non-agricultural land and temporary biodiversity	4 to 8 (estimated)	361.5	Final void and native vegetation – woodland and grassland	For the most part, no change in current agricultural land use. Areas returned to grassland with some patches of woodland may be available for grazing in the future	
	Total change in agricultural land use: -19 (100%)							Long term or Permanent

¹ Use of LSC Class as an indicator of agricultural resources in the areas proposed for disturbance by mining, the effect of mining is to result in less capable LSC Classes (e.g. LSC Class 6 to LSC Class 8).

5.1.1 Potential Impact on Landforms and Soils of the Proposed Disturbance Area

Table 5.2 summarises the loss of soil resources from each of the three separate components of the Proposed Disturbance Area. The soil types directly affected by the Project have low and moderately low fertility.

Table 5.2 -Soil Resources Impacted by the Proposed Disturbance Area

Proposed Disturbance Area	Soil Type	Fertility	Area (ha)	Permanent Loss of Soil Resource	
				Area	Percentage (%)
Hebden Road Upgrade Total Area 13.1 Ha	Brown Sodosol	Moderately Low	3.4	1 ha	30.00
	Stratic Rudosol	Moderately low	9.3	3.2 ha	34.4
	Clastic Rudosol	Low	0.4	0.3 ha	64
Rail Spur Extension Total Area 91.4 Ha	Brown Sodosol	Moderately low	88.6	88.6	100
	Stratic Rudosol	Moderately low	2.8	2.8	100
North Pit Continuation area Total Area 380.5 Ha	Brown Sodosol	Moderately low	369.8	369.8	100
	Stratic Rudosol	Moderately low	3.7	3.7	100
	Clastic Rudosol	Low	2.3	2.3	100
	Brown Kurosol	Moderately low	4.7	4.7	100

The Hebden Road Upgrade (area impacted), the Rail Upgrade and the North Pit Continuation area all involve reforming the land that will result in a permanently changed landform. The change in landform will generally increase the steepness of the slopes and the length of the slopes. This will also involve the formation of new soil types which will be identified as Anthrosoles or soils resulting from human activities causing a profound modification of original soil horizons.

The Closure Plan will be prepared in consultation with local and regional land use organisations.

The final approved closure plan will detail the stable land form elements across the Proposed Disturbance Area. Details about the post mining landform design are in Appendix 18 of the EIS (Mine Closure and Rehabilitation Assessment). Final landform design for the Project includes the following features:

- generally undulating terrain;
- reinstatement of drainage lines and controlled flow paths; and
- final voids which will fill over time with groundwater and surface water runoff.

Further detail about proposed final landforms and rehabilitation, as they relate to mitigation of risks to agriculture, is described in **Section 6.0**.

The Closure Plan will include an objective for restoring some land with slopes and soils equivalent to LSC Class 4 and 5, potentially suitable for grazing.

The existing Landscape Management Plan will be updated for the Project, addressing objectives and methods for soils handling, and post mining rehabilitation. The Landscape Management Plan will be prepared in consultation with Local Land Services (which will be operational across NSW from January 2014 and will bring together DPI, Livestock Health and Pest Authorities and CMAs) and must be approved by DTIRIS – DRE.

Prior to mining, topsoil that has been identified as suitable for stripping and stockpiling will be removed from the ground surface and stored for use in the post mining land rehabilitation process. The topsoil stripping and stockpiling process will be conducted in accordance with the Landscape Management Plan.

Initially post mining soil quality is expected to be constrained by:

- Stoniness, as soils are based on overburden material, with topsoil replaced on areas targeted for higher post mining land and soil capability.
- Limited structural integrity, as a formal B horizon will take time to develop.
- Shallowness, as the depth of the biomantle component of soil will be limited to re-spread topsoil.
- Fertility constraints including low Cation Exchange Capacity, relatively high Magnesium and Sodium, low pH and low Organic Carbon levels. These fertility constraints affect the current soil resources in the Proposed Disturbance Area.

Constraints in soil quality largely result from the significant modification of the B horizon and the lack of depth of a functional A horizon.

5.1.2 Potential Impacts on Land and Soil Capability of the Proposed Disturbance Area

Soil management processes to create and maintain the best achievable LSC classes over the Proposed Disturbance Area post mining, will be guided by a Landscape Management Plan which is part of the Closure and Decommissioning Plan for the Project.

The impact on soil and landform resources will lead to a change in LSC Classes across the Proposed Disturbance Area. Areas within the Hebden Road Upgrade area, where there will be a permanent land use change to infrastructure, will no longer have a LSC Classification.

The North Pit Continuation area will involve a change in LSC Class. The objective of rehabilitation is to create additional native vegetation corridors (LSC classes 6 to 7), with an area of LSC class 4 to 5, suitable for grazing. Areas of each LSC Class 7 will occur in different parts of the Project Area based on the final land form. An area of approximately 77 hectares has been identified as being potentially able to be rehabilitated to slopes and soil condition equivalent to LSC class 4 and 5, suitable for grazing. It is difficult to estimate the actual areas of each LSC Class until the final closure plan is approved.

The verification of soil characteristics and BSAL land (refer to **Section 3.5**) shows that there is no BSAL land in the Proposed Disturbance Area due to soil fertility constraints. The Project will not have a direct impact on BSAL land; that is, land of LSC classes 1 to 3.

In the Proposed Disturbance Area the key soil characteristics which distinguish Class 5 or poorer LSC from Class 4 or better LSC are:

- potential for soil structure decline relating to moderately sodic surface soils; and

- shallow soils (limited rooting depth due to gravel).

Post mining, the combination of terrain and soil constraints is expected to restrict LSC to LSC Classes 6 to 8, other than minor flatter areas, which will be rehabilitated to LSC Class 4 or 5 land. However, it should be noted that the current Land and Soil Classification system has not been designed to thoroughly assess Anthroposol soils and many of the criteria used are dependent on surface soil properties that can be effectively improved through specific management activities. In the Proposed Disturbance Area, soil depth, salinity hazards and waterlogging may become the important determinants of LSC Class rather than soil structure and acidification.

Over the long term, careful management of revegetation as well as soil organic content, acidity, structure and depth is expected to provide less constrained soils (refer to **Sections 6.1.4** and **6.2**); however, it may take many years to reproduce soils that have the resilience to maintain sustainable agricultural production.

5.1.3 Potential Physical Movement of Water Away from Agriculture – Proposed Disturbance Area and Context

The Project and associated water management system has the potential to impact on surface water systems. This includes potential impacts on:

- flow volumes in local water courses;
- flooding, flow rates, velocities and depths;
- water quality in local water courses;
- geomorphological and hydrological values of water courses, including environmental flows;
- riparian and ecological values of water courses; and
- water users, both in the vicinity and downstream of the Project Area.

In summary, these potential impacts could affect the value of water resources for agricultural uses in the Proposed Disturbance Area, Project Area and locality.

The Surface Water Assessment for the Project (Umwelt 2014a) notes that the water catchment context of the Project includes previous changes to the catchment areas of Yorks Creek, Swamp Creek, Bettys Creek and Main Creek. The existing approved mining operations include a number of measures to mitigate the impacts on annual flow volumes over the life of the Project due to changes in contributing catchments for local watercourses (e.g. diversion of clean water around mine areas and drainage of rehabilitated areas back to downstream catchments where the water quality is suitable for release).

The Project will result in no changes to the annual flow volumes for Stringybark Creek. The Project will result in a small increase in the catchment contributing to Yorks Creek. Annual flow volumes for these creeks are not expected to decrease as a result of the Project. Small decreases in the annual flow volumes of Swamp Creek and Bettys Creek are predicted. The potential volume decrease is not considered to be significant in the context of these ephemeral drainage systems, in that the changes in flows are less than the seasonal and annual variations in flow volumes comparing dry years to wet years.

A reduction to the catchment of Main Creek, compared to the currently approved landform, is proposed. This change will bring the flow volumes of the creek closer to the pre-mining situation.

Due to the limited impacts on local surface flow volumes, it is anticipated that the Project will have negligible impacts on major downstream watercourses including Bowmans Creek, Glennies Creek and the Hunter River.

In terms of potential impacts on water resources available to agricultural land users in and in the locality of the Project Area, the following potential impacts are noted, based on the proposed changes to surface drainage:

- The final voids are planned to fill with water over time following the closure of the mine. The majority of surface water flows will be diverted away from the void and directed into the existing creek lines, Main Creek and Bettys Creek, which ultimately flow into Glennies Creek and Bowmans Creek respectively. Water quality in Glennies Creek and Bowmans Creek is not expected to be negatively impacted due to a comprehensive surface water management plan that includes sediment dams and high flow management strategies.
- The final landform will generally be designed to direct runoff away from the final voids and into the Main Creek, Yorks Creek, Bettys Creek and Swamp Creek catchments. This will return catchment flows to Yorks and Main Creeks and return some of the natural flows to Swamp Creek.
- There are no surface or ground water irrigation licences within the Project Area. All existing agricultural use in the Project Area is on land owned by Glencore and currently managed by Colinta.
- There are no known licensed water users on waterways directly downstream of the Project Area along Yorks Creek, Swamp Creek, Bettys Creek or Main Creek.
- There are private landholders downstream of the Project Area on Main Creek, Glennies Creek and Bowmans Creek that retain basic landholder rights for domestic and stock use.
- As the Project will not reduce annual flow volumes in Main Creek compared to the currently approved landform conditions, basic landholder rights on Main Creek and Glennies Creek will not be affected by the Project.
- Bowmans Creek has a large catchment upstream of the Project Area. The impact of changes in the Project Area on flows in Bowmans Creek and in the reaches of Bowmans Creek downstream of the Project is considered to be negligible, resulting in negligible impacts on basic landholder rights downstream.
- It is noted that as part of their licence conditions, Mount Owen can extract water from Glennies Creek as a raw water supply for the Mount Owen Complex. It is not proposed to vary this extraction from the existing approved volume as part of the proposed Project.

Overall the impacts of the Project on the availability of surface water for agricultural users are considered to be minimal, with negligible risks to existing agricultural enterprises and production.

5.1.4 Vegetation and Biodiversity

Within the Proposed Disturbance Area, some areas of regenerating native vegetation will be impacted. Other than the alluvial flats on Bowmans Creek, rehabilitation will concentrate on restoring native vegetation. An area of approximately 40 hectares will be rehabilitated to open pasture, potentially suitable for grazing.

Native woody vegetation may be considered an indirect resource for agriculture as it supports insects, birds and animals that provide pollination and pest control services. Vegetation also impacts positively on water quality and positively or negatively on water balances (depending on the situation) as well as providing shelter for livestock. Depending on the location and the density of native vegetation it may have either positive or negative impacts on agriculture. Property vegetation management plans prepared by farmers in consultation with CMAs (Local Land Services from 2014) are designed to balance productive and biodiversity services.

The Hedben Road Upgrade area of the Proposed Disturbance Area will have no impact on native vegetation other than the removal of a limited grassland area which has a mix of introduced and native species. It is not planned to actively regenerate native vegetation in this area. Disturbance during infrastructure construction (lay down pads etc.) will be rehabilitated for agricultural use (refer to **Figure 5.1**). The actual road, bridge and rail overpass will be permanent infrastructure.

Post-mining the Mount Owen Rail Line would be rehabilitated if no other appropriate future use is identified.

The proposed North Pit Continuation area is currently an unused land and has about 50 per cent of the area covered in regenerating native shrubs and trees including areas of EECs. The remaining area is dominated by native grasslands. This area will be rehabilitated to native woodland. A lower slope area will be rehabilitated to open grassland with patches of woodland, and will have the potential to be used for agricultural resources or enterprises. Post mining use of the land will include active regeneration to a mix of grasses, shrubs and trees at varying densities. The post mine land use is aimed at native vegetation conservation and hence native vegetation condition and biodiversity is expected to improve post mining.

5.2 Impacts on Agricultural Resources of the Proposed Offset Areas

The agricultural resources (landforms, land and soil capability, access to water etc) of the biodiversity offset properties included as part of the Project will not be substantially impacted by the Project as the land use change involves passive regeneration of native vegetation with no change to soils, land form or water resources.

Land in the proposed offset areas is recognised to have high biodiversity value and high potential to enhance biodiversity value. On the basis of current government policy to protect remaining areas of EECs and other high biodiversity value aspects of the landscape, the biodiversity value of these properties is considered greater than the agricultural value. Use of the land for biodiversity conservation does not change its underlying agricultural resource value. Terrain, soil, water and water access will remain essentially the same as now.

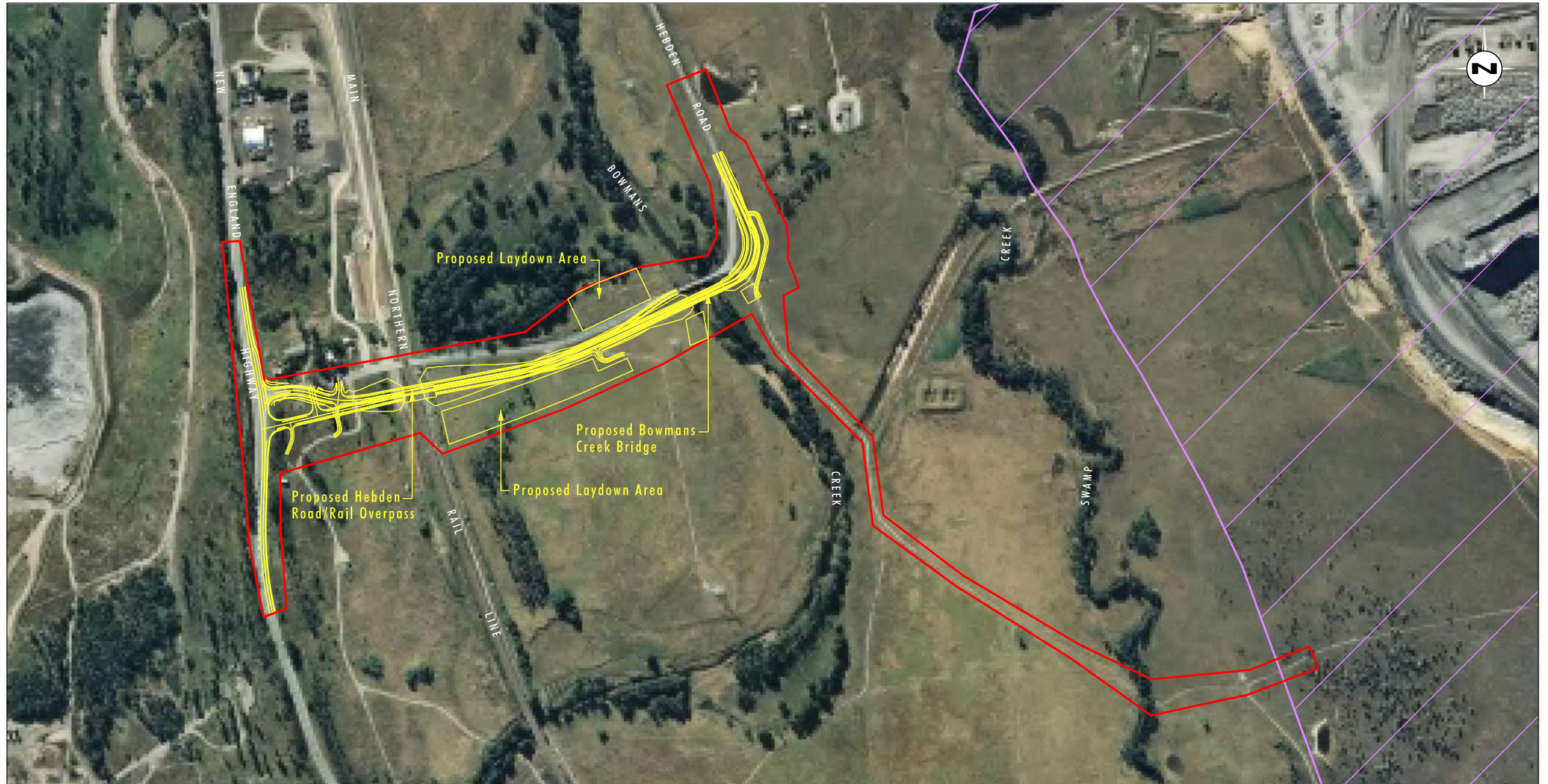


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)

Legend

- Project Area
- Proposed Hebden Road Upgrade Works
- Approved Glendell Disturbance Area

FIGURE 5.1

Proposed Hebden Road/Rail Overpass and
Proposed Bowmans Creek Bridge Duplication

Table 5.3 – Change to Agricultural Resource and Land Use - Offset Areas

Project Site	LSC Class**	Area (ha)	Current Landuse	LSC Class post development	Area (ha)	Landuse post development	Area of land Lost (-) or Gained (+) to agriculture (ha)	Permanent or Temporary Change
Esparanga	5	10.1	Dryland grazing	5	10.1	Biodiversity offset	-10.1	Permanent*
	6	133.9	Dryland grazing	6	133.9	Biodiversity offset	-133.9	Permanent*
	6	49	Conservation	6	49	Biodiversity offset	No change	
	7	9.8	Dryland grazing	7	9.8	Biodiversity offset	-9.8	Permanent*
	7	100	Conservation	7	100	Biodiversity offset	No change	
							Total change in agricultural land use -153.8 (-100%)	
Cross Creek	5	245	Dryland grazing	5	245	Biodiversity offset	-245	Permanent*
	7	122	Dryland grazing	7	122	Biodiversity offset	-122	Permanent*
							Total change in agricultural land use -367 (-100%)	
Stringybark Creek Habitat Corridor [#]	6	33.9	Dryland grazing	6	33.9	Biodiversity offset	-33.9	Permanent
	7	63.6	Dryland grazing	7	63.6	Biodiversity offset	-63.6	Permanent
							Total change in agricultural land use -97.5 (-100%)	

*There is no change in land, soil or water resources on biodiversity offset sites; however, given current Government expectations, the landuse will change permanently from agricultural production to biodiversity conservation.

**Based on LSC mapping at a regional scale by OEH 2012.

Indicates that numbers have been rounded.

5.3 Impacts on Agricultural Uses/Enterprises of the Proposed Disturbance Area and Offset Areas

5.3.1 Proposed Disturbance Area

The Project has a very limited direct permanent impact on small parcels of land that are currently used for agriculture. The Project will directly and permanently impact on approximately 23.3 hectares of land that is currently used for dryland cattle grazing within the Proposed Disturbance Area. This includes approximately 16 hectares of LSC Class 4 land, approximately 1 hectare of LSC Class 6 land and approximately 6.3 hectares of LSC Class 7 land in the Hebden Road Upgrade area and part of the North Pit Continuation area. It is noted that most of the 381 hectares of the Proposed North Pit Continuation area has not been used for agricultural purposes for approximately 15 years. This land is currently adjacent to the high wall of the existing North Pit and is not suitable for cattle grazing concurrently with mining. The change in use of this area has already occurred and been accounted for in previous environmental assessments for Mount Owen Complex.

The agricultural enterprise on surrounding Glencore owned lands is currently managed by Colinta on behalf of Glencore. Colinta currently manages approximately 4,350 hectares of mine owned land in the vicinity of the Project Area.

The impact area of 23.3 hectares is less than 1 per cent of the land currently managed by Colinta as a grazing enterprise. The loss of this land will not affect the viability of Colinta or how they interact with regional suppliers.

The value of dryland grazing land can be approximated using Gross Margin enterprise budgets produced by the DPI (DPI 2012). Current budgets indicate that a cow/calf operation, turning off yearlings, is the most profitable of the typical cattle enterprises undertaken in the Upper Hunter Valley region. The current gross margin analysis indicates that, after pasture maintenance costs have been removed, the expected return is about \$165/hectare per year.

Prices are currently low; and if the figure is increased by 20 per cent to about \$200/hectare return, the value of production on 23.3 hectares is \$4,700 per year over the 12 year life of the Project, or \$56,400. This land is not planned to be returned to agricultural production for some extended period post mining, as biodiversity conservation is considered a high value land use for this specific area. The long term value of loss to agriculture would increase in proportion to the length of time over which the land is excluded from productive agricultural use.

5.3.2 Offset Areas

Three properties which have previously been used for agriculture (dryland grazing enterprises) are proposed to be set aside as biodiversity offsets. The Cross Creek and Esparanga properties are not currently being used for agricultural enterprises but have been used for grazing within the past couple of years, while the Stringybark Creek Habitat Corridor is currently used for dryland grazing by Colinta.

Whilst these areas will not be directly disturbed by the Project, they will be set aside for permanent biodiversity conservation. This conservation management of the Offset Areas will not affect the biophysical attributes of the areas in question but does impact on future land use options.

Review of the LSC of the three biodiversity offset areas indicates that they contain a mix of Class 5 to Class 7 land (refer **Figures 3.9** and **3.21**).

Cross Creek (approximately 367 hectares), located on the northern boundary of the Project Area, is characterised by steep slopes, with rock outcrop occurring on the ridge crests and upper slopes of sub-catchments. This covers about a half to a third of the property. The downstream reaches of creeks on this property have some alluvial land forms and lower gradient undulating hills. Soils are of moderately low and moderately high fertility. The entire property area of 367 hectares is largely cleared and has been used for grazing in the past.

Agricultural production that could be undertaken on a property of this nature may be typified by cow/calf operations turning off weaners. The steep nature of parts of the property decrease the enterprise options while the alluvial country may be able to support higher value grazing operations.

Stringybark Creek Habitat Corridor (approximately 97.5 hectares), located on the north-western boundary of the Project Area, is characterised by steep slopes with rock outcrop occurring on the ridge crests and upper slopes. This covers approximately half of the property. Soils are of moderately low and moderately high fertility. The entire property area of 97.5 hectares has been used for grazing by Colinta. Like Cross Creek, agricultural production that could be undertaken on a property of this nature may be typified by cow/calf operations turning off weaners; however, the steep nature of parts of the property decreases the enterprise options.

Esparanga (approximately 302.8 hectares), located between Muswellbrook and Denman (refer to **Figure 1.3**), includes significant areas of very steep slopes (greater than 20 per cent and in some areas greater than 50 per cent). Two areas with lower slopes are mapped as having a high fertility. These two areas, both in the Bow Soil landscape, are also fully correlated spatially with EECs. These areas are mapped as LSC class 6. The highest LSC class on the property is a small area of LSC Class 5 along the south eastern boundary.

Approximately half this property would support a cow/calf operation turning off weaners but the other half of the property has very little agricultural value due to the steep and timbered nature of the country.

All three properties contain EECs which can constrain agricultural use in terms of managing (clearing/thinning) woodland or forest for grazing.

In summary, the three proposed offset areas are LSC Class 5 land at best, and are not currently used for grazing. Agricultural resources will not be impacted by the introduction of formal conservation management. There will be no change to the current use of Cross Creek Offset Area and Esparanga Offset Area, but the use of the Stringybark Creek Habitat Corridor will change from agriculture (grazing) to conservation.

However, as shown in **Table 5.3**, subject to any changes to the current government policy, the transfer of land use to conservation (biodiversity offset) in the three offset areas will result in approximately 767 hectares of land with agricultural resources (suitable for use as part of a dry land grazing enterprise) being permanently unavailable for agricultural uses.

5.4 Impacts on Agricultural Resources in the locality

Based on the information in **Section 3.0**, the Project will have a negligible impact on the agricultural resources of the locality. In particular:

- The Project will have a minimal impact on the availability of water resources for agriculture outside the Project Area. There will be small changes to the catchment area and flows from tributary creeks of Bowmans Creek and Glennies Creek. Both of these creeks have very large catchments, with flows from the creeks in and near Mount Owen Complex making up a very small proportion of the available water. The Project will not result in a loss of water quality in these creeks.
- The Project has no direct or indirect impact on the landforms of the locality of the Project Area.
- The Project has no direct or indirect impact on the soil resources of the locality of the Project Area. No BSAL land is affected and the areas of land of various LSC classes in the locality of the Project Area will not change.
- As noted in **Section 5.3**, the Project will not change the physical agricultural resources of the offset areas. Two of these Offset Areas are in the locality of the Project Area.

The Project will also have a minimal impact on local and regional agricultural services and infrastructure. Changes to the supply and viability of agricultural support services and infrastructure in the Mount Owen Complex Locality and the region are driven by agricultural and social trends operating at a scale well beyond this locality.

In particular:

- The Project will result in a very small and uncertain change in the number of cattle sent to market or processed at local sale yards and abattoirs. Colinta will continue to use surrounding Glencore owned areas for cattle grazing and will continue to use local services and infrastructure to support that enterprise.
- In relation to transport infrastructure, the realignment of Hebden Road, and the construction of a new bridge over the Main Northern Railway and Bowmans Creek will improve vehicle access for farmers who use Hebden Road to access local services. Delays at the rail crossing will be eliminated. This is a benefit to the agricultural infrastructure of the locality.

5.5 Impacts on Agricultural Enterprises in the Locality

5.5.1 Direct and Indirect Impacts on Rural Enterprises

The Project Area is situated within a rural locality which features rural and rural residential properties along Bowmans Creek, Glennies Creek and their catchments. Mining operations are also a major existing element of this landscape, with the operations of Ashton and Integra Coal Mines located to the south and south-east of the Mount Owen Complex.

Rural enterprises in the locality of the Project are also potentially impacted by the operations of the Ashton and Integra Coal Mines. This section evaluates the potential impacts of the Project on local agricultural enterprises, over and above the existing documented and approved potential impacts of the Mount Owen Complex, Ashton and Integra.

The main potential impacts on agricultural enterprises are associated with:

- Air quality or noise impacts exceeding the criteria for acquisition of private properties. Where this is the case, the relevant mine must acquire the affected property if the owner requests that they do so.
- Changes to accessibility or services that support the efficient operation of the agricultural enterprise. This includes road and rail access between the property and local or regional service suppliers and markets.
- Other impacts on social and economic conditions, such as competing demands for labour.

Other cumulative impacts on access to quality natural resources that support the operation of agricultural enterprises have also been considered. This includes, for instance, loss of forest habitat for birds and insects that pollinate crops, introduction of agricultural pests, reduced visual amenity, or loss of environmental quality for enterprises that require very high air or water quality.

5.5.2 Land Acquisition

Modelling of air quality and noise impacts of the Project indicates that the air quality and noise environment at a small number of properties in the locality of the Project will exceed the acquisition criteria set in NSW air and noise standards.

Table 5.4 provides summary information about properties that are affected in ways that are predicted to exceed acquisition criteria.

Table 5.4 – Potential property/land acquisitions for the Project

Property number	General location	Year of operations for acquisition	Reason for inclusion in acquisition area	Already in acquisition area?	Approximate Area	Use
R022	South-east of Project Area	10	Noise criteria	No	2.3 hectares	Rural residential
R023	South-east of Project Area	10	Air quality and Noise criteria	No	4.3 hectares	Rural residential
R021	South-east of Project Area	10	Noise criteria	No	0.7 hectares	Rural Residential

Properties that meet the criteria for acquisition as a result of potential impacts from the Project include three rural residential properties (with a total area of approximately 7 hectares) to the east of the Project Area.

If the relevant land owners decide to request acquisition of their properties, the land would become part of existing Mount Owen Complex owned land and potentially managed for agricultural purposes as a pastoral enterprise. In this case, the principal impact is one of a tenure change, rather than a land use change. It is possible that properties with and without residences could be leased back to community members, should acquisition be invoked.

Given that a small number and area of properties are involved and that the land is not currently used for agriculture, the potential impact on agricultural enterprises and production in the locality is considered negligible.

5.6 Impacts on Agricultural Support Services

The Project is predicted to have a potential impact on the tenure of five vacant properties and four rural residential properties in the rural landscape, over and above properties already identified as meeting acquisition criteria in relation to existing approved mining activities. These properties represent a very small proportion of the rural enterprises that use rural service facilities and infrastructure in the region. The change in tenure of these properties will not affect the need for agricultural services, as it is anticipated that the land will continue to be used for agricultural purposes. In this context the potential impact of the Project on agricultural support services in the region is very small.

5.6.1 Impacts on Visual Amenity

Visual amenity is an important value in rural areas for land owners who have attachment to the rural landscape, and for enterprises that attract visitors because of the rural ambience and lifestyle experience. In the Upper Hunter, the most important areas for visual values that attract visitors have been identified as CICs. For instance, the Viticulture CIC is based on wine grape and wine production, but also cellar door sales and lifestyle/landscape tourism. There are no CIC areas within 10 kilometres of the Project.

In the case of the Project:

- existing approved and operating open cut mines are part of the rural landscape of properties to the east, south-east and west of the Project area;
- the Mount Owen Mine is not readily visible from most rural properties, as they are screened by landform; and
- tourism is not an important land use along Hebden Road, Glennies Creek Road and Falbrook Road.

In this context, the impact of the Project on visual amenity is expected to be small and the economic value of any changes to visual amenity experienced at properties and vantage points in the locality is expected to be small.

This does not mean that there is no impact on the visual amenity or social environment of residents and landholders, but the impacts are expected to be small in the regional context. Details about how rural landholders express potential social impacts are included in the Social Impact and Opportunities Assessment for the Project (Appendix 5 of the EIS).

5.6.2 Impact on Agricultural Employment

The Project would result in a negligible impact on alternative agricultural uses, viticulture, rural residential or agricultural tourism land uses in the immediate vicinity. As such, the Project is not anticipated to negatively impact upon agricultural employment in the local area.

The Social Impact and Opportunity Analysis completed for the Project indicates that there has been an increase of 11 per cent employment in agriculture in Bridgman from 2006 to 2011. As the Project is proposing to continue with the existing operational workforce no additional impact to agricultural employment is expected.

5.7 Other Social and Economic Impacts Affecting Rural Land Uses

The issues and impacts discussed in this section are regional strategic planning challenges, not relating only to the specific development of the Project. In the locality of the Project, agricultural land use and the amenity of rural communities is affected by several mining operations. Whilst these issues have been raised by farmers in consultation about this Project, farmers also referenced the broader regional scale of the issues.

Potential impacts that have been noted by local farmers or rural residents are summarised in **Table 5.5**.

Additional information about these potential impacts can be found in the Social Impact and Opportunities Assessment for the Project (of the EIS).

Table 5.5 – Social and Economic Impacts of the Project and its Regional Cumulative Context

Issue raised	Details	Significance of the Project contribution to this issue
Other land use changes	Indirect impacts of rapid growth in the mining sector include: - Pressure for subdivision of productive rural properties to allow small rural block subdivisions. This is particularly the case close to major centres such as Singleton, but also applies to other areas. - Changes to the management of mine owned lands. - Where mines buy rural properties, long term residents are replaced by recent arrivals who are renters rather than land owners.	There are 174 residences in the locality including: 34 (19.5 per cent) owned by Glencore. 14 (8 per cent) owned by other mining operations. 10 (5.7 per cent) currently subject to Acquisition rights with other mining operations. 4 (2.3 per cent) currently subject to Acquisition rights with Glencore and other mining operations. - The remainder (64.5 per cent) are privately owned. The Project will result in the potential acquisition of an additional nine houses or parcels of land, moving them from private ownership to Glencore ownership, should they be acquired. This additional change in ownership is a minor impact on rural tenure and residential status. During construction, an additional 330 people are expected to be employed but ongoing operational employment will change little from the current numbers. Additional pressure from this Project for rural subdivision is expected to be minor.

Table 5.5 – Social and Economic Impacts of the Project and its Regional Cumulative Context (cont.)

Issue raised	Details	Significance of the Project contribution to this issue
Availability of rural workers	Farmers noted that high wages paid in the mining sector generally attract potential workers away from the farm sector. Skill shortages in the mining industry in recent years mean that people with relevant trade qualifications have been quickly taken up in mining positions.	This is a regional scale issue, with mining employees derived not only from the immediate locality, but from Singleton, Muswellbrook and importantly the lower Hunter. As noted above, during construction, an additional 330 people are expected to be employed during the Project, but ongoing operational employment will change little from the current numbers. The specific contribution of the Project to skill and employment tensions is minor.
Cumulative loss of regional rural infrastructure or facilities		Expected to be minimal
Agricultural land values	Farmers have suggested that rural property prices decline for properties adjacent to mining operations	There is currently no statistically significant evidence to suggest that mining operations have had negative consequences on housing prices in the Singleton area comprising close localities in the Mount Owen area.
Visual amenity and landscape values	Farmers have referred to the impact of mining operations in their locality on visual amenity, in terms of overburden stockpiles, bunds and visual aspects of air quality. These comments are not specific to the Mount Owen Complex, but to the broader landscape with several other mines in proximity to rural, rural residential and village residents.	Due to local topography there are limited views of the Project. Mine rehabilitation will continue throughout the life of the Project.
Social impact on rural communities	Farmers have referred to changes to the connectedness of rural communities, particularly in relation to membership and function of local community groups and services.	This is an existing issue in villages across the Hunter. The continuation of mining operations at the Project does not change the operational workforce, so does not present an additional threat to the function of local sporting teams and rural fire service etc. The Project will contribute to ongoing mining employment, helping to maintain a stable employment and population base in the region.

5.8 Uncertainty and Significance of Potential Impacts

The Project will extend the life of an existing mining operation by 21 years. Several other approved mining operations exist in the locality and near-regional context of the Project, with variable approved mine lives.

This section considers the overall significance of potential impacts of the Project on agricultural resources, production and enterprises. It also evaluates potential cumulative

impacts of multiple mining operations on the agricultural resources, production and enterprises of the locality. Aspects of uncertainty about future environmental and agricultural impact are also considered.

5.8.1 Significance of potential Project impacts

The significance of potential Project impacts on agricultural resources is considered here in terms of risk.

Table 5.6 provides a summary of the risks associated with the Project, based on the data and analysis presented in this report. This risk evaluation builds on the scoping risk assessment discussed in **Section 1.0**, which was used to identify the aspects of the Project which require in-depth investigation.

The preliminary risk assessment identified three issues as high risks to agricultural resources and enterprises, requiring detailed evaluation:

- the potential impact of the Project on land/soil that is of moderate to high fertility;
- potential permanent removal of productive agricultural land from agricultural use, outside the Project Area; and
- indirect impacts on agricultural productivity and the amenity of rural communities outside the Project Area, such as through changes to air quality or access to water resources.

Table 5.6 reviews the significance of these risks.

Table 5.6 – Review of High Risks to Agriculture Identified In Preliminary Risk Assessment

Risk	Preliminary Assessment	Results of Assessment and potential for mitigation	Final risk Evaluation
Potential impacts on high fertility agricultural land	High Risk	Detailed soil survey, sampling and laboratory analysis provided site specific information about potential BSAL land on the terrace of Bowmans Creek. The sandy soil material on this land is a Stratic Rudosol and has low to moderate fertility. This land is not BSAL. No other BSAL land is present in the Project Area. Apart from a small area of permanent infrastructure in this area (rail overpass and road bridge), the area disturbed during construction will be rehabilitated for ongoing agricultural use (grazing with some cultivation, with treatment to maintain fertility and structure). All other soils in the Proposed Disturbance Area are evaluated as LSC classes 4 to 7. They are not high fertility agricultural land and have significant constraints to intensive use. Post mining rehabilitation will focus on restoration of native vegetation, building on the biodiversity values of the Ravensworth State Forest. Some land of LSC classes 4-8 may be available for agriculture in the future.	Low risk

Table 5.6 – Review of High Risks to Agriculture Identified In Preliminary Risk Assessment (cont.)

Risk	Preliminary Assessment	Results of Assessment and potential for mitigation	Final risk Evaluation
Potential permanent removal of productive agricultural land, outside the Proposed Disturbance Area	High Risk	This refers to the Offset Areas and to future management of lands subject to acquisition. Three biodiversity offset areas are proposed. The total area of these properties is approximately 767 hectares. All are in undulating to steep terrain, of LSC classes 4 to 7 (there is a small area of Class 3 land on Esparanga). Both Cross Creek and Esparanga properties have been previously used as part of cattle grazing operations, while Stringybark Creek Habitat Corridor has been used as part of the Colinta grazing operations. Esparanga has significant areas of EEC and Cross Creek has some existing areas of EEC which would link directly to the biodiversity corridor through the Ravensworth State Forest and New Forest areas. Agricultural resources on the three offset areas will not be impacted by the Project, but agricultural uses will be permanently removed. There are some potential benefits for agriculture from managing the Offset areas for conservation, including water quality, and habitat for pollinators.	Moderate Risk
Indirect impact on agricultural activity and amenity in the rural community through environmental impact on key natural resources	High Risk	The Project direct and indirect impacts on water quality and river flows are negligible. Three rural residential properties may be subject to acquisition, primarily because of noise and air quality impacts over the life of the mine. Given that a small number and area of properties are involved and that the land is not currently used for agriculture, the potential impact on agricultural enterprises and production in the locality is considered negligible. Landholders in the locality of the Project have expressed concern about cumulative impacts of dust on air quality, from amenity and health perspectives. The Project will contribute to cumulative air quality in the Upper Hunter Valley, and this has been assessed in the Air Quality Impact Assessment report, to meet relevant criteria.	Low to Moderate risk

5.8.2 Uncertainty

DPI has advised in its guidelines that it requires the assessment of impacts to include consideration of the certainty of predicted impacts and the certainty of proposed mitigation outcomes (such as rehabilitation of mined land to LSC classes suitable for more intensive agriculture).

Some rural land owners have expressed concern about the certainty of predicted impacts, particularly on the amenity of rural lifestyles. Air quality and noise are primary concerns.

These aspects of land holder amenity, population health and rural lifestyles are a broader regional issue, with amenity and potential health impacts associated with mining projects and other uses over a wide area. Clarity about the drivers of rural air quality and noise environments is improving, for instance with the completion of new detailed studies on particulate sources in the Upper Hunter (OEH 2013). The results of these new studies will facilitate targeted projects to minimise health and amenity risks associated with all sources of air pollutants in the region. Open cut mines and diesel machinery contribute a significant component of the regional air particulate load, as do (seasonally) bushfires, domestic wood fired heaters, power stations and other transport sources.

In the local context, uncertainty about environmental impacts is associated with the presence of three separate operations (Mount Owen Complex, Ashton and Integra). However, uncertainty is driven not only by the intensity of mining development, but by potential environmental changes that are beyond the control of the mine operators or the community. These include the impacts of extended drought or high rainfall periods on air quality and river flows; and the potential impacts of climate change on the significance of different sources of pollutants in the atmosphere and on water quality and river flows. Modelling for the project has considered a range of scenarios, to address this uncertainty.

The direct impact of the Project on local uncertainty about environmental impacts and trends is considered to be minor.

Previous experience in the Upper Hunter region has also demonstrated that uncertainty about the viability of agricultural enterprises is associated with changing economic and regulatory contexts.

In relation to availability of labour for agricultural enterprises, the Project will require 330 additional employees during the construction stage, but will then continue to employ very similar numbers of operational staff to now, over the life of the Project. There is a relatively low level of uncertainty associated with this employment opportunity. More broadly in the region, the certainty of continuing mining employment will depend on national and state scale decisions. Similarly, State and national decisions about will affect the economic context of agricultural production and enterprises.

In relation to the proposed rehabilitation of land post mining, the Project is situated on land that has a small area of LSC Class 4 land, but consists primarily of LSC classes 6 and 7. It is proposed to restore a small area (approximately 40 hectares) to LSC Class 4 or 5 post mining (potentially suitable for grazing), with the remainder of the Project Area restored to LSC Classes 6 to 8 (on the steepest slopes). The LSC class 6 to 8 land will be used for native vegetation (woodland), enhancing biodiversity values post mining.

There is good evidence from the existing Mount Owen operations that sustainable rehabilitation of woodland vegetation communities can be achieved. There is good evidence that post mining landform and soil conditions can be managed to provide land of LSC classes suitable for sustainable grazing, provided this is a clear objective of the closure and rehabilitation process. In this case, reshaping of landforms and drainage lines, and management of topsoil resources can be targeted to provide LSC class 4 or 5 outcomes over specified areas. There is a relatively low level of uncertainty about the capacity of the Project to achieve its rehabilitation targets.

6.0 Mitigation and Management of Impacts on Agriculture

In this section:

In this section, proposed measures to mitigate potential impacts on agricultural resources and agricultural enterprises relate to:

- Land and soil quality goals for the region and for the Project area in that context.
- Final landforms, land and soil capability, closure planning and future land use.
- Research and development – rehabilitation for agriculture.
- Management of buffer lands.
- Management of offset areas.
- Ongoing partnerships with neighbouring farmers.
- Ongoing support in the rural community.

6.1 Planning for Post Mining Land Uses

6.1.1 Land and Soil Quality Goals for the region

The Project is within the areas covered by several related landscape scale environment and natural resources plans which set long term management targets for natural and agricultural resources. These include the *Singleton Local Environmental Plan (LEP) 2013*, the *DRE Synoptic Plan (1999)*, *Hunter and Central Rivers Catchment Action Plan 2013-2023* and the *Upper Hunter Strategic Regional Land Use Plan 2012*.

The goals of these plans relate to:

- Visual amenity, biodiversity and sustainable post closure use.
- Maximising future landscape value by implementing post mining rehabilitation that contributes to biodiversity conservation but also provides the prerequisites for a number of different uses, including agriculture and conservation.

Specific goals relating to the quality of soils as a key natural resource of the region are included in the Catchment Action Plan.

Table 6.1 summarises land and soil goals and targets for the region, as set out in the Catchment Action Plan, and as they are relevant to terrestrial landscapes in the Hunter catchment. The overall goal of land and soil management is to improve or maintain the ability of land and soils to provide ecosystem functions to support:

- Biodiversity;
- sustainable and viable agriculture; and

- community amenity and infrastructure.

overarching targets are:

- reduce soil loss and degradation;
- improve soil health and increase soil carbon; and
- prevent and minimise impacts of acid sulphate soils and salinity.

Table 6.1 also provides an overview of how proposed long term rehabilitation of the Project Area (including the mine footprint, surrounding areas and offset areas) will contribute towards achieving these regional goals.

Table 6.1 – CAP targets and outcomes, 2013-2023 for Land and Soil

Strategy	Proposed Regional Outcomes	How long term management of the Project Area and its surrounding lands and offsets are consistent with these regional outcomes
Prevent and minimise soil loss and degradation	Soil erosion is prevented or reduced where soils are productive and/or downstream impacts are greatest. Riparian zone vegetation buffers are created, protected and maintained to reduce sediment transport downstream. Eroding or unstable stream channels are stabilised to reduce sediment transport downstream. Minimum 70% groundcover is maintained. All land is managed within its assessed capability.	The Water Management Plan for the Project sets out measures to minimise erosion of disturbed areas throughout the life of the Project. The Project does not have a direct impact on high value agricultural soils (Class 1, 2 or 3 LSC classes). The Project will improve ground cover and stabilise stream banks in surrounding areas and offset areas. Glencore owned surrounding areas (Class 3, 4 and 5 LSC classes) and offset areas (Class 4-8 LSC classes) will be managed within their capability, in accordance with approved management plans. Of the 485 hectares of land which is directly impacted by the Proposed Disturbance Area, the mine closure plan envisages that the disturbed area will be rehabilitated to Class 4-7 LSC land. Management of offset areas will be directed to enhancing biodiversity values, including stable soils and ground cover.
Minimise contamination of soil and sediment	Contamination of soils and sediments is prevented and priority sites are remediated	Water Management Plan in place for the duration of mining and rehabilitation phases to manage sedimentation of local water ways. The closure strategy for the mine sets out protocols to ensure that any contaminated soil will be remediated to appropriate standards for agreed future use.
Increase soil carbon	Increase soil carbon to improve soil health	Soils in the Project Area have low soil carbon. Mount Owen currently participating in a research project which is investigating methods for restoring and enhancing soil carbon, during post mining rehabilitation.

Table 6.1 – CAP targets and outcomes, 2013-2023 for Land and Soil (cont.)

Strategy	Proposed Regional Outcomes	How long term management of the Project Area and its surrounding lands and offsets are consistent with these regional outcomes
Improve soil health through land management	Agricultural land managers have the skills and ability to manage the land to be both profitable and provide ecosystems services in the long term. Soil health is improved through management to enhance organic matter, nutrients, fertility, infiltration, soil moisture, soil structure and ground cover. Soil acidification is prevented and mitigated.	The Project has adopted land management goals for Glencore owned surrounding lands and offset areas, and for post mining rehabilitation of disturbed land, which focus attention on improved soil health. These will be delivered through strategies outlined in the Landscape Management Plan for the Project, which will provide details of the mine closure plan, final landforms and land use strategy. Section 6.3.3 and Section 6.4 discuss programs intended to enhance soil health in the Project Area after mining.
Minimise impacts of salinity and acid sulphate soils	Salinity impacts are prevented and minimised.	Some existing soils in the Project Area are moderately acidic (pH 5.5 or less). Groundwater in the Project Area is saline and final land forms/uses include a large water body within the final voids. Water held in this water body is expected to be saline, but suitable for some purposes. The final landform has been designed to minimise the catchment contributing to the final voids. As such it is predicted that the final voids will remain a self contained system with no spills predicted to downstream watercourses (Umwelt, 2014a).
Understand and reduce the impact of climate change on soils	The potential impacts of climate change on soils of value to agriculture and biodiversity are understood and managed by government, industry and land managers.	Assessments of water resources and biodiversity rehabilitation for the Project have taken into consideration the potential impacts of climate change on rainfall and surface runoff, slope stability, regeneration of native vegetation and threats such as invasive species.

6.1.2 Land and Soil Quality Objectives for the Project Area

Taking into account these strategic plans, the Strategic Framework for Mine Closure (ANZMEC & MCA 2000) and the specific site constraints and opportunities of the Project Area, rehabilitation objectives for the Project Area have been established in the Mine Closure and Rehabilitation Strategy (Umwelt 2014d). These focus on:

- sustainable biodiversity rehabilitation, through effective native vegetation corridors which promote fauna habitat development and movement opportunities;
- maintaining and providing additional habitat for a range of threatened fauna species;
- providing opportunities for future agricultural activities such as sustainable grazing; and

- maintaining options for other potential post mining land uses that may be determined in the detailed closure planning process.

Specific closure criteria for three key aspects of post mining rehabilitation to allow potential use of land for agriculture are noted in **Table 6.2**.

Table 6.2 – Closure Criteria for Landforms and Growing Media

Aspect	Objective	Preliminary closure criteria
Landform establishment and drainage	Landform suitable for final land use and compatible with surrounding landscape as sustainable native ecosystem.	• Rehabilitated slopes are generally 10 degrees. However, to allow for the creation of local relief in topography on the top of overburden dumps as well as the creation of alternative stable slope designs (i.e. if concave profiles are utilised), slope angles may exceed this criteria subject to approval by DRE. • No significant erosion is present that would constitute a safety hazard or compromise the capability of supporting the end land use. • Drainage structures (including drainage lines established in the final landform) are stable and there is no evidence of overtopping or significant scouring as a result of runoff. • Surface layer is free of any hazardous materials. • Any final void and associated highwall has been assessed by a qualified geotechnical engineer to validate that it is stable and does not pose a safety risk. • Tailings and reject emplacement areas will be capped and reshaped and be free draining. • Runoff water quality from rehabilitation areas is within the range of water quality data recorded from analogue sites and does not pose a threat to downstream water quality. • Note that the final landform will include three final voids, associated with the North Pit, BNP and proposed RERR Mining Area.
Growing Media Development	Growing media is capable of supporting sustainable vegetation growth.	• The rehabilitation surface is a suitable growing medium. • Soil pH to be in the range of equivalent landscape sites. • Monitoring demonstrates soil profile development in rehabilitated areas (e.g. development of organic layer, litter layer).

Table 6.2 – Closure Criteria for Landforms and Growing Media (cont.)

Aspect	Objective	Preliminary closure criteria
Ecosystem establishment	Revegetation is sustainable for the long term and only requires maintenance that is consistent with the intended final land use.	• Revegetation areas contain flora species assemblages characteristic of the desired native vegetation communities (including grassland communities). • Second generation trees are present or likely to be, based on monitoring in comparable older rehabilitation sites (i.e. evidence of fruiting of native species observed). • More than 75 per cent of trees are healthy and growing as indicated by the long term monitoring program. • There is no significant weed infestation such that weeds do not compromise a significant proportion of species in any stratum, including potential pasture grasses. • Appropriate bushfire hazard controls have been implemented on the advice from the NSW Rural Fire Service.

6.2 Indicative Post Mining Land Use

The indicative post mining land use for the Project Area will primarily involve the establishment of woodland areas. The objective is to create a native vegetation corridor network that promotes regional fauna movements between Mount Owen Complex, Ravensworth Operations, Liddell Coal Operations, Lake Liddell and the Ravensworth Operations Offset Areas.

Other portions of the Project Area, including the tops of overburden dump areas, the flatter area at the base of the North Pit Continuation emplacement areas, as well as capped tailings dams will be revegetated with open grassland with pockets of native vegetation. Rehabilitation activities will be undertaken progressively throughout the life of mine to allow maximum opportunities for the development of vegetation prior to mine closure. Some of these flatter, grassed areas will be rehabilitated to LSC classes 4 or 5, suitable for grazing activities.

During the preparation of the EIS, community (including local land holders) and stakeholder feedback was received on mine closure and potential post mining land uses and management issues (see **Section 4.3**). Closure options identified during this consultation included return of the land to agricultural enterprises similar to those that have existed in the locality in the past (primarily grazing, with some dairy farming on the alluvial landforms and soils along Glennies Creek). Other options that have been suggested include aquaculture (in post mining water bodies), commercial forestry, conservation, facilities for horse riding (including horse trails and pony club), golf course, water based recreation and other community uses. In broad terms the local community favoured a 'natural looking' final landform.

Depending on outcomes of final land use analysis to be completed as part of the detailed closure planning process five years from closure, it is the intent that rehabilitated areas could be used for sustainable agricultural purposes such as grazing. As such, revegetation may involve the use of both native and suitable pasture species for the establishment of grasslands in these areas. In this instance, pockets of native vegetation may be established as shelter belts to support grazing activities.

In consideration of the proposed operational life of the Project to 2030, the potential for other sustainable and economically productive post-closure land uses which might support a local rural community, such as those suggested in consultation, will be investigated in light of the local and regional land use strategies that may have further evolved towards the end of the mine life. This process will be undertaken as part of the detailed mine closure process and in consultation with relevant stakeholders.

6.3 Aspects of Operations and Closure to deliver Sustainable Land and Soil Resources

This section describes the actions proposed during mining operations and in the closure and rehabilitation process to minimise impacts on agricultural resources and specific aspects of sustainable landscape management which will allow for diverse post mining uses, including agriculture.

6.3.1 Stable and Productive Landform Design

As noted in **Table 6.2**, the post mining landform will generally be undulating country, with areas of flatter land and maximum slopes of around 10 degrees (approximately 18 per cent), generally equivalent to LSC Classes 4 to 5.

In particular, flatter areas on the site, including the tops of reshaped overburden areas and tailings dams are to be established to open grassland with pockets of native vegetation. Depending on the outcomes of the final land use analysis, to be completed as part of the detailed closure planning process, five years from closure, there is potential that these flatter areas could be used for sustainable agricultural purposes such as grazing.

The final landform design for the Project includes final voids at the North Pit, BNP and proposed RERR Mining Area. Over time, the voids will fill with groundwater and/or surface runoff from internal slopes.

The presence of the water filled final voids creates constraints and opportunities for users of the surrounding land. The post mining Landscape Management Plan will address land management and water management issues, providing detailed guidance on minimising constraints to sustainable long term use of surrounding lands for native vegetation and/or agriculture (grazing). The Landscape Management Plan would include the following actions, which are relevant to the concerns expressed by local landholders and to the potential for long term agricultural use of parts of the post mining landscape of the Project Area:

- ongoing engagement with local landholders about long term management of the landforms and water resource;
- design of the landforms with benches and graded slopes;
- detailed measures for ground cover management, runoff management and drainage line management to minimise erosion potential and to minimise the risk of downstream impacts on water quality or channel form in natural waterways;
- further investigation of innovative uses of the water bodies and water surface in the final voids, as part of long term land use planning for the region. It is expected that options and planning for final potential uses of the water body will evolve over time. If the Project is approved, mining will cease in 2030; and

- robust fencing, or other barrier constructions, of the high wall and other entry points to ensure that straying cattle cannot enter the area around the voids.

6.3.2 Soil Profile Rehabilitation for Improved Land and Soil Capability

The proposed mine plan provides for progressive rehabilitation of landforms, soils, drainage controls and vegetation.

Material characterisation of topsoil and subsoil will be conducted at an appropriate scale across the Proposed Disturbance Area and to confirm soil quality in stockpiles of topsoil and other materials to determine the potential limitations to rehabilitation for sustainable plant growth (native vegetation or pasture). The tests will address constraints such as sodicity, acid generating potential, soil carbon and fertility, to determine specific soil management techniques needed to provide viable soil materials.

Areas that may be established as open grassland or for potential viable and sustainable agricultural use have been identified in the flatter portions of the proposed final landform. Revegetation may involve the use of both native and suitable exotic pasture species for the establishment of grasslands in these areas with pockets of native vegetation, which may ultimately be utilised as shelter for livestock.

For rehabilitation areas which may be suitable for agriculture, the establishment of grazing areas, revegetation techniques will be consistent with local agricultural practices and are likely to involve sowing with grasses and legumes appropriate to the district and recognised as suitable for grazing. A similar mix may also be used in areas with steeper slopes to prevent scouring and subsequent soil loss.

6.4 Research and Development in Land and Soil Rehabilitation

The focus of post mining rehabilitation for previously approved mining operations at Mount Owen Complex has been on biodiversity outcomes including species and habitat diversity and connectivity. Both mined and non-mined lands have been committed to biodiversity uses, in consultation with State agencies (DP&E, OEH, State Forests and, Local Land Services within DPI).

The existing Mount Owen operation has a strong track record in post mining rehabilitation for biodiversity outcomes and has worked closely with the Centre for Sustainable Ecosystem Restoration at Newcastle University for several years. The collaboration has focused on improving the design and management of post mining rehabilitation to achieve enhanced biodiversity outcomes on rehabilitated land. The Mount Owen Complex area is uniquely placed for biodiversity management because of the presence of the remnant Ravensworth State Forest. The Ravensworth State Forest vegetation complex, including the remnant of undisturbed forest and new forest areas revegetated post mining, is now a regionally significant biodiversity conservation area.

This focus is also consistent with the Synoptic Plan for the Hunter Valley (1999) and with biodiversity targets for the region in natural resource management planning.

Final landform design in the Project Area is intended to provide stable landforms and flow structures. The slope of these landforms, the presence of rock at or very close to the surface, low fertility and limited soil structure mean that post mining soil and land capability in existing rehabilitated parts of Mount Owen operations is unlikely to be better than LSC Class 6. For many areas, this represents a decline in the LSC of the potential agricultural lands and a long term loss of agricultural capability.

Parts of the Project Area are currently LSC Class 4 or 5. The Project proposes to rehabilitate an equivalent area of land to LSC class 4 or 5, with potential for long term use for grazing.

To inform stakeholders of the rehabilitation process and proposed outcomes and opportunity to provide feedback on long term land management of the Project Area, Glencore and Mount Owen will:

- conduct ongoing monitoring and reporting of water quality and rehabilitation performance;
- maintain its Community Consultative Committee and the regular meetings and briefings for the Committee, including information about closure planning and landform / landuse targets; and
- continue to support the Upper Hunter Mining Dialogue, taking part in discussion of best practice mine closure planning and implementation to achieve sustainable agricultural lands where that is the preferred post mining land use.

Continue to consult and work with the relevant stakeholders, to identify opportunities to achieve sustainable agricultural and biodiversity offset uses in the landscape, consistent with the CMA's regional natural resource management targets.

Where relevant, contribute to rehabilitation and land management related research.

6.5 Agricultural Use of Surrounding Mount Owen Owned Lands

The Project has the potential for acquisition of approximately 7 hectares of land by Glencore. This land is currently used for rural residential purposes. Acquisition rights for this land are available because of noise or dust impacts on residences located on the land. If acquisition rights are invoked, the properties will become part of the mine owned land of the Project. Glencore currently owns 4,350 hectares of agricultural land in the vicinity of the existing operations, which is not directly impacted by mining or Biodiversity Offset. This land is currently managed for agricultural purposes, mainly dryland cattle grazing, by Colinta on behalf of Glencore (see **Section 4.4**).

In this case, the principal impact is one of a tenure change, rather than a land use change. It is possible that properties with and without residences could be leased back to community members, should acquisition be invoked.

6.5.1 Management of Pests, Diseases and Invasive Plant Species

Weeds, feral pests and other biosecurity issues have been identified as potential impacts to be managed on biodiversity offsets, rehabilitated mining land and agricultural land owned and managed by Glencore at the Mount Owen Complex.

The introduction and spread of weeds is always a risk where the movement of personnel, vehicles or water and the removal or suppression of effective competitive species occurs on a regular and widespread basis. Weeds have the potential to cause significant degradation to neighbouring agricultural land as well as impact negatively on the success of rehabilitation across the Project Area.

Both introduced feral fauna species such as foxes, rabbits, hares, pigs, wild dogs and cats, as well as increasing unmanaged populations of native species such as kangaroos have the potential to impact significantly on both agricultural and non-agricultural land uses in the locality of the Project Area.

Management strategies for feral animals and noxious weed control are currently detailed in the Mount Owen Complex Flora and Fauna Management Plan, which will be incorporated into a revised and consolidated Landscape Management Plan should the Project be approved. The Landscape Management Plan would capture the existing feral animal and noxious weed control measures outlined below.

- Noxious and other undesirable weed species within the Project Area will be controlled through an integrated approach involving a combination of chemical and physical control methods, and careful pasture management.
- Regular monitoring of revegetation and regeneration areas will be undertaken to determine the impact of feral animals, particularly on vegetation establishment. Feral animal control works will be undertaken periodically to control feral animals, and will consider ecological impacts.

Mount Owen recognises the importance of maintaining contact with surrounding landowners to determine where there are particular weed, pest or fencing issues that need to be addressed. Adequate resources will be directed to monitoring and managing land management impacts as they are identified or arise.

6.5.2 Stock Management across Shared Boundaries

As part of consultation in relation to the Project, some landowners in the locality of the Project have commented on occasional issues with retrieving stock which may have strayed across property boundaries and into densely vegetated rehabilitation areas.

The Project will work in partnership with relevant land owners to minimise the risk of stock straying onto land that is part of the Project Area and will also work with relevant landowners to develop communications and practical stock recovery processes.

6.5.3 Property Management Plans for Surrounding Mount Owen Owned Land Used for Agriculture and Offset Areas

Mount Owen will review and amend the existing Biodiversity Offset Strategy to include the proposed offset areas. These plans will be integrated with the broader management of the Glencore owned surrounding area and offset lands owned by Mount Owen in the locality and the broader upper Hunter Region to ensure the best natural resource and agricultural land use outcomes at the landscape scale.

These plans will address the resilience of natural resources on these parcels of land (soil, water, biodiversity), including managing a range of threats (such as invasive plants and feral animals) as well as measures required to manage any enterprises on those lands in accordance with the LSC of the land.

In preparing these Management Plans, Mount Owen would consult with relevant stakeholders and State agencies, such as DPI Agriculture, Local Land Services and OEH.

6.6 Ongoing Community Engagement

Community involvement has been a key element of the Project in order to obtain a comprehensive understanding of the issues and perspectives of neighbouring landholders in proximity to the Project Area. An extensive program of consultation has been ongoing

throughout the assessment to inform the Social Impact and Opportunity Assessment and the broader environmental assessment studies.

The issue of land management on mine owned land, was identified by stakeholders during the consultation program and provides an opportunity to further build and develop relationships with neighbouring landholders through the implementation of ongoing engagement mechanisms at the site level. Accordingly, Mount Owen has committed to consideration of mechanisms to further involve the community in land management, e.g. working group/CCC involvement.

Mount Owen will continue to consult with the local community, including the agricultural community, through a range of mechanisms, including CCC meetings, community newsletters, open days and personal meetings.

6.7 Monitoring and Reporting the Condition of Agricultural Resources and Industries

Mount Owen will monitor the condition of agricultural resources on land that it owns and/or manages. Monitoring over the life of the mine and during closure and rehabilitation is a commitment in the Surface Water Assessment (Umwelt 2014a) for the Project and in the Ecology Assessment and Mine Closure and Rehabilitation Assessment (Umwelt 2014b & 2014d).

It is envisaged that a detailed monitoring program will be prepared as part of the development of the Mine Operations Plan (MOP) and be reported in subsequent annual reports that are submitted to relevant government agencies and made available to the community. Completion criteria, including those relevant to potential grazing uses of parts of the Project Area, will be finalised as part of the detailed mine closure planning process and presented in the Final Closure Plan for approval by the relevant government agencies.

The gradual achievement (or otherwise) of these completion criteria will be assessed and discussed in the annual report, which will include the identification of any failures of the criteria and measures taken to address any such issues. This ongoing monitoring and reporting adds both clarity and certainty to the conditions needed to support preferred post mining land uses, including agriculture.

It is proposed that monitoring that is relevant to agricultural land use within the Project Area and outside the Project Area (where applicable) will include:

- water quality at discharge points (as per EPL licence conditions);
- water quality in creeks downstream of the operation areas, as set out in the Surface Water Management Plan for the Project;
- stability of rehabilitated landforms and drainage structures. This monitoring is discussed further in the Mine Closure and Rehabilitation Assessment for the Project (Appendix 18 of the EIS);
- development of soil profile characteristics on rehabilitated land, including monitoring of organic content, pH, sodicity and fertility. Details of proposed monitoring of post mining landforms and soils are in the Mine Closure and Rehabilitation Assessment for the Project (see Appendix 18 of the EIS);

- condition of ground cover (grasses) and other species/habitats in rehabilitated areas. Where there is potential to use parts of the rehabilitated area for grazing at some time in the future, Mount Owen will also consider monitoring of nutrient value of rehabilitated grassland. Details of proposed biodiversity monitoring are in the Ecology Assessment for the Project (Appendix 11 of the EIS); and
- Mount Owen will maintain a weather station at the Mount Owen Complex with real time monitoring of temperature, rainfall and wind speed and direction.

Results of monitoring programs will be made available to the community in annual reports, project specific reports and in presentations to the Upper Hunter Mining Dialogue and other forums, as appropriate.

6.8 Adaptive Management to Achieve Agreed Land and Soil Goals

Mount Owen accepts that potential agricultural uses of the locality may change over time and that knowledge of how open cut mining areas can be rehabilitated to LSC classes suitable for quality grazing land may also increase over time. The commitments made in the AIS are based on current knowledge and capacity.

Proposed management actions to minimise potential impacts on agricultural resources, production, enterprises and communities will be included in a series of management plans which provide for action, monitoring, reporting and review. This adaptive process allows for the adoption of improved approaches that meet environmental, social and economic objectives more effectively.

6.8.1 Summary of Proposed Management Plans Relevant to Agricultural Resources and Enterprises

Table 6.3 summarises the existing management plans that will be updated and implemented to guide the protection and rehabilitation of agricultural resources on the Project Area to minimise long term risks to agricultural resources and enterprises.

Table 6.3 – Summary of Relevant Management Plan Updates for Adaptive Management and Mitigation

Relevant Management Plan	Management Issues Addressed With Best Practice
Landscape Management Plan	Landform design. Final void management. Soil reinstatement and remediation, including monitoring of ongoing soil chemistry relative to requirements for sustainable, productive grazing uses. Drainage line reinstatement and stability. Revegetation strategy. Final land uses for the Project Area. Monitoring of ground surface and ecological condition. Rehabilitation Monitoring. Monitoring of stocking rates and production values.
Water Management Plan	Water quality in tributary creeks draining from the Project Area and in Bowmans Creek and Glennies Creek downstream of the Project Area.

Table 6.3 – Summary of Relevant Management Plan Updates for Adaptive Management and Mitigation – cont.

Relevant Management Plan	Management Issues Addressed With Best Practice
Social Involvement Plan	Community Consultative Committee activities. Community surveys and results. Investment in agricultural and soil research.
Biodiversity Offset Management Plans	Land management on biodiversity offset properties, including feral animal and weed species management and any proposals for thinning.

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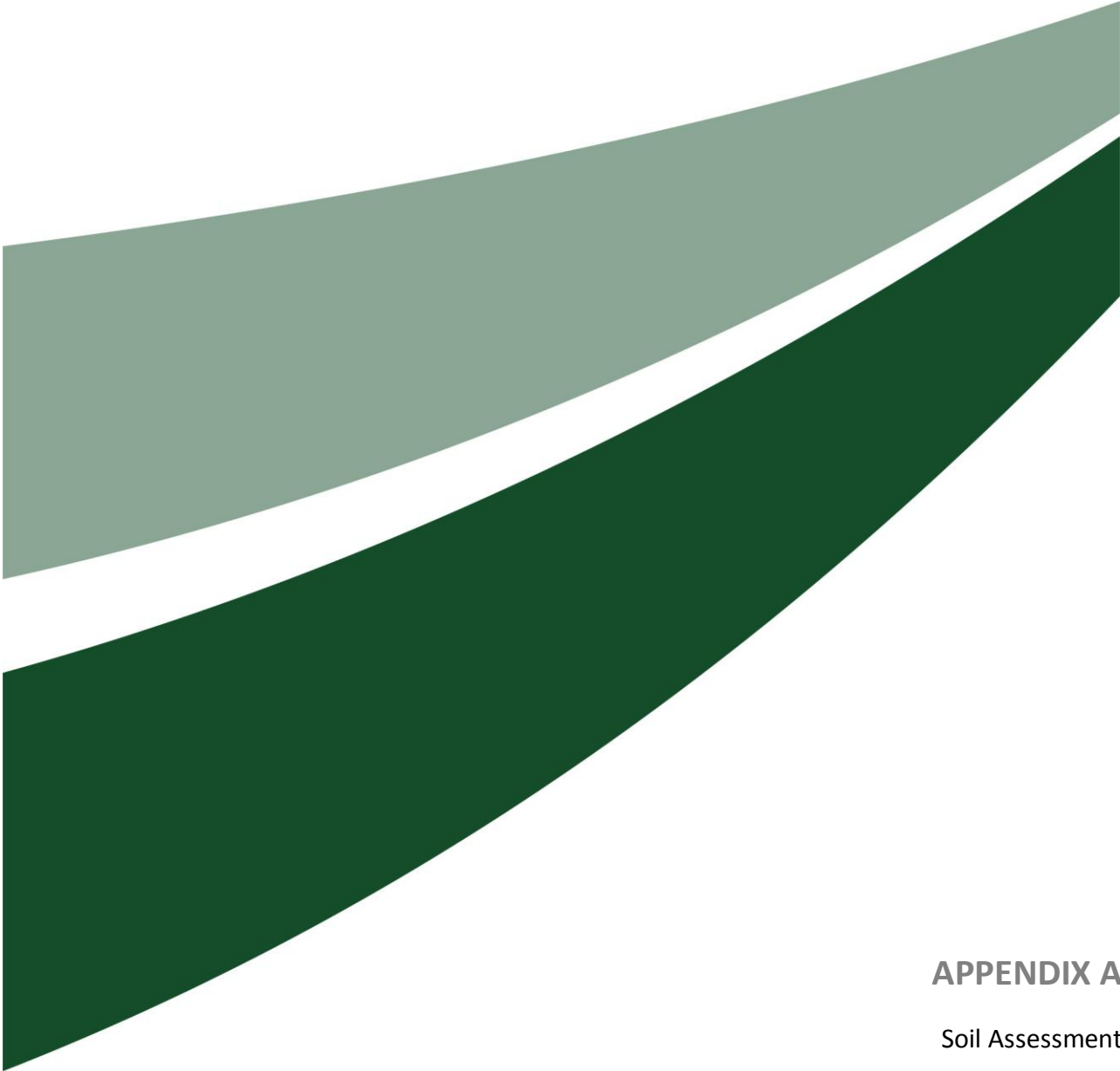
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APPENDIX A

Soil Assessment

**Mount Owen Continued
Operations Project**

SOIL ASSESSMENT

FINAL

October 2014

Mount Owen Continued Operations Project

SOIL ASSESSMENT

FINAL

October 2014

Prepared by
Umwelt (Australia) Pty Limited
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TABLE OF CONTENTS

1.0	Introduction	1
1.1	Offsets and Surrounding Areas	1
2.0	Soil Survey and Assessment Methodology	2
2.1	Personnel	2
2.2	Reference Map and Desktop Review	2
2.3	Field Survey	3
2.3.1	Survey Design	3
2.3.2	Detailed Soil Profile Descriptions	4
2.3.3	Soil Laboratory Assessment.....	5
2.3.4	Mapping Observations.....	6
2.4	Soil Classification.....	6
3.0	Soil Survey Results	6
3.1	Soil Type 1 – Stratic Rudosol	7
3.2	Soil Type 2 – Clastic Rudosol	9
3.3	Soil Type 3 – Brown Sodosol	11
3.4	Soil Type 4 – Brown Kurosol	13
4.0	Land and Soil Capability Assessment.....	15
4.1	Land and Soil Capability Methodology.....	16
4.2	Land and Soil Capability Assessment.....	18
5.0	Biophysical Strategic Agricultural Land	21
5.1	Biophysical Strategic Agricultural Land Assessment – Upper Hunter SRLUP.....	22
5.1.1	Verified Soil Fertility in the Proposed Disturbance Area	22
5.2	BSAL Assessment – Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land	23
6.0	Soil Use for Rehabilitation.....	24
7.0	Summary of Assessment Findings.....	24
8.0	References	25

FIGURES

1.1	Locality Plan.....	1
1.2	Mount Owen Locality Regional Setting.....	1
1.3	Potential Biophysical Strategic Agricultural Land and Critical Industry Clusters – Upper Hunter SRLUP Mapping.....	1
2.1	Regional Soil Landscapes	2
2.2	Existing Landforms and Slopes	3
2.3	Soil Sampling Areas of Exclusion	4
3.1	Proposed Hebden Road Upgrade Works Area - Soil Types.....	6
3.2	Proposed Rail Upgrade Works Area - Soil Types	6
3.3	Proposed North Pit Continuation Area – Soil Types	6
4.1	Proposed Hebden Road Upgrade Works Area Land and Soil Capability.....	17
4.2	Proposed North Pit Continuation Area Land and Soil Capability.....	17
4.3	Proposed Rail Upgrade Works Area Land and Soil Capability	17

PLATES

3.1	Soil Forming Materials in the Stratic Rudosol Soil at Site 14 (K)	7
3.2	Landscape Context at the Stratic Rudosol Soil at Site 14 (K).....	7
3.3	Soil Forming Materials in the Clastic Rudosol Soil at Site 25 (B).....	9
3.4	Landscape Context at the Clastic Rudosol Soil at Site 25 (B)	9
3.5	Soil Forming Materials in the Brown Sodosol Soil at Site 24 (D).....	11
3.6	Landscape Context at the Brown Sodosol Soil at Site 24 (D).....	11
3.7	Soil Forming Materials in the Brown Kurosol Soil at Site 26	11
3.8	Landscape Context at the Brown Kurosol Soil at Site 26	11

APPENDICES

1 Laboratory Test Results

1.0 Introduction

The Mount Owen Continued Operations Project (the Project) proposes to extend the life of the current Mount Owen open cut coal operation for 12 years from 2018 to 2030. This will involve an extension to the existing North Pit towards the south-east as well as upgrades to some rail and road infrastructure. The Project includes a Proposed Disturbance Area (**Figure 1.1**) covering a total of 485 hectares with three separate components. These include:

- an upgrade to the southern end of Hebden Road with a rail overpass over the existing Northern Rail Line and a two-way bridge across Bowmans Creek to improve safety for road users (13.1 hectares);
- an upgrade to the existing Mount Owen rail spur with an additional line and northern turnout to allow more efficient train storage and movements (91.4 hectares); and
- continuation of the existing mining operations within the North Pit to the south beyond the current approved North Pit shell (approximately 380.5 hectares).

The Project also includes two off-site biodiversity offset properties that are currently partially used for agricultural production. These are the property 'Esparanga' (303.2 hectares), located between Muswellbrook and Denman and the property 'Cross Creek' (367.4 hectares) located on the northern boundary of the Project Area (refer to **Figure 1.2**).

Umwelt (Australia) Pty Limited has undertaken a detailed assessment of the soils and the associated land and soil capability of the land directly affected by the Project (the Proposed Disturbance Area). This forms part of the Agricultural Impact Statement (AIS) which is an integrated component of the environmental impact assessment process required for the approval of the Project. The soils assessment included a review of past soil surveys and soil mapping undertaken within the existing mine lease as well as a detailed soil survey undertaken across the Proposed Disturbance Area.

The objectives of this detailed soil assessment of the Proposed Disturbance Area were to:

- describe, classify and map the soil types;
- assess the land and soil capability to determine the potential agricultural value and limitations;
- verify the mapping of Biophysical Strategic Agricultural Land (BSAL) identified in the *Strategic Regional Land Use Plan Upper Hunter* (Upper Hunter SRLUP) (DP&I 2012b) (refer to **Figure 1.3**);
- analyse the suitability of the soils for use in rehabilitation; and
- provide baseline data on the physical and chemical fertility of the soils for potential use in future rehabilitation monitoring.

This report describes the methodology of the soil survey and presents the results of the soil assessment of the Proposed Disturbance Area.

1.1 Offsets and Surrounding Areas

The biodiversity offset properties have been assessed in the main body of the AIS using existing regional scale mapping of soil type, fertility, slope and land and soil capability, as



FIGURE 1.1
Locality Plan

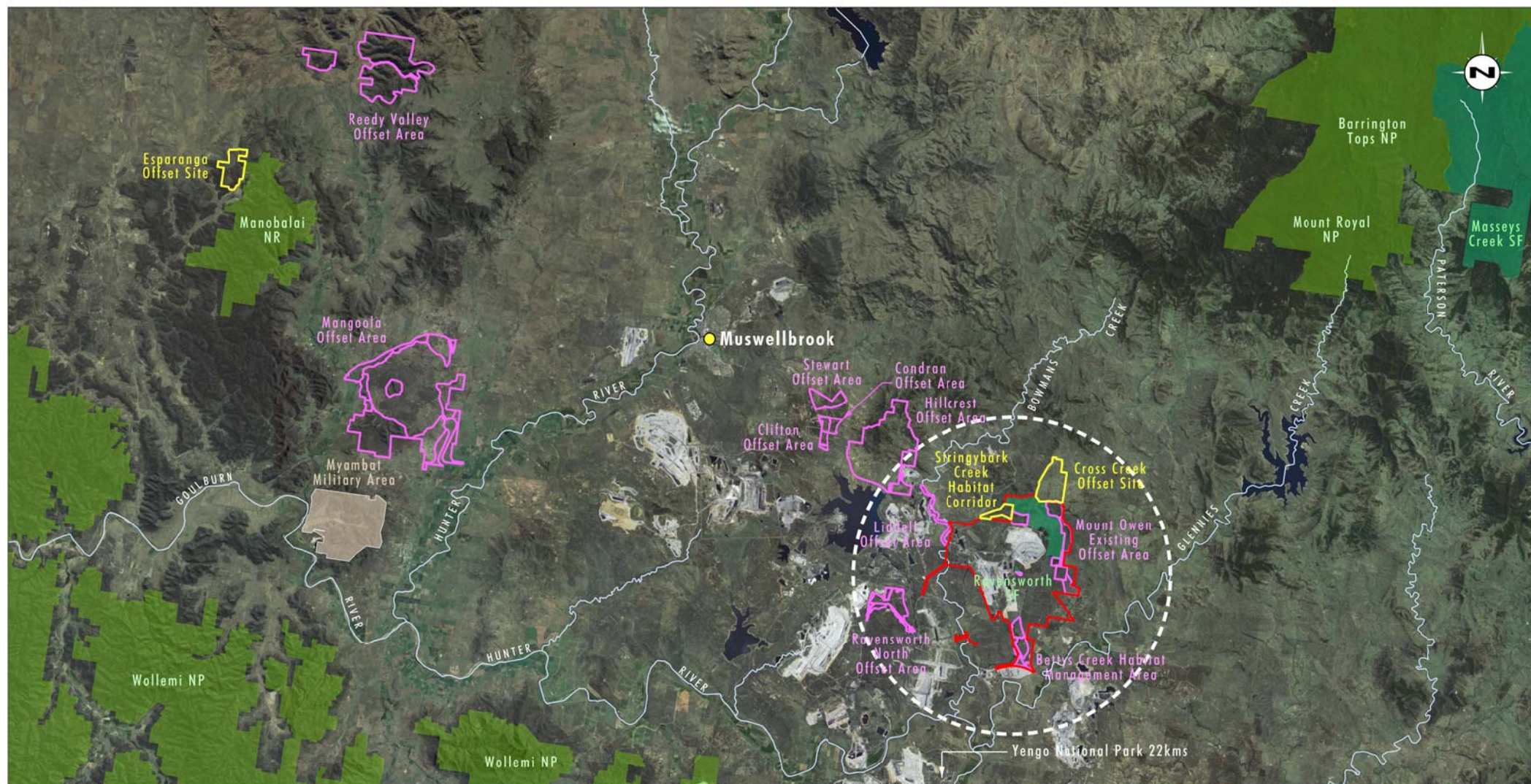


Image Source: Google Earth (2009)
Data Source: Department of Lands (2003), LPI (2012), OEH (2013), State of NSW (2013), Mount Owen (2014)

0 5.0 10.0 15.0km
1:350 000

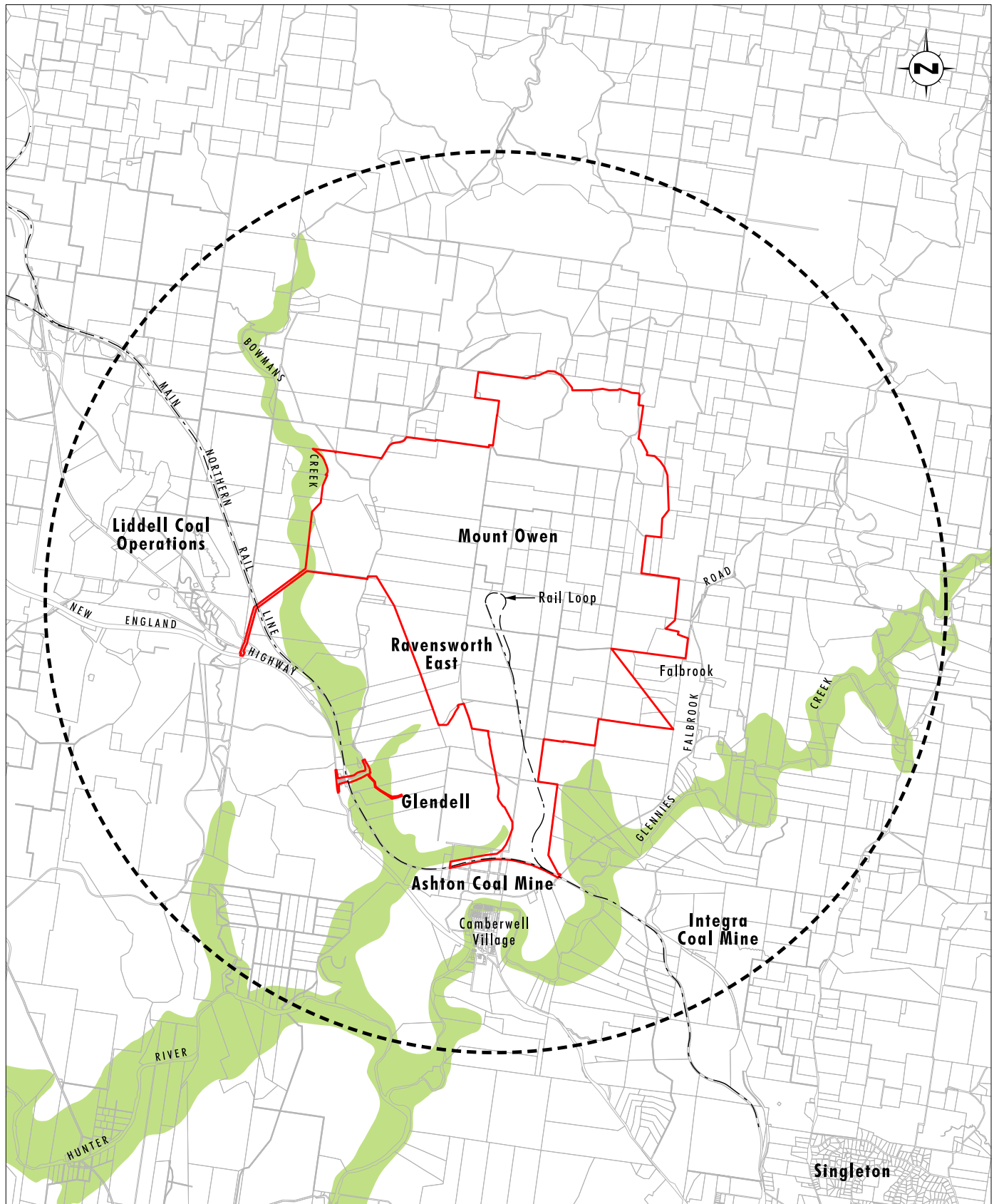
Legend

- Project Area
- Existing Glencore Offsets
- Proposed Mount Owen Offsets
- National Park/Nature Reserve (NP/NR)
- State Forest (SF)
- Crown Reserve
- Mount Owen Complex Locality (10km Radius from Rail Loop)

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20140926 10:33

FIGURE 1.2

Mount Owen Complex Locality
Regional Setting



Data Source: Mount Owen (2014)
 BSAL: OEH (2011)
 Note: Absence of critical industry clusters is due to their not being mapped as occurring within the locality.

Legend

- Project Area
- Mount Owen Complex Locality (10km Radius from Rail Loop)
- Biophysical Strategic Agricultural Land (BSAL)

FIGURE 1.3

Potential Biophysical Strategic
 Agricultural Land and Critical Industry
 Clusters - Upper Hunter SRLUP Mapping

well as localised vegetation mapping, to determine potential agricultural value and/or limitations.

2.0 Soil Survey and Assessment Methodology

2.1 Personnel

The soil survey and assessment were prepared by Umwelt staff, Rachel Rummery and Pam Dean-Jones, qualified and experienced in natural resources, soils and agriculture. The survey design, field methods, soil recording and report were peer reviewed by Mr Peter Fogarty, Principal of Soil and Land Conservation Consulting, who is a Certified Practising Soil Scientist Level 3 with the Australian Society of Soil Science Australia.

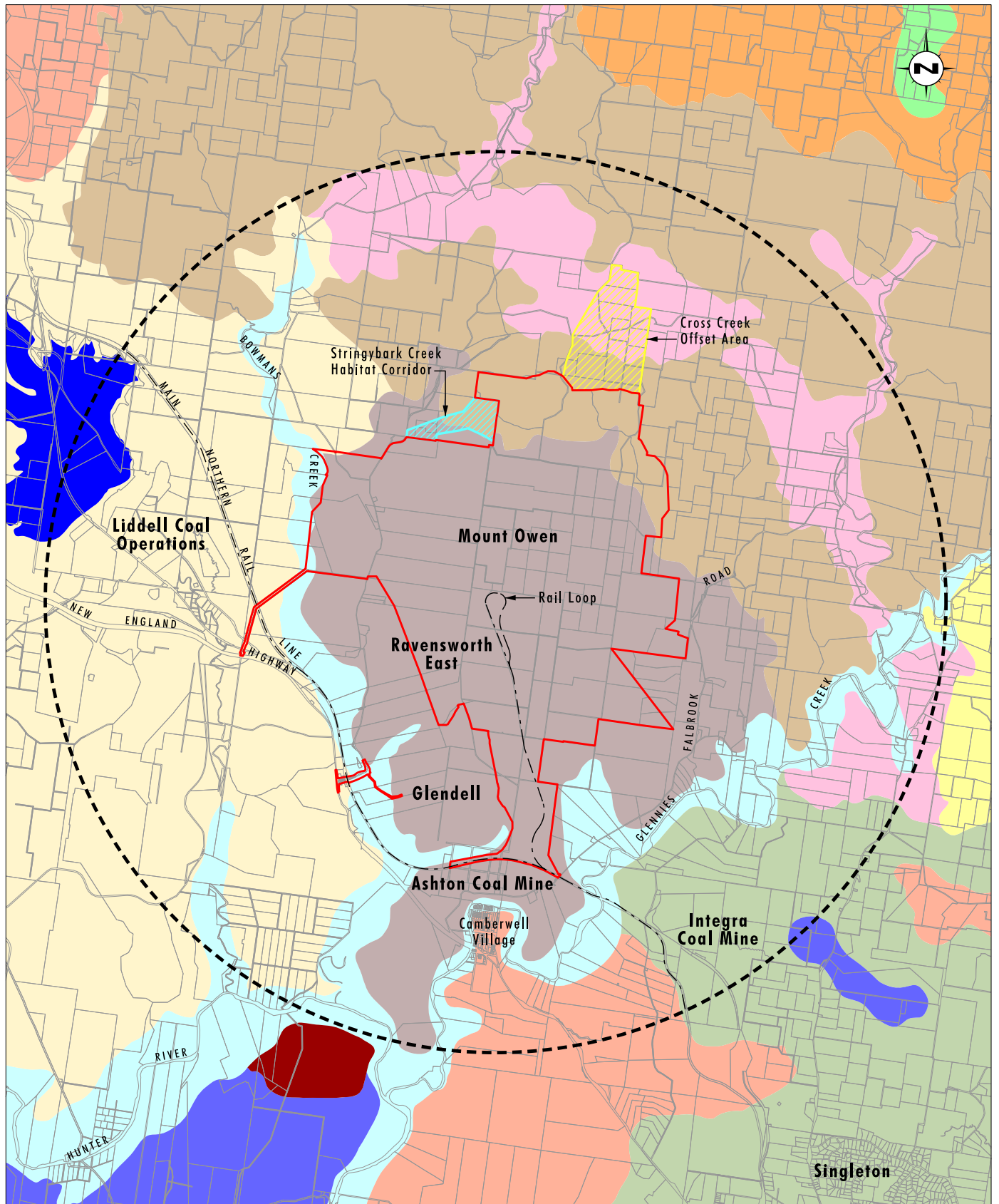
Mr Fogarty participated in part of the field survey and assisted with soil profile descriptions and soil identification.

2.2 Reference Map and Desktop Review

Initially a desk top assessment of the soils and other features in the Project Area¹ was conducted using:

- aerial photos;
- topographic maps at 1:25,000 scale;
- the *Soil Landscapes of the Singleton 1:250,000 Sheet* (Kovac and Lawrie 1991) (refer to **Figure 2.1**);
- *Strategic Regional Land Use Policy: Guideline for Agricultural Impact Statements* (DP&I 2012a), the *Agricultural Impact Statement: Technical Notes* (DPI 2013) the *Upper Hunter Strategic Regional Land Use Plan* (Upper Hunter SRLUP) (DP&I 2012b), the *Land and Soil Capability Assessment Scheme; Second Approximation* (OEH 2012) and the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013) to define and explain information required about soils and soil landscapes to meet the NSW Government expectations for agricultural impact assessment and appropriate protocol for the identification and verification of strategic agricultural land;
- land and soil capability mapping and fertility mapping prepared by the NSW Office of Environment and Heritage (OEH) (OEH 2012, OEH and OASFS 2013);
- BSAL maps from the Upper Hunter SRLUP (DP&I 2012b); and
- soil survey, soil sampling and analysis technical references (refer to **Table 2.1**) as specified in the DPI guidelines and technical notes (noted above).

¹ For the purpose of the AIS, the Project Area is the area which will be covered by the Development Application. It encompasses the currently approved development consent areas for the Mount Owen Mine and Ravensworth East Mine as well as the Proposed Disturbance Area described in **Section 1.0**.



Data Source: Mount Owen (2014)
Soil Landscapes: NSW Department of Environment,
Climate Change and Water (DECCW) (2010)

0 2.0 4.0 6.0km
1:120 000

Legend

- | | | | |
|---|---|---|--|
| Project Area | Soil Landscapes: | Roxburgh | Jerrys Plains |
| Mount Owen Complex Locality
(10km Radius from Rail Loop) | Hunter | Sedgfield | |
| Cross Creek Offset Area | Rosevale | Water | |
| Stringybark Creek Habitat Corridor | Greenland | Branxton | |
| | Bayswater | Scrumlo | |
| | Lambs Valley | Lethbridge | |
| | Bridgeland | | |

FIGURE 2.1

Regional Soil Landscapes

Table 2.1 - Soil Survey, Soil Sampling and Analysis Technical References

Aspect	Requirements Set Out in Reference
Soil sampling and survey	McKenzie, N.J., Grundy, M.J., Webster, R., Ringrose-Voase, A.J. (2008). <i>Guidelines for Surveying Soil and Land Resources</i> , 2nd ed. CSIRO Publishing, Victoria, Australia.
Soil classification	Isbell, R.F. (2002). <i>The Australian Soil Classification</i> . CSIRO Australia, Collingwood, VIC.
Soil physical measurements	McKenzie, N., Coughlan, K., & Resswell, H. (2002). <i>Soil physical measurement and interpretation for land evaluation</i> . Collingwood, Australia: CSIRO Publishing.
Soil chemical measurements	Rayment, G. E., and Lyons, D. J. (2011). <i>Soil Chemical Methods: Australasia</i>
Land and Soil Capability	Office of Environment and Heritage (OEH). (2012). <i>The Land and Soil Capability Assessment Scheme; Second Approximation</i> .
BSAL verification	OEH and OASFS, 2013

The review of mapping and documentation provided an overview of the land and soil characteristics of the Project Area and highlighted locations where detailed soil survey and verification assessment were required. It also informed the detailed survey design.

In developing the field survey plan, the following were also taken into account:

- a detailed LIDAR slope analysis, using 2012 data (refer to **Figure 2.2**) undertaken across the Project Area to identify correlations between landform elements and soil types to assist with land and soil capability mapping, BSAL verification and soil distribution;
- identification of areas of environmental and cultural significance. These were not physically sampled but observations of conditions were made in the field; and
- identification of significant areas of prior site disturbance or current infrastructure for exclusion from the soil survey.

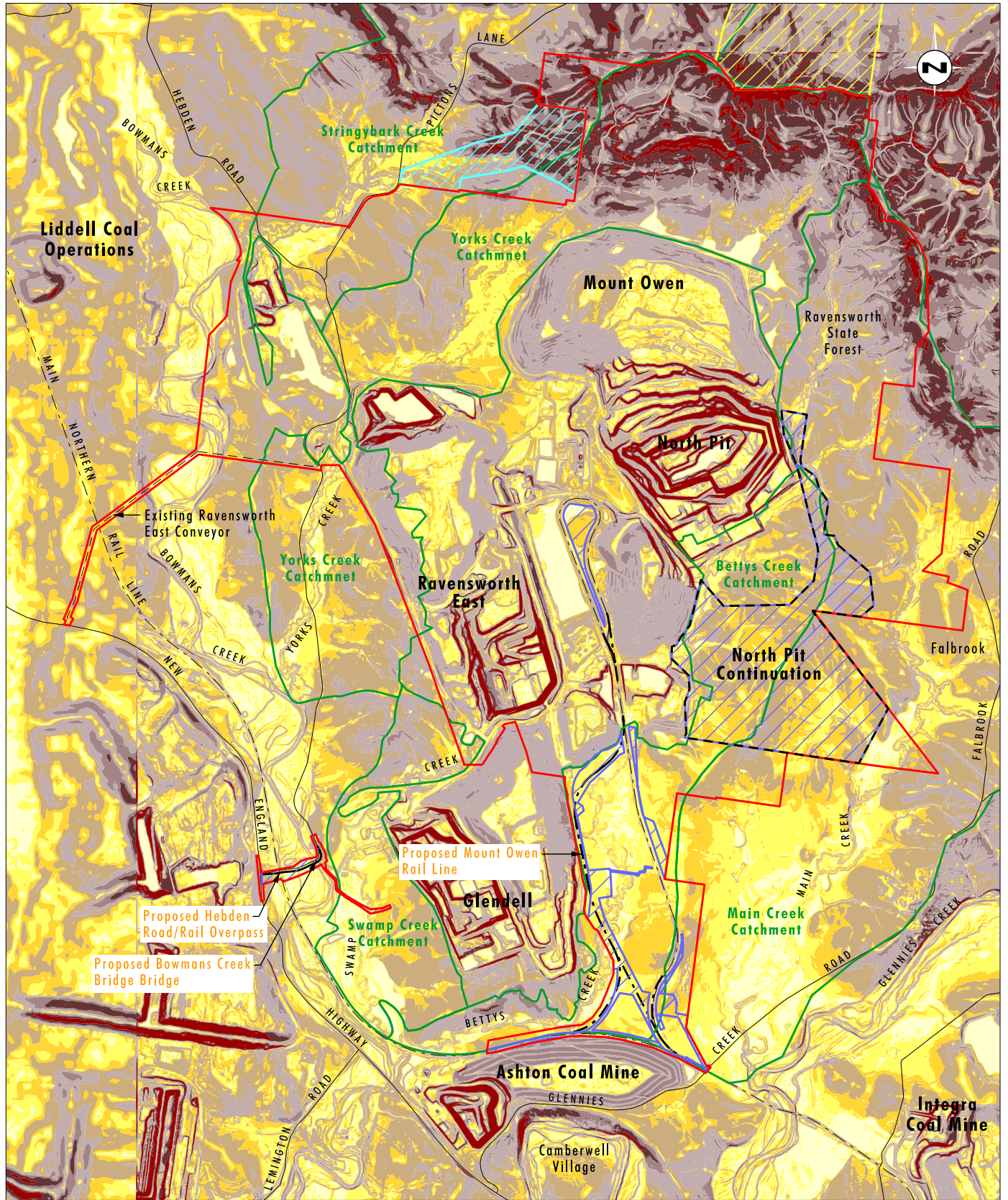
2.3 Field Survey

2.3.1 Survey Design

The field survey of the Proposed Disturbance Area was a comprehensive soil survey conducted in accordance with the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et. al.* 2008). Detailed descriptions of full soil profiles, laboratory analyses of surface and subsoil samples and observations of sites were combined to provide an integrated quantitative soil survey of the Proposed Disturbance Area.

The soil survey was undertaken in September 2012, July 2013 and June 2014.

The soil survey was conducted at a scale of 1:25,000 with the location and type of samples and observations presented in **Figure 2.3** and summarised below in **Table 2.2**. A total of 41 sites were assessed. In addition, the three visits to the Proposed Disturbance Area involved significant driving between soil sampling sites which enabled observations of slopes, vegetation types and landform features to confirm soil mapping.



Data Source: Mount Owen (2014)

0 1 2 3 km
1:60 000

Legend

- | | | |
|--|--|---|
| Project Area | Slope Class: | > 50% |
| Proposed North Pit Continuation | < 1% | |
| Proposed Rail Upgrade Works | 1-3% | |
| Proposed Hebdon Road Upgrade Works | 3-5% | |
| Proposed Disturbance Area | 5-10% | |
| Cross Creek Offset Area | 10-20% | |
| Stringybark Creek Habitat Corridor | 20-33% | |
| Catchment Boundary | 33-50% | |

FIGURE 2.2
Existing Landforms and Slopes

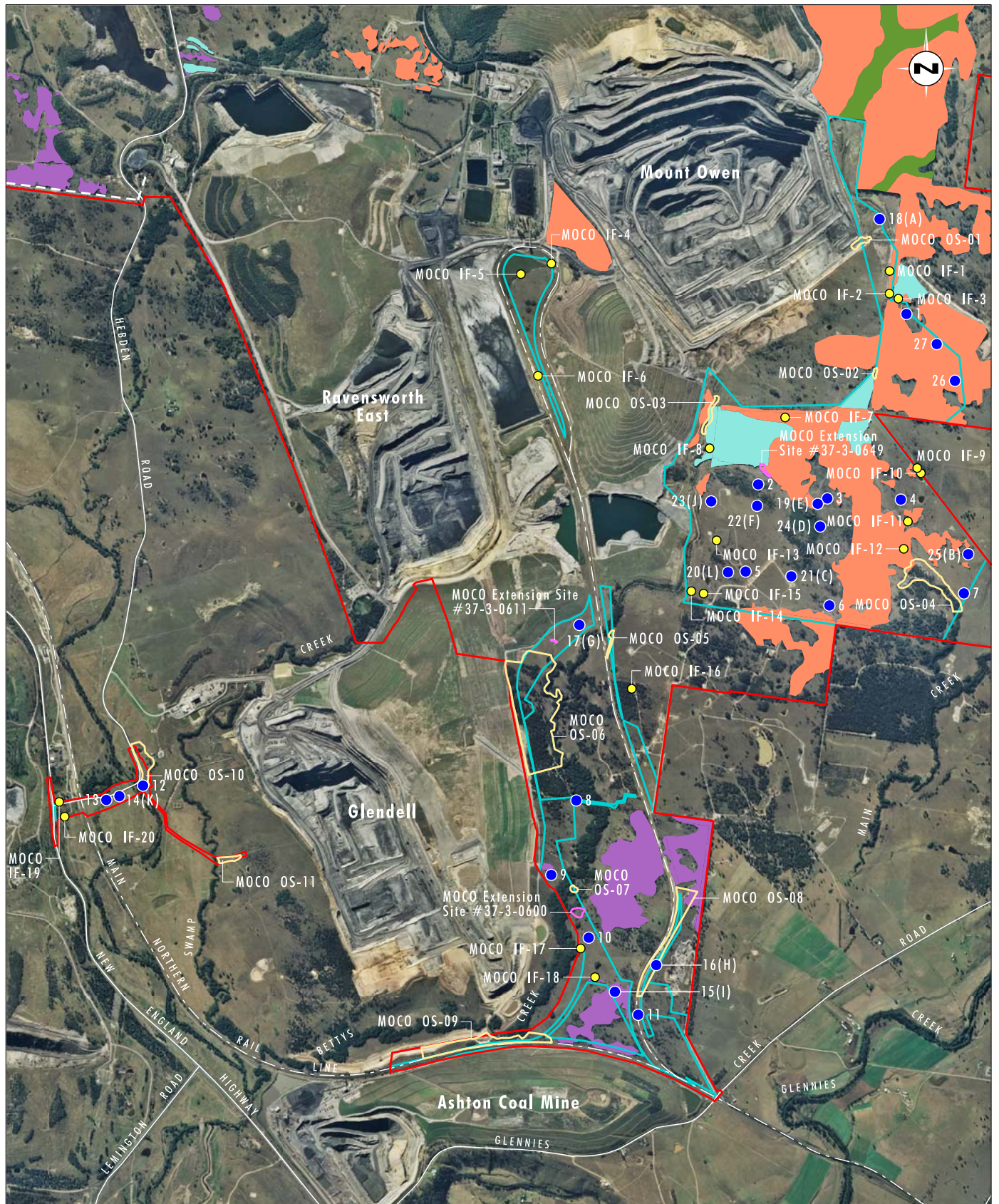


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014), OzArk (2013)

0 0,5 1,0 2,0 km
1:40 000

Legend

- | | |
|---|---|
| Project Area | Central Hunter Grey Box - Ironbark Woodland (EEC) |
| Proposed Disturbance Area | Hunter Lowlands Red Gum Forest (EEC) |
| Artefact Scatter | Planted Ironbark - Spotted Gum - Grey Box Forest (EEC) |
| Extensions to Previously Recorded Sites | Central Hunter Ironbark - Spotted Gum - Grey Box Forest (EEC) |
| ● Isolated Find | |
| ● Soil Sampling Site | |

File Name (A4): R08/APPI/3109_821.dgn
20140829 13.00

FIGURE 2.3
Soil Sampling
Areas of Exclusion

The Proposed Disturbance Area covers three soil landscapes, the Hunter, Bayswater and Liddell Soil Landscapes (Kovac and Lawrie 1991). The small area of the Liddell Soil Landscape on the western edge of the Hebden Road upgrade site was excluded from sampling due to significant disturbance of the site in association with the New England Highway, the Main Northern Railway Line and the Ravensworth Village (refer to **Figure 2.3**).

Table 2.2 – Soil Survey Observations and Density

Proposed Disturbance Area	Area (ha)	Soil Landscape, Land and Soil Capability (LSC) Class (Desktop)	Shallow Shovel Pit Sites	Number of Soil Auger Sites	Number of Laboratory Analysis Sites (includes samples from auger sites and shallow shovel pits)	Number of Mapping Observation Sites
Hebden Road Upgrade	13.1	Hunter, Liddell LSC Class 3	2 12, 13	1 Site 14 (K)	3 Sites 12 to 14 (K)	3
Rail Spur Extension	91.4	Bayswater LSC Class 4 and 5	4 8, 9, 10, 11	3 Sites 15 (I) - 17 (G)	5 Sites 8-11, 17 (G)	3
North Pit Continuation	380.5	Bayswater LSC Class 4 to 7	7 1-7	10 Sites 18 (A) - 27	13 Sites 1-7, 22 (F) - 27	4
TOTAL	485	-	13	14	21	9

2.3.2 Detailed Soil Profile Descriptions

Soil cores were dug with a 100 millimetre hand auger to approximately 750 millimetres, or to bedrock if shallower, and were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST 2009). Detailed soil profile morphological descriptions recorded the parameters specified in **Table 2.3**. All soil profiles were recorded on standard Soil and Land Information System (SALIS)² forms and have been submitted to the SALIS database. Copies of all soil record forms can be provided if required.

² SALIS provides descriptions of soils, landscapes and other geographic features and is used to improve planning and decision-making related to land management.

Table 2.3 – Soil Profile Description Parameters

Descriptor	Application
Horizon depth	Weathering characteristics, soil development, fertility
Field colour	Permeability, aeration, susceptibility to dispersion / erosion
Mottles – presence, colour	Permeability, aeration
Field texture – A and B horizon	Erodibility, hydraulic conductivity, permeability, water holding capacity, root penetration
Horizon boundary distinctness	Erosional/depositional status, textural grade, identification of Australian Soil Classification
Consistence force	Structural stability, dispersion, ped formation
Structural pedality grade	Soil structure, root penetration, permeability, aeration
Ped type and size	Soil structure, root penetration, permeability, aeration
Gravel – presence, quantity, size	Water holding capacity, erosional/depositional character, permeability, root penetration
Field pH – A and B horizon	Identification of Australian Soil Classification
Roots – presence, depth	Effective rooting depth

2.3.3 Soil Laboratory Assessment

A total of 21 topsoil samples (0 to 10 centimetres) and 19 subsoil samples (approx 20 to 30 centimetres) were collected for analysis by the NATA accredited Soil Conservation Service Laboratory at the Scone Research Centre. A range of physical and chemical tests to characterise the inherent fertility, stability/erodibility, salinity and pH of the soils were undertaken.

The tests conducted are outlined in **Table 2.4**. These tests have also informed the classification of the soils based on the Australian Soil Classification which requires characterisation of both the A and B horizons of the soil, particularly in the case of duplex soil types. The samples chosen for laboratory analysis were representative of the different soil types encountered while soil coring.

Table 2.4 – Laboratory Analysis Tests

A Horizon (0-10 cm) – Sites 1 to 13	B Horizon (10-20cm) – Sites 1 to 11 and 13
pH (water and CaCl ₂)	pH (water and CaCl ₂)
Cation Exchange Capacity (me/100g)	
Exchangeable Sodium, Potassium, Calcium, Magnesium, Aluminium (me/100g)	
Available Phosphorus (mg/kg)	
Emerson Aggregate Test	Emerson Aggregate Test
Texture	Texture
A Horizon (0-10cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 25 (B), 26 and 27	B2 Horizon (approx 20-30 cm) – Sites 14 (K), 17 (G), 18 (A), 22 (F), 23 (J), 24 (D), 26 and 27
All tests as above plus:	All tests as above plus:
Organic Carbon (Walkley Black)	Cation Exchange Capacity and Exchangeable Cations (me/100g)

NB: The Walkley Black test for Organic Carbon was used following consultation with staff of DPI.

The Certified Analyses of the soil samples are provided in **Appendix AA**. The Exchangeable Sodium Percentage (ESP) and the Calcium:Magnesium Ratio were calculated from the test results also provided in **Appendix AA**.

2.3.4 Mapping Observations

Mapping observations consisted of:

- examining existing exposed cuttings of soil profiles including eroded gullies, track cuts and pipeline cuts; and
- surface observations located between full profile description sites.

In addition, observations of landform, vegetation and rock outcrops were made to confirm soil mapping boundaries.

2.4 Soil Classification

The Australian Soil Classification (ASC) system (Isbell 1996) and nomenclature was used for identifying and naming the soils in this survey.

3.0 Soil Survey Results

Four different soil types were identified in the Proposed Disturbance Area. **Figures 3.1, 3.2 and 3.3** illustrate the distribution of the three soil types across the Proposed Disturbance Area.

Rudosols associated with the Hunter soil landscape are the dominant soil type in the Hebden Road upgrade section of the Proposed Disturbance Area. Rudosols also occur in the south-eastern part of the Proposed Disturbance Area associated with the tributaries of Main Creek. Sodosols associated with the Bayswater Soil Landscape are the dominant soil types in the Rail Spur extension and North Pit extension Proposed Disturbance Areas. There is also an area of Kurosols along the eastern edge of the North Pit Continuation area. **Table 3.1** summarises the areas occupied by each soil type. Overall, the Proposed Disturbance Area is dominated by Brown Sodosol soils.

Table 3.1 – Overview of Soil Types in the Proposed Disturbance Area

Soil Type		Soil Landscape	Land Area	
			Hectares	Percentage (%)
1	Stratic Rudosol	Hunter, Bayswater	15.8	3.2
2	Clastic Rudosol	Hunter, Bayswater	2.7	0.6
3	Brown Sodosol	Bayswater	461.8	95.2
4	Brown Kurosol	Bayswater	4.7	1.0
Total			485	100

Representative soil samples for each soil type are described in **Sections 3.1, 3.2, 3.3 and 3.4**.

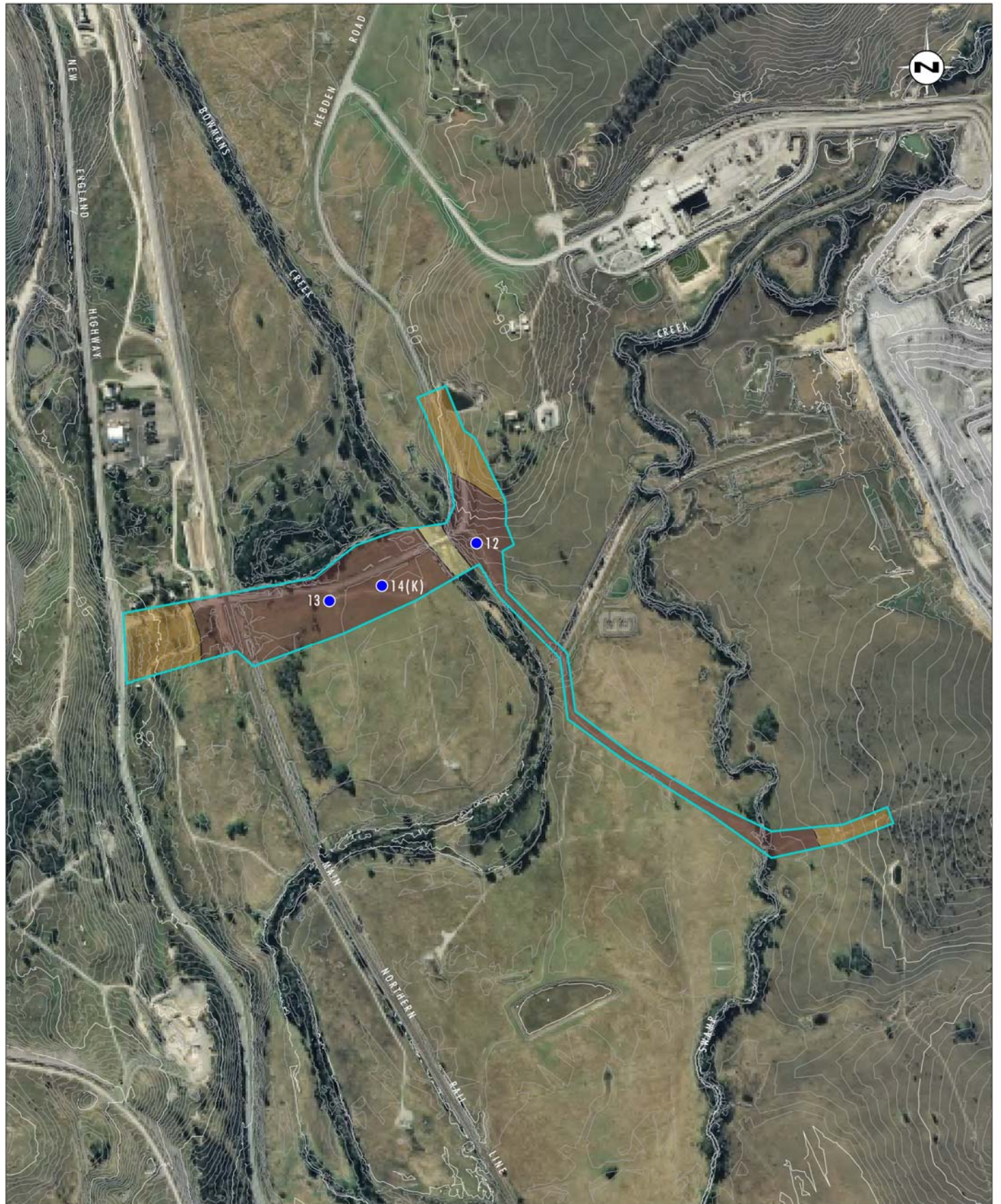


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 100 250 500m
1:10 000

Legend

- Proposed Disturbance Area
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

FIGURE 3.1

Proposed Hebden Road
Upgrade Works Area - Soil Types

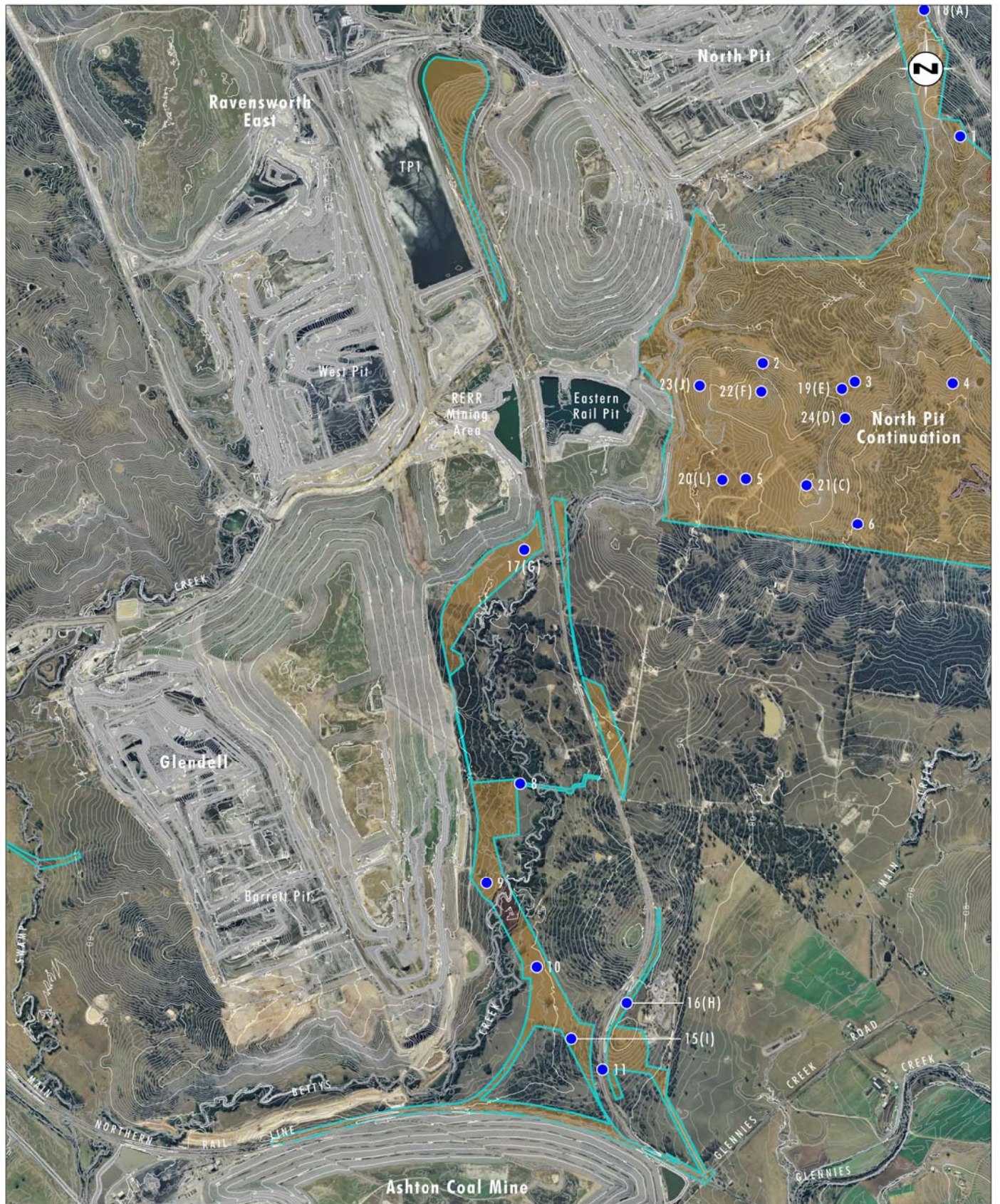


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.5 1.0 1.5 km
1:30 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Stratic Rudosol
- Soil Sampling Site

File Name (A4): R08/APP/3109_801.dgn
20140926 10.01

FIGURE 3.2

Proposed Rail Upgrade
Works Area - Soil Types

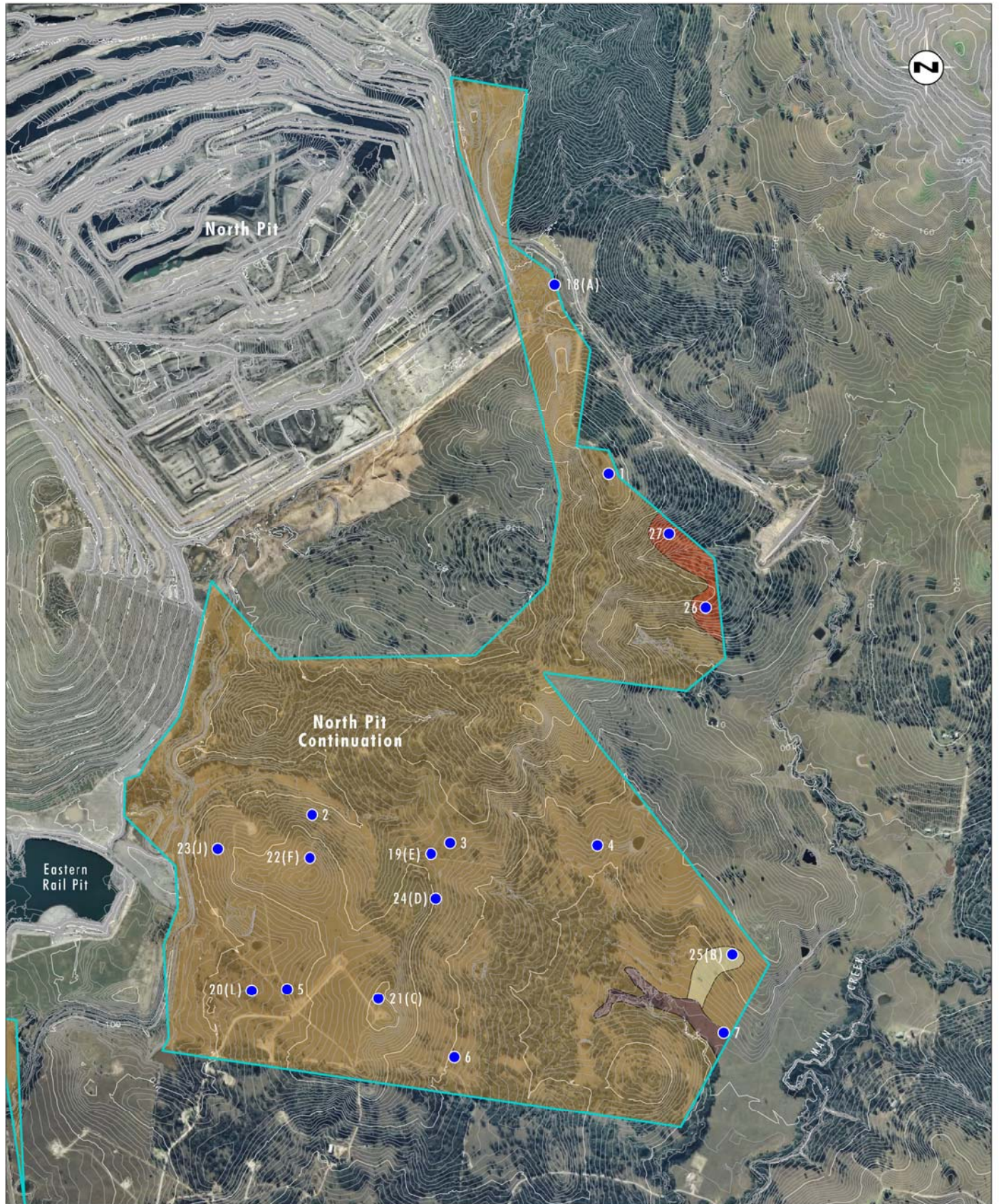


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.25 0.5 1.0 km
1:20 000

Legend

- Proposed Disturbance Area
- Brown Kurosol
- Brown Sodosol
- Clastic Rudosol
- Stratic Rudosol
- Soil Sampling Site

File Name (A4): R08/APP/3109_800.dgn
20140808 9.22

FIGURE 3.3

Proposed North Pit
Continuation Area - Soil Types

3.1 Soil Type 1 – Stratic Rudosol

Table 3.2 summarises the profile characteristics of Stratic Rudosol soils in the Proposed Disturbance Area. Stratic Rudosols cover approximately 15.8 hectares of the Proposed Disturbance Area. These soils are young depositional alluvial soils associated with the Bowmans Creek terrace in the west of the Proposed Disturbance Area (Hebden Road upgrade) and the drainage lines draining into Main Creek in the south-eastern part of the Proposed Disturbance Area (North Pit extension).

The soil profile is characterised by well drained, weakly structured fine sandy loam topsoil with little differentiation through to the subsoil. The pH is neutral throughout the soil depth, the topsoil is non-saline, non-sodic and has a low to moderate Cation Exchange Capacity. The Land and Soil Capability Class is 4 (refer to **Section 4.0**). This is because the pH of the profile meets the criteria for Class 4 with the local rainfall and soil texture, with the most limiting hazard being soil acidity.

From other observations on the Bowmans Creek terraces, stratified gravels occur at depth in the alluvial deposits.

Plate 3.1 illustrates the soil forming materials in the Stratic Rudosol soil type at Site 14 (K).

Plate 3.2 illustrates the landscape context of this soil type at Site 14 as an example. **Figure 2.3** illustrates the location of Site 14 (K).



PLATE 3.1
Soil Forming Materials in the Stratic Rudosol Soil at Site 14 (K)



PLATE 3.2
Landscape Context of the Stratic Rudosol Soil at the Site 14 (K)

Table 3.2 – Stratic Rudosol description from the Proposed Disturbance Area

Typical Site Description												
Australian Soil Classification Order and Suborder			Stratic Rudosol									
Soil Landscape Unit			Hunter									
Slope Class			0 – 5 %									
Landscape position			Flat Creek Terrace									
Field sites			7, 13, 14 (K)									
LSC Class			Class 4; Refer to LSC Guidelines - Table 12. pH in CaCl2 with Hunter rainfall and site surface texture is within the range for Class 4.									
Physical Characteristics Site 14 (K)												
Horizon		Depth (m)		Description								
A1		0 - 0.15		Brown fine sandy loam; weak structure; 2-5 mm crumb peds with moderately weak consistence; neutral pH (6.5); rapidly drained; no gravel; no mottles; diffuse boundary; few fine roots present.								
B1		0.15 – 0.55		Brown fine sandy loam; weak structure; 5-10 mm sub- angular blocky peds with moderately weak consistence; neutral pH (6.5), rapidly drained, no gravel; no mottles, gradual boundary, few medium roots.								
B2		0.55 - >0.75		Brown fine sandy loam; weak structure; 5-10 mm sub-angular blocky peds with moderately weak consistence; neutral pH (6.5); rapidly drained, no gravel; no mottles; no roots. Based on other studies on these terraces, stratified creek gravels are known to occur at depth in the alluvial deposit.								
Soil Chemical Characteristics:												
Method		C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2	
Sample Id		EC (dS/m)	pH	pH (CaCl2)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 14 (K) Horizon A		0.03	6.9	5.8	11.0	0.3	0.8	5.2	2.2	<0.3	4	2.89
Site 14 (K) Horizon B		0.01	7.1	5.7	12.4	0.4	0.2	6.6	2.9	nt	nt	nt
Method		P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id		EAT	clay	silt	f sand	c sand	gravel	Texture				
Site 14 (K) Horizon A		3(1)	13	15	48	22	2	sandy loam				
Site 14 (K) Horizon B		3(1)	nt	nt	nt	nt	nt	sandy loam				

3.2 Soil Type 2 – Clastic Rudosol

Table 3.3 summarises the characteristics of Clastic Rudosol soils in the Proposed Disturbance Area. Clastic Rudosols cover 2.7 hectares of the Proposed Disturbance Area and are young depositional soils associated with Bowman's Creek and tributaries of the Main Creek. The soil profile is characterised by well drained, moderately structured sandy loam topsoil overlying a gravel layer which is overlying a massive clay.

The pH is neutral to slightly acid throughout the soil depth, the topsoil is non-saline, non-sodic and has a moderately low Cation Exchange Capacity. The Land and Soil Capability Class is 7 with the most limiting hazard being soil depth due to the gravel layer (refer to **Section 4.0**).

Plate 3.3 illustrates the soil forming materials in a Clastic Rudosol in the Proposed Disturbance Area at Site 25 (B).

Plate 3.4 illustrates the landscape context of the Clastic Rudosol, based on the example at Site 25 (B). **Figure 2.3** shows the location of Site 25 (B).

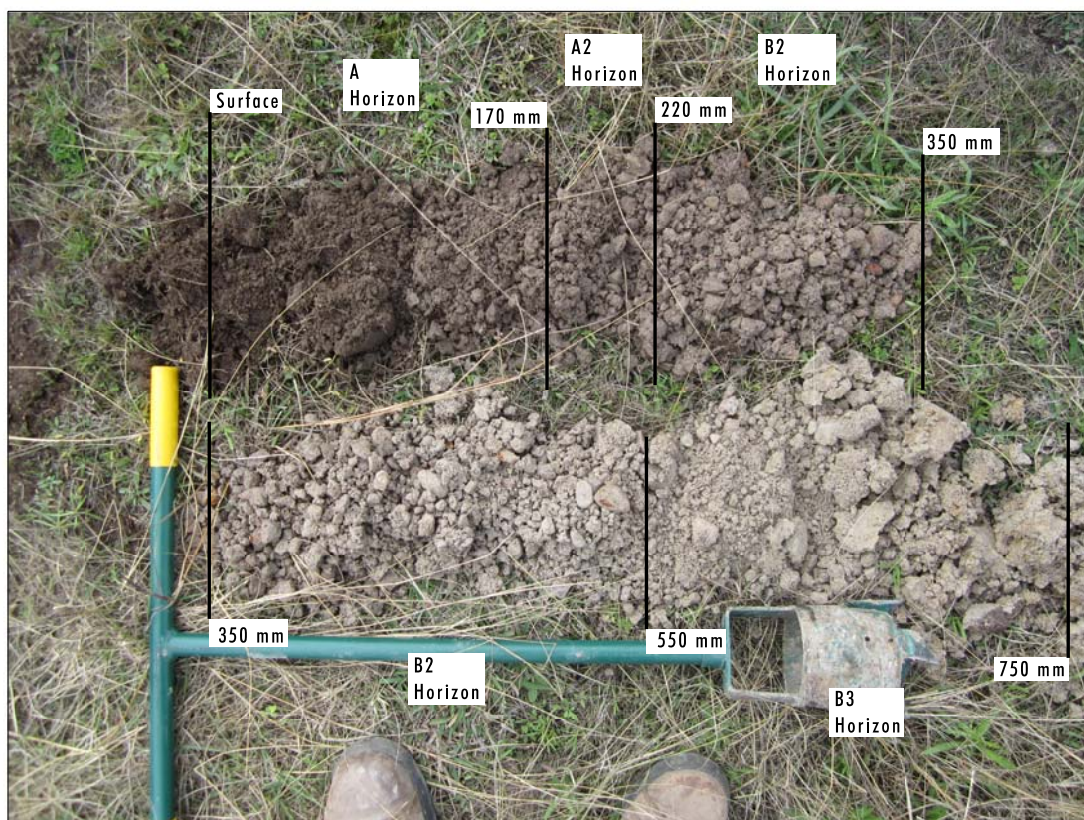


PLATE 3.3
Soil Forming Materials in the Clastic Rudosol Soil at Site 25 (B)



PLATE 3.4
Landscape Context of the Clastic Rudosol Soil at Site 25 (B)

Table 3.3 – Clastic Rudosol description from the Proposed Disturbance Area

Typical Site Description											
Australian Soil Classification Order and Suborder				Clastic Rudosol							
Soil Landscape Units				Hunter, Bayswater							
Slope Class				0 – 5 %							
Landscape position				Flat floodplain (exposed in the bank), colluvial deposit on lower slope							
Field sites				12, 25(B)							
LSC Class				Class 7; main limitation – soil depth due to gravel layer							
Physical Characteristics Site 25 (B)											
Horizon	Depth (m)	Description									
A1	0 - 0.17	Brown loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; neutral pH (6.0); rapidly drained; no gravel; no mottles; abrupt boundary; common fine roots present.									
A2	0.17 – 0.22	Brown fine sandy loam; moderate structure; 2-5 mm sub- angular blocky peds with moderately firm consistence; slightly acid pH (5.5), rapidly drained; 20–50% sub-rounded gravel (6-20mm); no mottles, gradual boundary, common fine roots.									
Gravel layer	0.22 – 0.55	Brown medium clay; slightly acid pH (5.5); rapidly drained; 50-90% sub-rounded gravel (20-60mm); no mottles; gradual boundary; no roots.									
B2/B3	0.55 - >0.75	Grey heavy clay; massive structure; slightly acid pH (5.5); very slow drainage; <2% gravel; 2-10% distinct orange mottles; no roots.									
Soil Chemical Characteristics											
Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)						C8A/3	C6A/2
Sample Id	EC (dS/m)	pH	pH (CaCl2)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 25 (B) Horizon A	0.02	5.9	4.9	7.2	0.2	0.1	3.5	1.3	0.4	3	1.91
Method	P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id	EAT	clay	silt	f sand	c sand	gravel			Texture		
Site 25 (B) Horizon A	5	10	17	31	30	12			sandy loam		

3.3 Soil Type 3 – Brown Sodosol

Table 3.4 summarises the characteristics of Sodosol soils in the Proposed Disturbance Area. Sodosols cover 461.8 hectares of the Proposed Disturbance Area and are associated with the undulating Bayswater Soil Landscape.

These soils have well drained sandy loam to loam topsoils with a strong texture contrast at 0.2 to 0.35 metres to a poorly drained, strongly structured sodic clay B horizon which is not strongly acidic. The soils are neutral to slightly acidic throughout the profile, the cation exchange capacity is low to moderate, the soils are non-saline and slightly to extremely sodic in the topsoil and strongly sodic in the subsoil.

The Emerson Aggregate tests indicate the soils (both topsoils and subsoils) are dispersible and hence prone to water erosion, with the hazard increasing in the subsoil. The Land and Soil Capability Classes range from 4 to 7 depending on the site. The main hazards are soil structure decline, soil acidity (low pH in the topsoil and subsoil) and soil depth.

Plate 3.5 illustrates the soil materials in the Brown Sodosol profile at Site 24 (D).

Plate 3.6 illustrates the landscape context of the Brown Sodosol soil at Site 24 (D). **Figure 2.3** illustrates the location of site 24 (D).

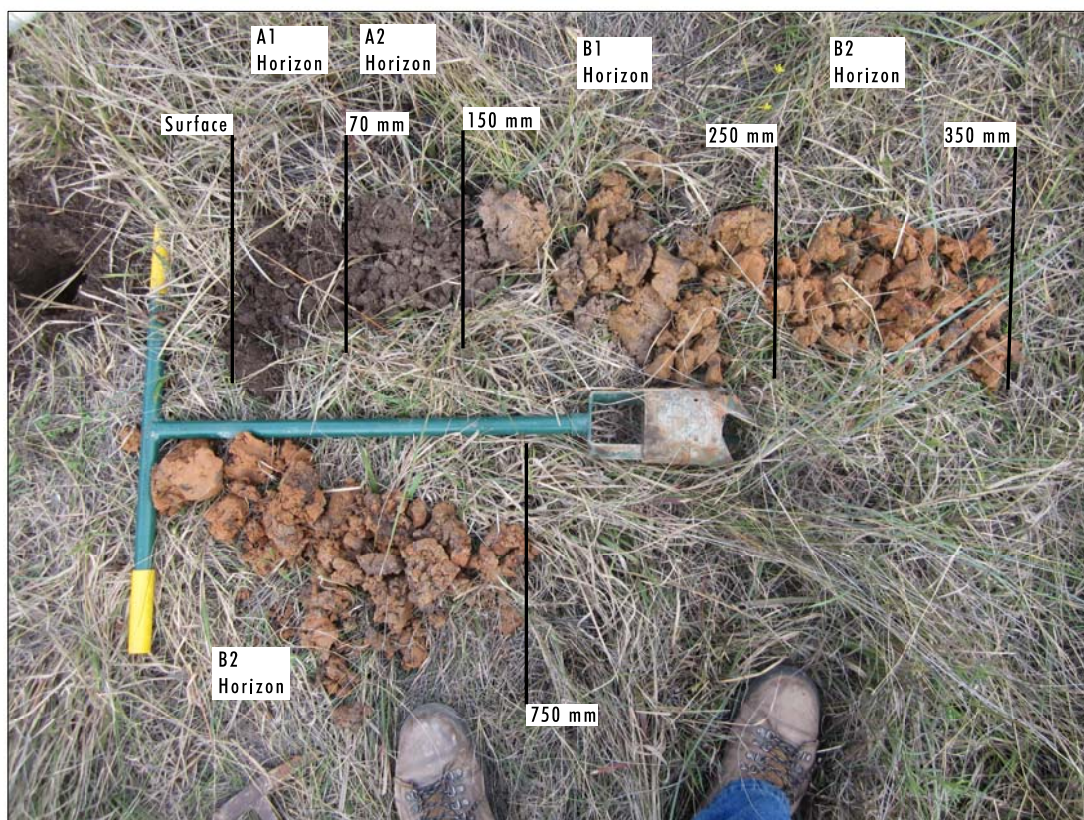


PLATE 3.5
Soil Forming Materials in the Brown Sodosol Soil at Site 24 (D)



PLATE 3.6
Landscape Context of the Brown Sodosol Soil at Site 24 (D)

Table 3.4 – Brown Sodosol description from the Proposed Disturbance Area

Typical Site Description												
Australian Soil Classification Order and Suborder			Brown Sodosol									
Soil Landscape Unit			Bayswater									
Slope Class			0–5 %, 5-10%									
Landscape position			Undulating, ranging from crest to lower slope									
Field sites			1-6, 8-11, 15 (I), 16 (H), 17 (G), 18 (A), 19 (E), 20 (L), 21 (C), 22 (F), 23 (J), and 24 (D)									
LSC Classes			Class 4-7; main limitations – soil structure decline, soil acidification and soil depth in some locations									
Physical Characteristics Site 24 (D)												
Horizon		Depth (m)	Description									
A1		0 - 0.07	Black /brown loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5); rapidly drained; no gravel; no mottles; sharp boundary; common fine roots and few medium roots present.									
A2		0.07 – 0.15	Grey fine sandy clay loam; moderate structure; 2-5 mm sub-angular blocky peds with moderately firm consistence; slightly acid pH (5.5), rapidly drained; common sub-rounded coarse gravel; no mottles; clear boundary, common fine roots and medium roots present.									
B1		0.15 – 0.25	Brown heavy clay; massive structure with moderately strong consistence; slightly acid pH (5.5); very slow drainage; no gravel; 2-5% distinct dark mottles; few fine roots and no medium roots.									
B2		0.25 - >0.75	Brown heavy clay; massive structure with moderately strong consistence; very slightly acid pH (6.0); very slow drainage; no gravel; 20-50% distinct dark mottles; no roots									
Soil Chemical Characteristics												
Method		C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2	
Sample Id		EC (dS/m)	pH	pH (CaCl2)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 24 (D) Horizon A		0.04	5.7	4.7	10.5	<0.1	0.6	3.7	3.3	0.4	1	2.72
Site 24 (D) Horizon B		0.28	5.9	4.8	25.7	3.4	0.6	2.1	17.0	<0.3	nt	nt
Method		P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id		EAT	clay	silt	f sand		c sand		gravel	Texture		
Site 24 (D) Horizon A		5	14	20	40		20		6	sandy loam		
Site 24 (D) Horizon B		2(3)	nt	nt	nt		nt		nt	medium clay		

3.4 Soil Type 4 – Brown Kurosol

Table 3.5 summarises the characteristics of Kurosol soils in the Proposed Disturbance Area. Kurosols cover approximately 4.7 hectares of the Proposed Disturbance Area and are associated with the undulating Bayswater Soil Landscape.

These soils have reasonably well drained sandy loam to clay loam topsoils, including a bleached and weakly structured fine sand A2 horizon, with a strong texture contrast at 0.05 to 0.25 metres to a poorly drained, strongly structured sodic clay B horizon which is also strongly acidic. The soils are moderately to strongly acidic at the surface becoming more acid with depth with high Aluminium levels, the cation exchange capacity is moderate, increasing with depth as the clay content increases. The soils are non-saline and moderately sodic in the topsoil increasing to strongly sodic in the subsoil. It is noted that there is very little difference between the Brown Sodosol and Brown Kurosol soil types, with Sites 26 and 27 being determined Brown Kurosol due their having a slightly more acidic B-horizon.

The Emerson Aggregate tests indicate the soils (both topsoils and subsoils) are either stable or mildly dispersible when wet, with the hazard increasing in the subsoil. The high aluminium is likely to offset the impact of the high sodium levels in the subsoils. The Land and Soil Capability Classes range from 4 to 5 depending on the site. The main hazards are water erosion, soil acidity (low pH in the topsoil and subsoil), waterlogging and soil depth.

Plate 3.7 illustrates the soil materials in the Brown Kurosol profile at Site 26.

Plate 3.8 illustrates the landscape context of the Brown Kurosol soil at Site 26. **Figure 2.3** illustrates the location of site 26.

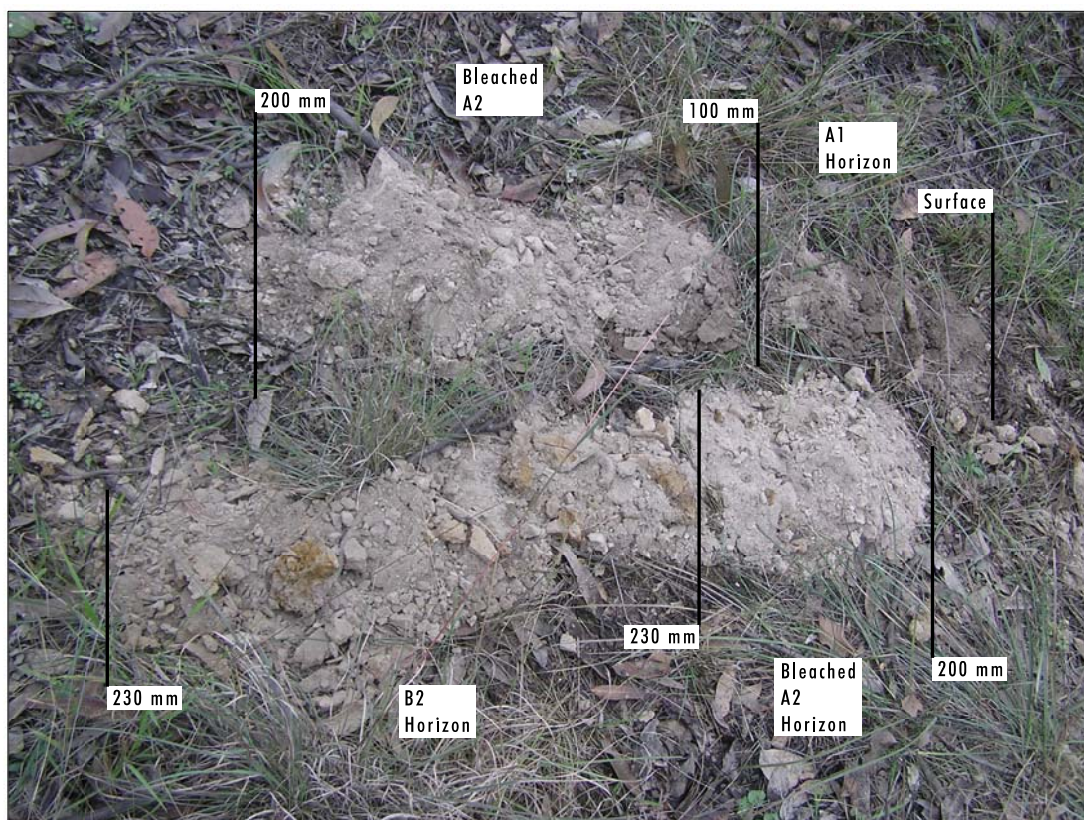


PLATE 3.7
Soil Forming Materials in the Brown Kurosol Soil at Site 26



PLATE 3.8
Landscape Context of the Brown Kurosol Soil at the Site 26

Table 3.5 – Brown Kurosol description from the Proposed Disturbance Area

Typical Site Description												
Australian Soil Classification Order and Suborder		Brown Kurosol										
Soil Landscape Unit		Bayswater										
Slope Class		0–5 %, 5-10%										
Landscape position		Undulating, ranging from crest to lower slope										
Field sites		26, 27										
LSC Classes		Class 4-5; main limitations – water erosion, soil acidification, waterlogging and soil depth in some locations										
Physical Characteristics Site 24 (D)												
Horizon	Depth (m)	Description										
A1	0 - 0.1	Brown sandy loam; weak structure; 1-2 mm sub-angular blocky peds with moderately weak consistence; moderately acid pH (5.0); rapidly drained; no gravel; no mottles; abrupt boundary; common fine and medium roots present.										
A2	0.1 – 0.23	Pale fine sand; moderate structure; 10-20 mm sub-angular blocky peds with moderately firm consistence; rapidly drained; no gravel; no mottles; abrupt boundary, few fine and medium roots present.										
B1	0.23 – 0.30 Profile continued deeper but too dry to sample	Brown heavy clay; moderate structure: 20-50mm sub angular blocky peds with firm consistence; strongly acid pH (4.5); very slow drainage; no gravel; 2-10% distinct orange mottles; few fine and medium roots.										
Soil Chemical Characteristics												
Method		C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)					C8A/3	C6A/2	
Sample Id		EC (dS/m)	pH	pH (CaCl2)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
Site 26 Horizon A		0.06	6.1	5	9.6	0.3	0.4	4.6	3	1.8	2	2.07
Site 26 Horizon B		0.19	5.5	4.5	14.2	1.9	0.3	2.5	8.4	2.6	nt	nt
Method		P9B/2	P7B/2 Particle Size Analysis (%)									
Sample Id		EAT	clay	silt	f sand	c sand	gravel	Texture				
Site 26 Horizon A		8	10	15	46	29	<1	sandy loam				
Site 26 Horizon B		2(1)	nt	nt	nt	nt	nt	heavy clay				

4.0 Land and Soil Capability Assessment

Land capability is the inherent physical capacity of the land to sustain a range of land uses and management activities in the long term without degradation to soil, land, air and water resources. The OEH have developed a system to assess land and soil capability (LSC) in NSW described in the *Land and Soil Capability Assessment Scheme, Second Approximation* (OEH 2012) known as the LSC Guideline.

The scheme uses biophysical features of the land as well as the management inputs required to manage the land sustainably to classify land into one of eight classes. The LSC classes are described in **Table 4.1**. Eight hazards are assessed for each land type and the overall LSC class is the most limiting hazard.

Table 4.1 - Land and Soil Capability Classes – General Definitions

LSC Class	General Description
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
LSC Class 1	Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
LSC Class 2	Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
LSC Class 3	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
LSC Class 4	Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
LSC Class 5	Moderate–low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.

Table 4.1 - Land and Soil Capability Classes – General Definitions (cont.)

LSC Class	General Description
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
LSC Class 6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
LSC Class 7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
LSC Class 8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

4.1 Land and Soil Capability Methodology

This section reviews the LSC class of soils in the Proposed Disturbance Area, using the results of field and laboratory tests. The LSC classes derived from this assessment are relevant at the Project scale, rather than the regional scale.

The biophysical features of landform position, slope, drainage, climate, soil type and characteristics have been used to identify the eight hazards that are assessed by the LSC scheme. The hazards are:

- water erosion;
- wind erosion;
- soil structure decline;
- soil acidification;
- salinity;
- waterlogging;
- shallow soils; and
- mass movement.

Each hazard is assessed against set criteria described in the LSC Guideline and ranked from 1 (least limiting) to 8 (most limiting) to determine the overall LSC ranking as the most limiting hazard.

The LSC classification has been applied to the Proposed Disturbance Area in accordance with the LSC Guideline. **Table 4.2** outlines the criteria for assessing each hazard considered.

The LSC classes for each soil sampling site are detailed in **Table 4.3**.

Table 4.2 – Criteria for assessing LSC Class

Hazard	Criteria
Hazard 1: Water Erosion	The water erosion hazard is largely based on the location of the site and slope. The presence of sodic/dispersible soils or gully erosion influences the LSC class on 10 to 20 per cent slopes. The Proposed Disturbance Area is in the Eastern and Central Division of NSW. Slopes across the Proposed Disturbance Area range from 0 to 5 per cent, 5 to 10 per cent and > 10 per cent and are less than 500 metres long. Water erosion is a low risk hazard across the majority of the Proposed Disturbance Area.
Hazard 2: Wind Erosion	There are four factors used to determine the level of wind erosion hazard. Three of these factors were assessed to be consistent across the Proposed Disturbance Area. • The wind erosive power has been mapped as 'moderate' (The NSW Wind Atlas). • The average annual rainfall of the Project Area is in the >500 millimetres class. • The exposure of the Project site was determined to be 'moderate' across the Proposed Disturbance Area. The determining factor with regard to the wind erosion hazard was the surface soil texture according to the LSC Guideline.
Hazard 3: Soil Structure Decline	To assess the structure, stability and resilience of the soil, the LSC classification assesses the soil structure decline hazard using the criteria of: • surface soil texture; • surface soil sodicity; and • degree of self mulching. The calculated Exchangeable Sodium Percentage (ESP) (refer to Appendix 1) has been used to assess the surface soil sodicity according to the LSC guidelines where: • ESP < 3 per cent is very low, • ESP 3 to 5 per cent is low; • ESP 5 to 8 per cent is moderate; • ESP 8 to 15 per cent is high; and • ESP >15 per cent is very high.
Hazard 4: Soil Acidification Hazard	The soil acidification hazard is assessed using three criteria: • soil buffering capacity (based on Great Soil Groups, surface soil texture or geology of parent material); • pH of the surface soil; and • mean annual rainfall. The Great Soil Groups were used to determine soil buffering capacity and the Project site falls in the 550 to 700 millimetres mean annual rainfall category. The pH of the surface soils was measured in the laboratory.
Hazard 5: Salinity	The salinity hazard requires an estimation of the recharge potential, the discharge potential and the soil salt store for the site. At the Project site the mean annual evaporation rate is over twice as high as the mean annual rainfall (BOM 2013) which indicates that the recharge potential of the site was low. The discharge potential varies depending on the landscape position and was assessed as moderate. The soil salt store is mapped as low and this is confirmed by laboratory EC measurements of the soil samples.

Table 4.2 – Criteria for assessing LSC Class (cont.)

Hazard	Criteria
Hazard 6: Waterlogging hazard	Waterlogging hazard is assessed on the drainage potential of the soil as well as the duration and return period of waterlogging events. Field evidence of drainage and waterlogging including soil texture, presence of mottles and vegetation features such as the presence of wet area plants (e.g. rushes) were assessed.
Hazard 7: Shallow Soils and Rockiness	The shallow soils hazard is assessed on the level of rock outcropping in combination with the depth of soil. Gravel layers at some sites limited the effective rooting depth.
Hazard 8: Mass Movement	The mass movement hazard is assessed through a combination of three criteria: • mean annual rainfall; • presence of mass movement; and • slope class.

4.2 Land and Soil Capability Assessment

The Proposed Disturbance Area has been assessed in detail for the Land and Soil Capability of each soil sampling point (refer to **Table 4.3**). The classes are mapped on **Figure 4.1, 4.2** and **4.3**. The LSC was assessed on a site basis rather than a soil type basis as there were site specific differences in factors such as slope, landscape position and soil characteristics that impacted on LSC Classes. In **Table 4.3**, the orange shading indicates the most limiting factor, which defines overall LSC class.

Table 4.3 – Land and Soil Capability for Sampled Sites

Site No.	Soil type	Hazard Criteria								Overall class
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	
1	Sodosol	2	2	3	4	1	2	6	1	6
2	Sodosol	3	2	6	4	1	3	7	1	7
3	Sodosol	2	2	6	4	1	3	3	1	6
4	Sodosol	2	3	3	4	1	3	3	1	4
5	Sodosol	3	2	6	4	1	3	3	1	6
6	Sodosol	3	2	6	4	1	3	3	1	6
7	Rudosol	2	3	3	4	1	1	3	1	4
8	Sodosol	2	2	6	4	1	3	2	1	6
9	Sodosol	1	2	7	4	1	3	2	1	7
10	Sodosol	1	3	7	4	1	3	3	1	7
11	Sodosol	1	2	6	4	1	3	3	1	6
12	Rudosol	2	2	3	4	1	1	7	1	7
13	Rudosol	1	3	3	4	1	1	1	1	4



Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 100 250 500m
1:10 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/APP/3109_667.dgn
20140808 9.32

FIGURE 4.1

Proposed Hebden Road Upgrade Works Area
Land and Soil Capability

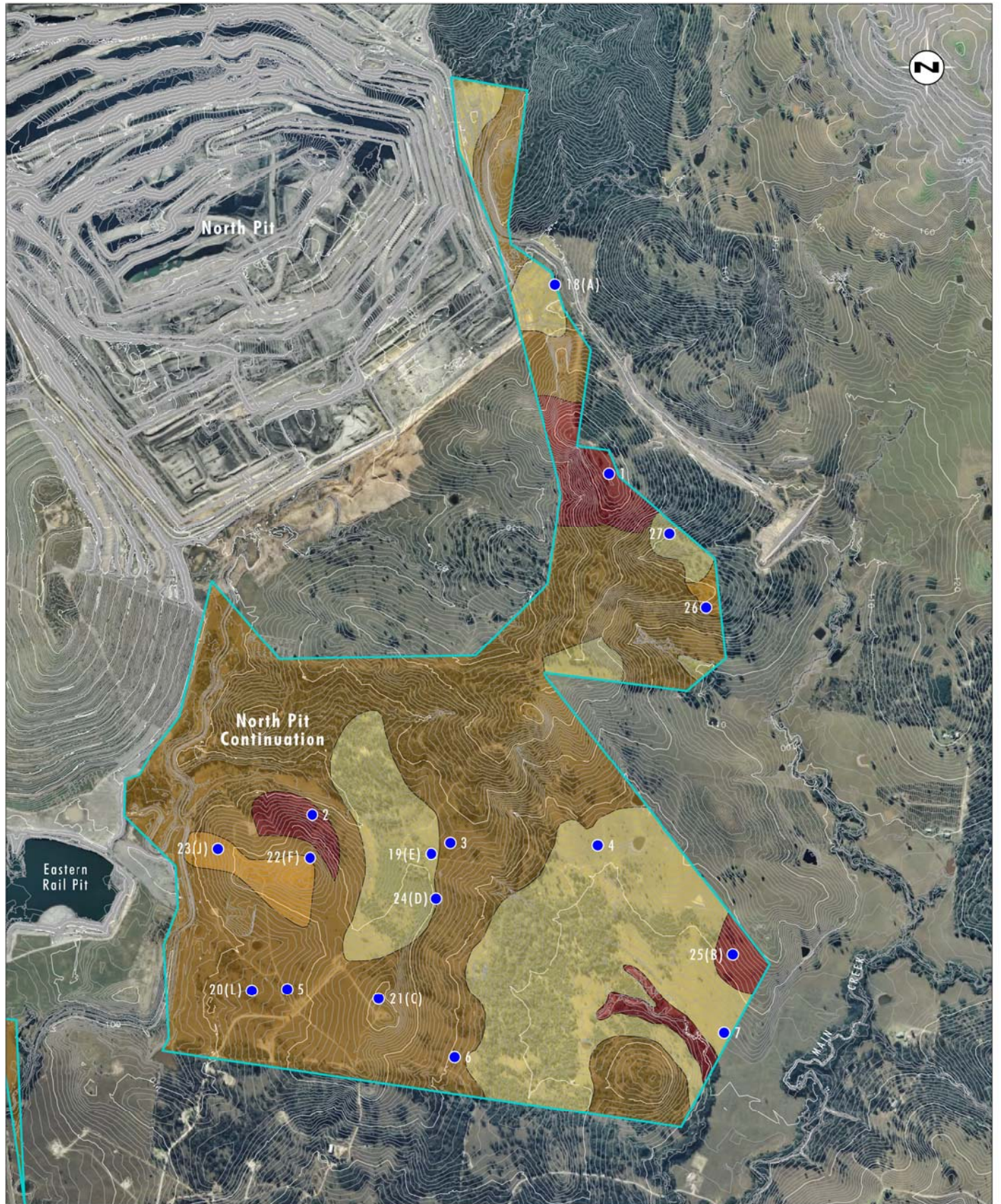


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.25 0.5 1.0 km
1:20 000

Legend

- Proposed Disturbance Area
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/APP/3109_802.dgn
20140808 9:30

FIGURE 4.2

Proposed North Pit Continuation Area
Land and Soil Capability

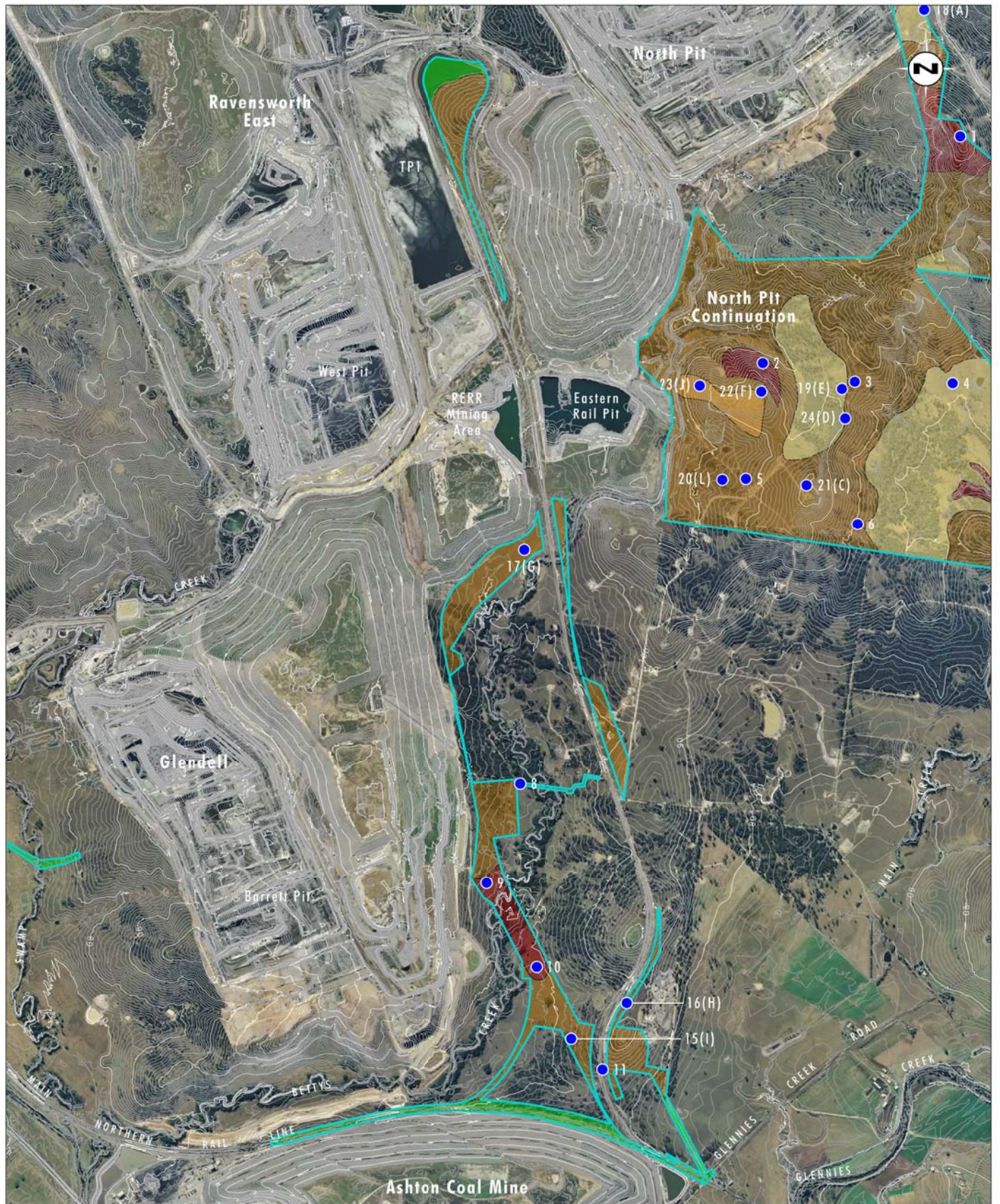


Image Source: Mount Owen (2013)
Data Source: Mount Owen (2014)
Note: Contour Interval 1m

0 0.5 1.0 1.5 km
1:30 000

Legend

- Proposed Disturbance Area
- Infrastructure Not Assessed
- LSC Class 4
- LSC Class 5
- LSC Class 6
- LSC Class 7
- Soil Sampling Site

File Name (A4): R08/APP/3109_803.dgn
20140805 13.40

FIGURE 4.3

Proposed Rail Upgrade Works Area
Land and Soil Capability

Table 4.3 – Land and Soil Capability for Sampled Sites (cont.)

Site No.	Soil type	Hazard Criteria								
		Water erosion	Wind erosion	Structure	Acidity	Salinity	Water-logging	Soil depth	Mass movement	Overall class
14 (K)	Rudosol	1	3	3	4	1	1	3	1	4
15 (I)	Sodosol	2	2	6	4	1	3	3	1	6
16 (H)	Sodosol	2	2	6	4	1	3	3	1	6
17 (G)	Sodosol	2	2	6	4	1	3	3	1	6
18 (A)	Sodosol	2	2	3	4	1	3	3	1	4
19 (E)	Sodosol	2	2	3	4	1	3	3	1	4
20 (L)	Sodosol	2	2	6	4	1	3	3	1	6
21 (C)	Sodosol	2	2	6	4	1	3	3	1	6
22 (F)	Sodosol	2	5	3	4	1	2	3	1	5
23 (J)	Sodosol	2	4	3	5	1	4	3	1	5
24 (D)	Sodosol	2	2	3	4	1	3	3	1	4
25 (B)	Rudosol	2	2	3	4	1	2	7	1	7
26	Kurosol	3	2	3	5	2	4	3	1	5
27	Kurosol	4	2	3	4	2	4	4	1	4

Land and Soil Capability Classes 4 to 7 occur in the Proposed Disturbance Area. The Proposed Disturbance Area is assessed as containing moderate through to very low capability land. The most common limitations were soil structure decline and soil acidification.

Overall, the verified LSC classes at the project scale are lower than the regional scale mapping of LSC indicated. LSC Class 6 is the most common in the Proposed Disturbance Area, but LSC Class 4 is also relatively common.

Table 4.4 presents the area and percentage of LSCS in each component of the Project Disturbance Area. **Figure 3.1, 3.2 and 3.3** illustrate these locations.

Table 4.4 - Land and Soil Capability Classes across the Proposed Disturbance Area

Proposed Disturbance Area Site	LSC Class	Area (ha)	Percentage of Site (%)
Hebden Rd Upgrade Sites 12, 13 and 14 (K)	4	4.0	30.5
	6	1.3	9.9
	7	0.5	3.8
	Infrastructure - not assessed	7.3	55.7
	TOTAL	13.1	100
Rail Spur Extension Sites 8, 9, 10, 11, 15 (I), 16 (H), 17 (G)	6	64.3	70.4
	7	8.7	9.6
	Infrastructure - not assessed	18.4	20
	TOTAL	91.4	100
North Pit Continuation Sites 1, 2, 3, 4, 5, 6, 7, 18 (A), 19 (E), 20 (L), 21 (C), 22 (F), 23 (J), 24 (D), 25 (B), 26 and 27	4	111.9	29.4
	5	8.9	2.3
	6	235.9	62.0
	7	23.8	6.3
	TOTAL	380.5	100

Further information regarding the capabilities and limitations of soil classes in the Proposed Disturbance Area is provided below.

Class 4 – This land is moderately capable of a range of land uses including grazing with pasture improvement, limited cropping with restricted cultivation and some horticulture. It has moderate to severe limitations that require specialist management practices or inputs to overcome and maintain sustainable productivity. There is widespread potential for soil acidification across the Proposed Disturbance Area due to soils with low buffering capacity and low surface pH. This limitation could be managed with the use of acid tolerant perennial pastures and/or the use of lime.

Class 5 – This land is moderate to low capability and can be used for grazing and permanent horticulture such as orchards. There are severe limitations for high impact agricultural practices.

Class 6 – This land is low capability and can be used for limited land uses such as grazing, forestry and nature conservation. There is widespread risk of soil structure decline across many of the Sodosol soils of the Proposed Disturbance Area. The majority of sites recorded moderate surface soil sodicity which would require maintenance of surface soil vegetation cover to prevent erosion and inputs of gypsum to effectively manage the sodium levels. The subsoils were also strongly sodic and prone to dispersion adding to the limitations of these soils.

Class 7 – This land is very low capability and should be used for conservation or selective forestry. The Class 7 land only occupies limited areas of the Proposed Disturbance Area where there are localised soil depth issues, including a gravel layer inhibiting rooting depth, and two sites, sites 9 and 10, with very high surface ESP levels that may have been affected by previous land management activities that has caused the topsoil to have been lost through sheet erosion.

5.0 Biophysical Strategic Agricultural Land

The Upper Hunter SRLUP (DP&I 2012b) has identified approximately 11 hectares of BSAL within the Project Area (refer to **Figure 1.3**). This land is mapped in association with the floodplain and low terraces along Bowman's Creek which will be impacted by the proposed upgrade of the Hebden Road. There are no Critical Industry Clusters within the locality of the Project.

Verification of the BSAL mapping was conducted across the entire Proposed Disturbance Area by assessing all soil sampling sites in accordance with both the criteria outlined in the Upper Hunter SRLUP. **Table 5.1** presents the criteria from the Upper Hunter SRLUP and the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (OEH and OASFS 2013).

Table 5.1 – Biophysical Strategic Agricultural Land Criteria Upper Hunter SRLUP and Interim OEH Protocol

Upper Hunter SRLUP Criteria
land that falls under soil fertility classes 'high' or 'moderately high' under the <i>Draft Inherent General Fertility of NSW</i> (OEH),
land capability classes I, II or III under the Land and Soil Capability Mapping of NSW (OEH),
- reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or - properties within 150m of 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 5L/s and total dissolved solids of less than 1,500mg/L.
OEH Interim Protocol
land that falls under soil fertility classes 'moderate' under the <i>Draft Inherent General Fertility of NSW</i> (OEH),
land capability classes I or II under the Land and Soil Capability Mapping of NSW (OEH),
- reliable water of suitable quality, characterised by having rainfall of 350mm or more per annum (9 out of 10 years); or - properties within 150m of 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 5L/s and total dissolved solids of less than 1,500mg/L.

Sections 5.1 and **5.2**, below, present the assessment against each. Both assessments determined there is no BSAL within the Project Disturbance Area

5.1 Biophysical Strategic Agricultural Land Assessment – Upper Hunter SRLUP

The minimum requirement for reliable rainfall was met across the Project site where mean annual rainfall is greater than 600 millimetres (BOM), therefore the LSC Class and the soil fertility were assessed for each soil type identified within the Proposed Disturbance Area. Results are presented in **Table 5.2**.

Table 5.2 – Applied BSAL Criteria- SRLUP Upper Hunter

Soil Type	LSC Class	Fertility*	BSAL	BSAL Limitation
Stratic Rudosol	4	Moderately low	No	LSC Class and fertility
Clastic Rudosol	7	Low	No	LSC Class and fertility
Brown Sodosol	4 to 7	Moderately low	No	LSC Class and fertility
Brown Kurosol	4 to 5	Moderately low	No	LSC Class and fertility

* Fertility correlated with ASC classes (OEH and OASFS2013).

Under the criteria of the Upper Hunter SRLUP the fertility classes and LSC classification failed to meet the criteria for BSAL across the Proposed Disturbance Area.

5.1.1 Verified Soil Fertility in the Proposed Disturbance Area

Each soil type was assessed on the basis of soil fertility factors as classified by the ASC. The Stratic Rudosol soils associated with the Bowman's Creek floodplain and terraces are classified as moderately low fertility and yet are mapped at a regional scale as probable BSAL. Soil testing undertaken in the field and the laboratory at Sites 13 and 14 (K) show the typical indicators of inherent soil fertility, including Cation Exchange Capacity (CEC), Particle Size Analysis/Texture, and Organic Carbon, reinforce the ASC classification. Cation Exchange Capacity is moderately low (10-11 meq/100g), Particle size analysis identifies a relatively low clay percentage (13 per cent) in a fine loamy sand and Organic Carbon (Walkley Black) is moderate (2.89 per cent). The surface pH (Ca Cl₂) is 5.6–5.8 and in combination with a low buffering capacity and mean annual rainfall between 550 and 700 millimetres indicates a potential acidification risk which is identified as LSC Class 4.

The Clastic Rudosols are classified as low fertility under the ASC. This is also reinforced by laboratory testing of Sites 12 and 25 (B) which measured a low CEC (7.2-7.4 meq/100gm), a low clay percentage (10 per cent) and a moderately low Organic Carbon (1.91 per cent). The surface pH (CaCl₂) is 4.9-5.0 and the buffering capacity of the soil is low, indicating a potential soil acidification risk. Further these soils are constrained by a 30 centimetres thick gravel layer within the root zone which effectively limits the depth of the soil and placing these soils in LSC Class 7.

The Brown Sodosols and Kurosols are classified as moderately low fertility under the ASC. The sites tested with the Proposed Disturbance Area had Cation Exchange Capacities ranging from low (2.8 meq/100gm) to high (35.6 meq/100gm) where the high values had high sodium levels and low Calcium to Magnesium ratios associated with them. Surface pH (CaCl₂) was generally below 5, surface soils had low clay percentages, low buffering capacity and moderately low Organic Carbon levels. LSC Classes ranged from 4 to 7 with the constraints relating to potential acidification and soil structural limitations.

The fertility classes and LSC classification fail to meet the criteria for BSAL across the Proposed Disturbance Area.

5.2 BSAL Assessment – Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land

This methodology identifies access to a reliable water supply and then uses a 12 step BSAL verification process, summarised in **Table 5.3**.

The site must meet all 12 criteria including being greater than 20 hectares in area to be assessed as BSAL. That is, if any of the conditions are not met, the site is rejected as BSAL and the remaining conditions are not assessed.

Table 5.3 – 12 Step Process for BSAL Verification

Step	Criteria	BSAL Definition
-	Reliable water supply	Reliable water of suitable quality, characterised by having rainfall of 350 millimetres or more per annum (9 out of 10 years)
1	Slope	Slope less than or equal to 10%
2	Rock outcropping	Less than 30% rock outcrop
3	Unattached rock fragments	Less than or equal to 20% of site has unattached rock fragments > 60 millimetres diameter
4	Gilgais	Less than or equal to 50% of the site has gilgais > 500 metre deep
5	Slope	Slope < 5% (If yes, go to 6, if no go to 7b)
6	Rock outcrop	Nil rock outcrop (if yes, go to 7a, if no got to 7b)
7a	Fertility	Soil has moderate fertility
7b	Fertility	Soil has moderately high or high fertility
8	Soil depth	Effective rooting depth to a physical barrier > 750 millimetres
9	Drainage	Drainage better than poor
10	pH	PH range from 4.5 to 8 in Calcium chloride in upper 600 millimetres
11	Salinity	Salinity less than or equal to 4 dS/m
12	Effective rooting depth	Depth to chemical barrier > 750 millimetres
13	Minimum area	Area greater than or equal to 20 hectares.

Under the interim protocol all soil types across the Proposed Disturbance Area failed to meet the criteria for BSAL based on soil fertility being low to moderately low.

Soil fertility is based on the relative fertility of the Australian Soil Classification classes listed in Appendix 2 of the Interim Protocol for the Site Verification and Mapping of Biophysical Strategic Agricultural Land (OEH and OASFS 2013). Based on laboratory testing the fertility classes and LSC classification fail to meet the criteria for BSAL across the Proposed Disturbance Area (refer to **Section 5.1.1**).

6.0 Soil Use for Rehabilitation

All surface soils within the Proposed Disturbance Area are suitable for harvesting for later use in rehabilitation of the Project Area. The depth of suitable soil varies from 10 to 20 centimetres. The surface soils across the Proposed Disturbance Area have potential issues with soil acidity, soil sodicity, low to moderate Cation Exchange Capacity and moderate Organic Carbon (DSNR n.d.).

The soils are also relatively high in Magnesium compared with Calcium. Throughout rehabilitation the topsoil materials should be tested for pH and Exchangeable Sodium Percentage and appropriate amounts of lime and gypsum applied to ensure sustainable rehabilitation success.

7.0 Summary of Assessment Findings

This soil survey, LSC assessment and BSAL verification have been undertaken in accordance with the Guidelines for Surveying Soil and Land Resources (McKenzie *et al.* 2008) in addition to recent NSW government protocols. The key findings of this assessment are as follows:

- three soil types have been identified across the Proposed Disturbance Area:
 - Brown Sodosols, moderately low fertility duplex soils, occupy 461.8 hectares or 95.2 per cent of the Proposed Disturbance Area and correspond to the Bayswater Soil Landscape;
 - Brown Kurosols, moderately low fertility duplex soils, occupy 4.7 hectares or 1 per cent of the Proposed Disturbance Area and correspond to the Bayswater Soil Landscape;
 - Stratic Rudosols, young weakly structured moderately low fertility alluvial soils, cover 15.8 hectares (3.2 per cent) of the Proposed Disturbance Area and correspond to the Hunter Soil Landscape and isolated patches of the Bayswater Soil Landscape; and
 - Clastic Rudosols, low fertility alluvial soils overlying gravel, occupy 2.7 hectares (0.6 per cent) and are associated with the current Bowmans Creek and past tributaries of Main Creek.
- LSC assessment identified land Classes 4 to 7 across the Proposed Disturbance Area. The majority of the Proposed Disturbance Area is Class 6 (301.5 hectares, 62 per cent of the assessed land). These classes are suited to grazing operations, limited cropping with minimal cultivation, permanent horticulture, forestry and conservation. The main hazards associated with the identified soil types were soil acidification, soil structure decline, and soil depth in some areas.
- BSAL verification using both the Upper Hunter SRLUP assessment methodology and the OEH *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* identified there was no BSAL within the Proposed Disturbance Area. All soils failed to meet the criteria of adequate soil fertility.
- Topsoils to a depth of 20 centimetres would be suitable for rehabilitation with some management inputs to correct pH and sodicity.

8.0 References

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(Accessed 12 Aug 2013)



APPENDIX 1

Laboratory Test Results



SOIL TEST REPORT

Page 1 of 2

Scone Research Centre

REPORT NO: SCO14/113R1

REPORT TO: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2283

REPORT ON: Four soil samples
Your ref: MGA 56

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 26 June 2014

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
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A handwritten signature in blue ink, appearing to read 'SR Young'.

SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 2 of 2

Report No: SCO14/113R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2283

Lab No	Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)						C8A/3	P9B/2	
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	EAT	Texture
1	Site 26 A 0-10cm	0.06	6.1	5.0	9.6	0.3	0.4	4.6	3.0	1.8	2	8	Sandy loam
2	Site 26 B >23cm	0.19	5.5	4.5	14.2	1.9	0.3	2.5	8.4	2.6	nt	2(1)	Heavy clay
3	Site 27 A 0-5cm	0.05	5.7	4.5	16.1	0.7	0.8	4.4	9.6	3.0	3	3(2)	Clay loam
4	Site 27 B >15cm	0.07	5.4	4.2	19.0	1.2	0.6	2.0	12.0	5.1	nt	3(3)	Heavy clay

nt=not tested

Lab No	Method	P7B/2 Particle Size Analysis (%)					C6A/2
	Sample Id	clay	silt	f sand	c sand	gravel	OC %
1	Site 26 A 0-10cm	10	15	46	29	<1	2.07
2	Site 26 B >23cm	nt	nt	nt	nt	nt	nt
3	Site 27 A 0-5cm	28	23	34	15	<1	3.83
4	Site 27 B >15cm	nt	nt	nt	nt	nt	nt

nt=not tested



END OF TEST REPORT

SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO13/220R1

REPORT TO: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

REPORT ON: Thirteen soil samples
Ref: Mount Owen (MOCO) Project

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 26 August 2013

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
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SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 2 of 3

Report No: SCO13/220R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

Lab No	Method	C1A/5	C2A/4	C2B/4	C5A/4 CEC & exchangeable cations (me/100g)						C8A/3	C6A/2
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	OC (%)
1	Site K (14) A	0.03	6.9	5.8	11.0	0.3	0.8	5.2	2.2	<0.3	4	2.89
2	Site K (14) B	0.01	7.1	5.7	12.4	0.4	0.2	6.6	2.9	nt	nt	nt
3	Site G (17) A	0.05	6.1	4.9	11.3	0.7	0.5	3.1	4.5	<0.3	3	2.01
4	Site G (17) B	0.23	6.1	4.9	25.8	3.9	0.1	5.1	12.6	<0.3	nt	nt
5	Site A (18) A	0.10	6.1	5.3	14.5	0.4	0.7	6.9	4.8	<0.3	3	5.07
6	Site A (18) B	0.07	6.1	4.6	15.8	1.2	0.1	1.6	7.9	<0.3	nt	nt
7	Site F (22) A	0.02	5.9	4.7	7.1	<0.1	0.2	2.1	1.5	<0.3	7	1.96
8	Site F (22) B	0.01	6.3	4.7	7.7	0.2	0.2	1.8	3.6	<0.3	nt	nt
9	Site J (23) A	0.06	5.7	4.7	8.3	<0.1	0.8	3.5	2.1	<0.3	3	2.16
10	Site J (23) B	0.33	5.5	4.5	35.6	4.2	0.7	2.0	23.5	0.7	nt	nt
11	Site D (24) A	0.04	5.7	4.7	10.5	<0.1	0.6	3.7	3.3	0.4	1	2.72
12	Site D (24) B	0.28	5.9	4.8	25.7	3.4	0.6	2.1	17.0	<0.3	nt	nt
13	Site B (25) A	0.02	5.9	4.9	7.2	0.2	0.1	3.5	1.3	0.4	3	1.91



SOIL CONSERVATION SERVICE
Scone Research Centre

Page 3 of 3

Report No: SCO13/220R1
Client Reference: Pam Dean-Jones
Umwelt (Australia) Pty Ltd
75 York Street
Teralba NSW 2284

Lab No	Method	P9B/2	P7B/2 Particle Size Analysis (%)					Texture
	Sample Id	EAT	clay	silt	f sand	c sand	gravel	
1	Site K (14) A	3(1)	13	15	48	22	2	sandy loam
2	Site K (14) B	3(1)	nt	nt	nt	nt	nt	sandy loam
3	Site G (17) A	3(1)	14	25	36	13	12	silty loam
4	Site G (17) B	2(3)	nt	nt	nt	nt	nt	heavy clay
5	Site A (18) A	8	is	is	is	is	3	sandy clay
6	Site A (18) B	2(3)	nt	nt	nt	nt	nt	medium clay
7	Site F (22) A	5	4	11	21	20	44	loamy sand
8	Site F (22) B	2(1)	nt	nt	nt	nt	nt	coarse sandy clay loam
9	Site J (23) A	5	6	14	26	36	18	loamy sand
10	Site J (23) B	2(2)	nt	nt	nt	nt	nt	heavy clay
11	Site D (24) A	5	14	20	40	20	6	sandy loam
12	Site D (24) B	2(3)	nt	nt	nt	nt	nt	medium clay
13	Site B (25) A	5	10	17	31	30	12	sandy loam

is = insufficient sample; nt = not tested



END OF TEST REPORT

SOIL TEST REPORT

Page 1 of 3

Scone Research Centre

REPORT NO: SCO12/320R1

REPORT TO: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

REPORT ON: Twenty five soil samples
Mt Owen

PRELIMINARY RESULTS
ISSUED: Not issued

REPORT STATUS: Final

DATE REPORTED: 17 October 2012

METHODS: Information on test procedures can be obtained from Scone
Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
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SR Young
(Laboratory Manager)

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 2 of 3

Report No: SCO12/320R1
Client Reference: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

Lab No	Method	C1A/4	C2A/3	C2B/3	C5A/4 CEC & exchangeable cations (me/100g)						C8A/2	P9B/2	
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	CEC	Na	K	Ca	Mg	Al	P (mg/kg)	EAT	Texture
1	Site 1 10cm	0.03	6.1	5.0	10.2	0.4	0.9	3.6	3.6	0.2	2	3(1)	sandy clay loam
2	Site 2 10cm	0.04	6.0	4.8	7.1	0.5	0.6	3.4	3.8	0.4	2	3(1)	clay loam sandy
3	Site 3 10cm	0.03	6.1	4.8	8.7	0.5	0.6	2.4	5.5	0.5	1	2(1)	light clay
4	Site 4 10cm	0.03	6.0	4.9	5.1	0.4	0.3	2.7	2.6	0.4	1	5	sandy loam
5	Site 5 10cm	0.03	6.2	4.9	9.3	0.6	0.6	3.5	5.2	0.4	1	3(1)	light clay
6	Site 6 10cm	0.03	6.1	4.8	6.3	0.4	0.3	2.6	3.4	0.5	1	3(1)	sandy clay loam
7	Site 7 10cm	0.02	5.7	4.7	2.8	0.2	0.2	1.7	1.3	0.1	2	7	loamy sand
8	Site 8 10cm	0.06	6.2	4.9	14.2	1.1	0.6	4.7	7.6	0.3	1	2(1)	light medium clay
9	Site 9 10cm	0.11	6.9	5.4	9.7	2.2	0.5	3.0	4.4	0.3	2	2(1)	silty clay
10	Site 10 10cm	0.05	5.8	4.5	3.6	0.6	0.1	1.8	2.0	0.4	1	3(1)	fine sandy clay loam
11	Site 11 10cm	0.03	6.1	4.9	13.1	0.7	0.6	4.7	6.5	0.2	1	2(1)	silty clay
12	Site 12 10cm	0.11	5.8	5.0	7.4	0.4	0.9	4.2	2.9	0.4	6	3(1)	fine sandy loam
13	Site 13 10cm	0.06	6.5	5.6	10.7	0.2	1.6	6.7	2.5	0.4	34	3(1)	fine loamy sand

SOIL CONSERVATION SERVICE
Scone Research Centre

Page 3 of 3

Report No: SCO12/320R1
Client Reference: Rachel Rummery
Umwelt Australia
PO Box 768
Bendemeer NSW 2355

Lab No	Method	C1A/4	C2A/3	C2B/3	P9B/2	
	Sample Id	EC (dS/m)	pH	pH (CaCl ₂)	EAT	Texture
14	Site 1 10-20cm	0.03	6.1	4.9	3(1)	sandy clay
15	Site 2 10-20cm	0.04	6.3	5.0	2(1)	sandy clay
16	Site 3 10-20cm	0.04	6.4	5.0	2(1)	medium heavy clay
17	Site 4 10-20cm	0.01	6.3	4.9	3(1)	coarse loamy sand
18	Site 5 10-20cm	0.04	6.8	5.3	2(1)	medium clay
19	Site 6 10-20cm	0.03	6.7	5.1	2(1)	sandy clay
20	Site 7 10-20cm	<0.01	6.1	4.8	2(1)	coarse loamy sand
21	Site 8 10-20cm	0.10	6.4	5.2	2(1)	heavy clay
22	Site 9 10-20cm	0.06	6.9	5.4	2(1)	clay loam
23	Site 10 10-20cm	0.10	6.8	5.4	2(2)	sandy clay loam
24	Site 11 10-20cm	0.06	6.7	5.3	2(1)	medium clay
25	Site 13 10-20cm	0.03	6.5	5.5	7	fine sandy loam



END OF TEST REPORT

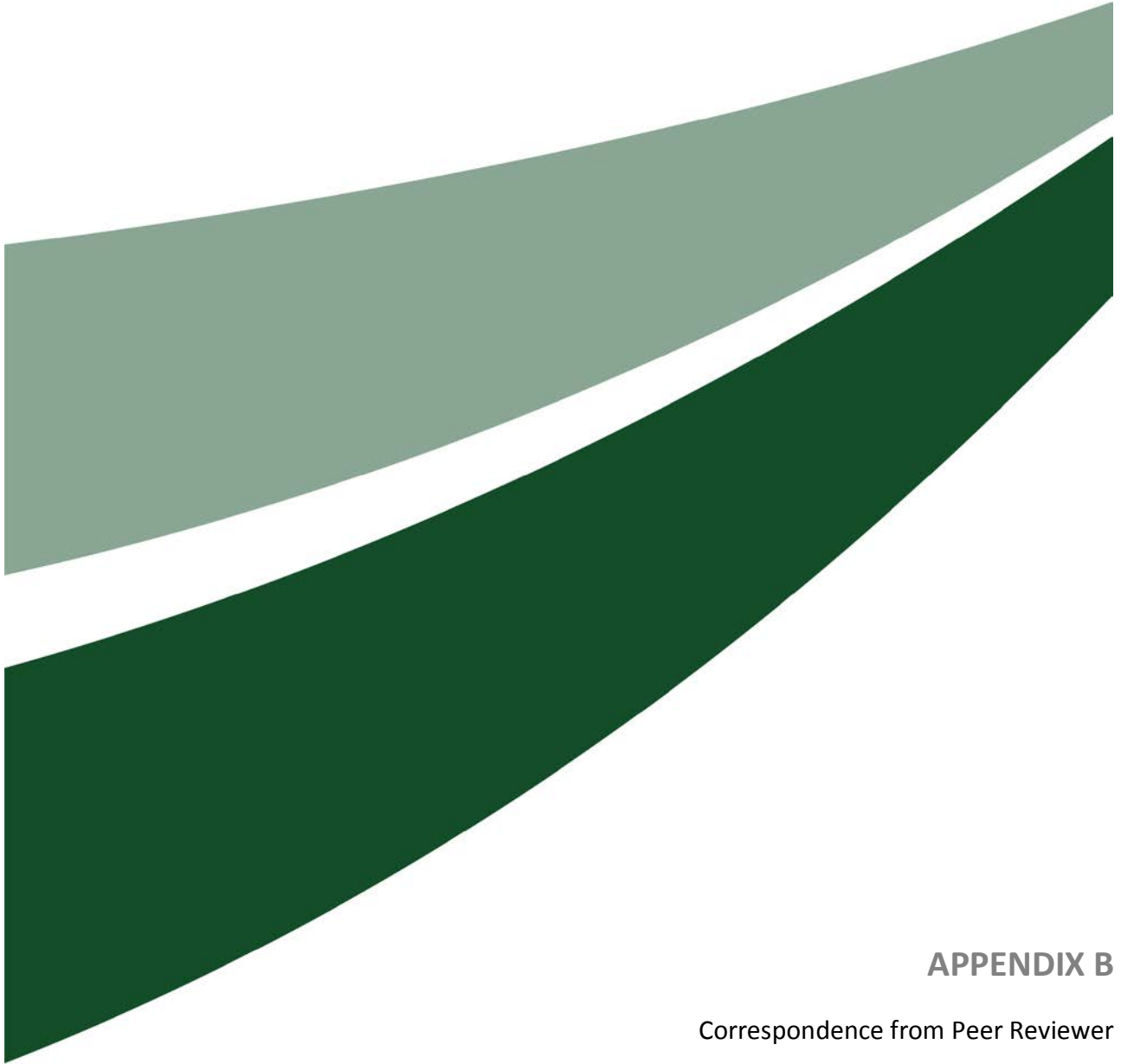


Newcastle

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APPENDIX B

Correspondence from Peer Reviewer

August 1, 2014

Ms Pam Dean-Jones
Manager, Communities & Landscapes/Associate
Umwelt (Australia) Pty Limited
75 York Street
Teralba, NSW 2284

Soil and Land Conservation Consulting

Dear Ms Dean-Jones

Certification of Mount Owen Continued Operation Soil Assessment

I am satisfied that the *Mount Owen Continued Operation Soil Assessment* complies with the requirements for such assessments as defined in the various NSW Government publications, in particular *Interim protocol for site verification and mapping of biophysical strategic agricultural land* and *Agricultural Impact Statement technical notes*.

My certification of the soil assessment is based on my ongoing involvement with the project. This included the planning of the sampling strategy, attending field work for a full day to ensure sampling methodology and data recording were adequate, and ongoing consultation in the preparation of the report. I have reviewed the survey report thoroughly, including checking the soil descriptions and classification, and the analytical data. The comments I provided have been incorporated to my satisfaction. As such, I believe the report provides a methodical and reliable record of soil conditions in the survey area following a well planned and thorough field investigation. Considerable care has been taken to comply with NSW Government agency requirements for sampling strategy and soil data collection, and the conclusions regarding Biophysical Strategic Agricultural Land are sound.

I hereby certify that the report is a true and accurate account of the soils in the Mount Owen Continued Operation survey area, and the conclusions regarding Biophysical Strategic Agricultural Land are valid.



Peter Fogarty
Certified Professional Soil Scientist (Leading Professional)

Peter Fogarty BA, Dip Nat Res, Certified Professional Soil Scientist

PO Box 485, Jamison, ACT 2614 ph: 0409 129608 email: slcc@grapevine.com.au

Soil survey and assessment for forestry, agriculture, urban development; land degradation assessment;
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