APPENDIX 27

Agricultural Impact Statement

umwelt
Environmental & Social Consultants

GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

Agricultural Impact Statement

FINAL

November 2019

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Agricultural Impact Statement

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Limited

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Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
AIS	Agricultural Impact Statement
ASC	Australian Soil Classification
BCD	Biodiversity and Conservation Division within DPIE
BoM	Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
CEC	Cation exchange capacity
CICs	Critical Industry Clusters
Colinta	Colinta Holdings Pty Limited
DPI	Department of Primary Industries
DPIE	Department of Planning Industry and Environment
ESP	Exchangeable Sodium percentage
Glencore	Glencore Coal Pty Ltd
Project	Glendell Continued Operations Project
Project Area	All land required for the Project
Interim Protocol	Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land
K	Potassium
km	Kilometre
LGA	Local Government Area
Project Locality	Five km buffer area around the Additional Disturbance Area
LSC	Land and Soil Capability
m	metre
Mining SEPP	State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007
MOP	Mining Operations Plan
OEH	Office of Environment and Heritage, now BCD
P	Phosphorous
RBA	Reserve Bank of Australia
Region	Singleton Local Government Area (LGA) and Muswellbrook LGA
SEARs	Secretary's Environmental Assessment Requirements
SLR	Soil and land resource
SRLUP	Strategic Regional Land Use Plan
Umwelt	Umwelt Australia Pty Ltd

1.0 Introduction

Glendell Tenements Pty Limited (the Proponent) has engaged Umwelt (Australia) Pty Limited (Umwelt) to complete an Agricultural Impact Statement (AIS) for the Glendell Continued Operations Project (the Project). The purpose of the assessment is to address the requirements of the Secretary's Environmental Assessment Requirements (SEARs) relating to impacts of the Project on agricultural land, resources and land use on and in the vicinity of the Project Area. The AIS forms part of an Environmental Impact Statement (EIS) being prepared by Umwelt to accompany an application for development consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Project.

1.1 Project overview

The Glendell Mine forms part of the Mount Owen Complex located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres (km) north-west of Singleton, 24 km south-east of Muswellbrook and to the north of Camberwell (refer to **Figure 1.1**). The Mount Owen Complex open cut operations are located in the north-eastern part of the Upper Hunter Valley which has been heavily dominated by coal mining and power station operations for many decades. Rural and rural residential land uses also surround the Mount Owen Complex (refer to **Figure 1.1**).

The Project is the extension of open cut mining operations north from the existing Glendell Mine to extract an additional 135 million tonnes (Mt), approximately, of run of mine (ROM) coal. This extension of the Glendell Pit is referred to as the Glendell Pit Extension. The Glendell Pit Extension will extract reserves down to and including the Hebden seam. The Project would extend the life of mining operations at Glendell to approximately 2044 and provide ongoing employment.

The key features of the Project include:

- extension of open cut mining to the north of the existing Glendell Mine until 2044
- extraction of approximately 135 Mt of ROM coal
- continued integration of the mine with the wider Mount Owen Complex, including the use of the Mount Owen coal handling and preparation plant (CHPP), rail loop and associated infrastructure for ROM coal processing and product coal transport
- demolition of the existing Glendell Mine Infrastructure Area (MIA) and the construction of a new MIA
- realignment of a section of Hebden Road
- realignment of the lower reach Yorks Creek
- relocation of the Ravensworth Homestead
- other ancillary infrastructure works such as the construction of a Heavy Vehicle Access Road
- progressive rehabilitation of the site.

The key features of the Project are shown on **Figure 1.2**.

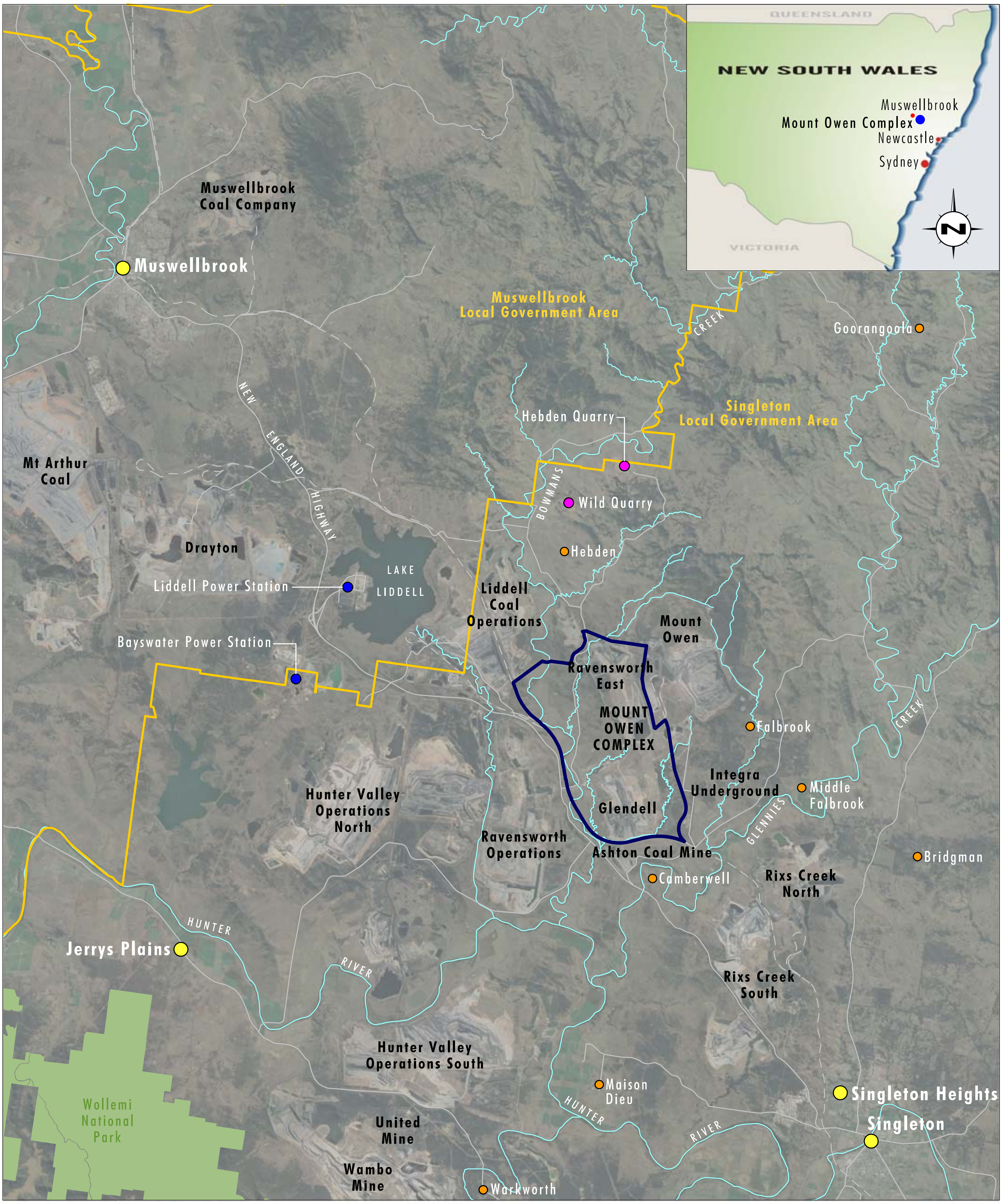

Image Source: Google Earth (2018)
Data Source: Glencore (2019), OEH (2018)

0 2.5 5.0 10km

Legend

- Project Area
- Local Government Area Boundary
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Village/Localities
- Power Stations
- Quarry

FIGURE 1.1

Project Locality

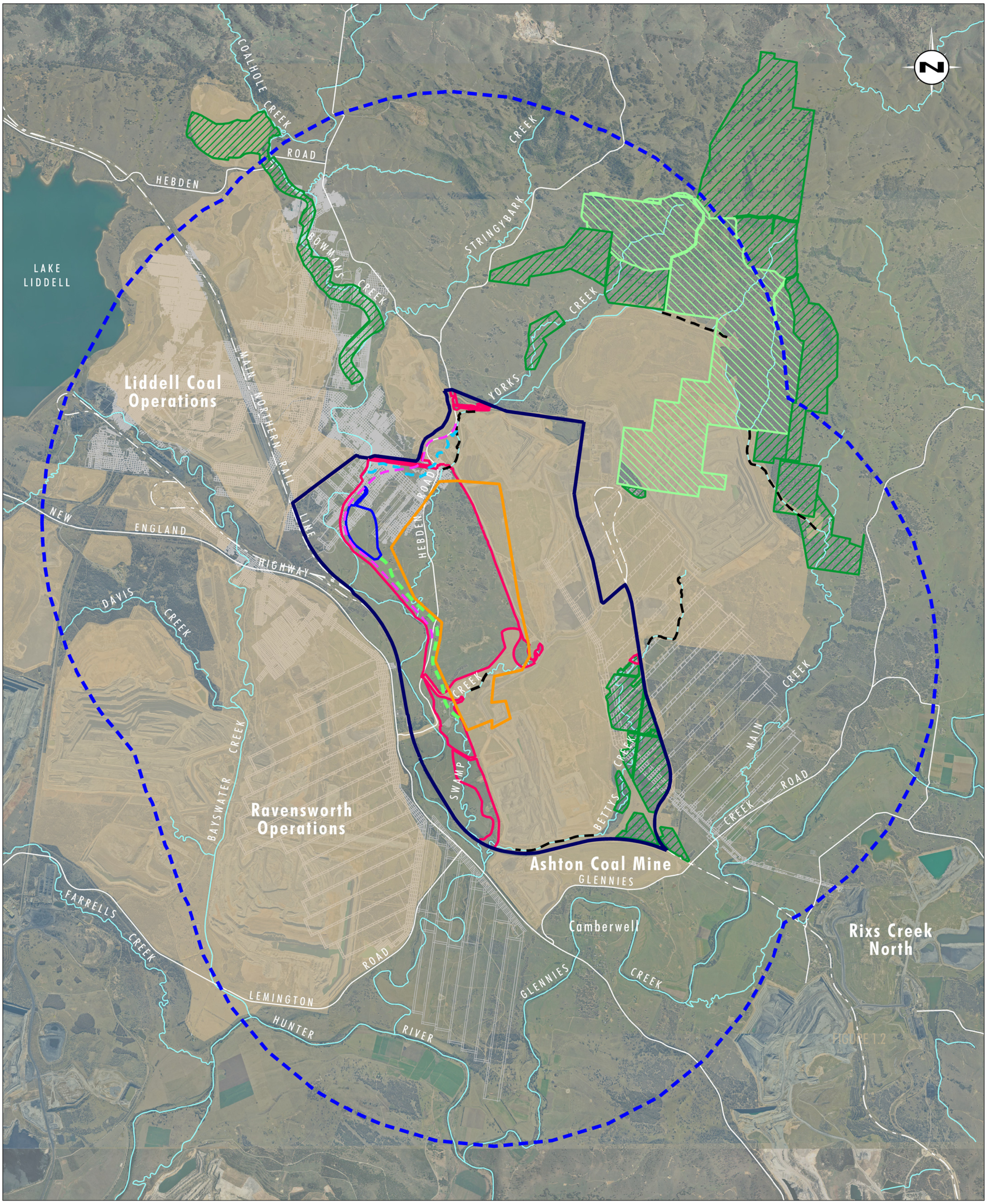

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 1 2 4 km

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Glendell Pit Extension
- Existing Creek Diversion
- New Glendell MIA
- Heavy Vehicle Access Road
- Yorks Creek Realignment
- Hebden Road Realignment
- Mining and Infrastructure Related Distirbance
- Offsets/Conservation Area
- Ravensworth State Forest
- Underground Workings

FIGURE 1.2

Key Features of the Project

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20191128 15.57

1.2 Project locality and the Project area

This AIS assesses the potential impacts of the Project to agriculture in a regional and site-specific context.

Region

The Project Area is located in the Singleton Local Government Area (LGA) and in close proximity to the Muswellbrook LGA (refer to **Figure 1.1**), the Region therefore comprises of both LGAs. The Singleton and Muswellbrook LGAs have a size of approximately 489,285 hectares (ha) and 340,490 ha, respectively. Both LGAs support an extensive and established mining industry with large areas of associated land disturbance.

Agriculture in both LGAs encompasses a range of commodities, the most important being livestock, both for slaughter and livestock product. Livestock for slaughter includes cattle and calves, poultry, sheep and lambs, pigs and goat, with slaughter of cattle and calves making up for over half of the of the gross agricultural product value for both LGAs. Milk production is the central livestock production commodity, with wool and egg production also occurring. The most important crop production in both LGAs is hay and silage production. Further agricultural commodities are broadacre crops, fruit and nuts, grapes, vegetables for human consumption, as well as nurseries and cut flowers.

The assessment of this area is based on the review of publicly available data.

Project Locality

The AIS technical notes define the locality as the area of the parish or an appropriate proportional area of the parish if the project area is on the edge of a parish (DPI, 2013a). The Project Area is located in the Liddell Parish, which has a maximum width and length of approximately 10 km. Based on the size of the Liddell Parish, the Project Locality in this AIS refers to a five km buffer area around the Project Additional Disturbance Area (refer to **Figure 1.2**) and covers approximately 19,060 ha.

Land use within the Project Locality is dominated by mining operations. Glencore operates the Mount Owen Complex, Integra Underground, Liddell Coal Operations and Ravensworth Operations within the Project Locality. The Ashton Coal Mine and Rix's Creek North are also located in the Project Locality (refer to **Figure 1.2**).

Other land uses within the Project Locality include the Hebden and Wild Quarries to the north-west of Glendell Mine and limited cattle grazing and rural residential holdings. Ravensworth State Forest and Glencore biodiversity offset and conservation areas are also located within the Project Locality (refer to **Figure 1.2**). Land owned by Glencore and its subsidiaries within the Project Locality that is not used for mining related purposes is utilised for cattle grazing and rural residential leases (subject to environmental conditions). The cattle grazing operations are currently managed by Colinta Holdings Pty Limited (Colinta), a Glencore subsidiary. There are also a number of rural/rural residential localities within the Project Locality including Hebden to the north, Glennies Creek, Falbrook and Middle Falbrook to the east and south-east and Camberwell to the south.

Project Area

The Project Area and associated Additional Disturbance Area are shown on **Figure 1.2**. The Project Area comprises approximately 2,900 ha and the Additional Disturbance Area comprises approximately 750 ha. The proposed mining operations have the potential to result in direct and indirect impacts to agricultural resources within the Project Area. Direct impacts are associated with the disturbance of land and indirect impacts associated with areas that will not be disturbed however the use of the land will be restricted due to close proximity of the proposed mining operations.

Land within the Project Area that is not subject to mining is currently used for low intensity grazing. Cropping within the Project Area has historically been largely limited to the flatter alluvial terraces associated with Bowmans Creek. There has been limited cropping of alluvial terraces in recent years other than localised areas used for improved pastures for grazing. Areas away from alluvial terraces have largely been used for grazing.

The assessment of the Project Area is based on the detailed technical studies undertaken to support the Environmental Impact Statement (EIS) for the Project.

Biodiversity Offsets

A Biodiversity Development Assessment Report (BDAR) (Umwelt, 2019) has been prepared in accordance with the Biodiversity Assessment Method (BAM). No specific offset sites in relation to the Project have been identified, therefore assessment of potential offset sites have not been included in this assessment.

Report Structure

Section 1.0 describes the Project and the general approach to the scope of the assessment.

Section 2.0 provides an overview of the AIS requirements, aims and objectives of the assessment, as well as the scope, scale and method of the assessment.

Section 3.0 provides an outline of the agricultural land use and production of the Region, the Project Locality and the Project Area.

Section 4.0 provides information about the agricultural resources of the Region, Project Locality and Project Area.

Section 5.0 provides an assessment of the level of impact (temporary and permanent) the Project may have on agricultural resources and enterprises in the Region, Project locality and the Project Area.

Section 6.0 assesses the extent of the potential impacts using a risk assessment process and proposes mitigation measures to be implemented to reduce the risk of impact on agricultural resources and enterprises.

2.0 Assessment requirements, Project scope and approach

The agricultural impact assessment has been prepared in accordance with the requirements included in the Secretary's Environmental Assessment Requirements (SEARs), the *Upper Hunter Strategic Regional Land Use Plan* (DPI, 2012) (Upper Hunter SRLUP), the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) and the *Agricultural Impact Statement Technical Notes* (DPI, 2013a).

2.1 Secretary's Environmental Assessment Requirements (SEARs)

The SEARs outline the specific requirements for the Project EIS, including the assessment of the agricultural impacts and land use compatibility of the development. **Table 2.1** provides the SEARs requirements and relevant sections of the AIS where they are addressed.

The AIS is required to assess the potential impact of the Project on:

- agricultural land mapped as Biophysical Strategic Agricultural Land (BSAL) or land which a detailed soil survey identifies as BSAL within the Project Area or in close proximity of this
- agricultural resources in the proposed disturbance footprint and the surrounding locality. Agricultural resources are defined as land on which agriculture is dependent
- other agricultural land uses and infrastructure, within or in close proximity to the Project Area, or where relevant, more broadly in the region.

2.2 Upper Hunter Strategic Regional Land Use Plan (SRLUP)

The Project Area is located in the Upper Hunter Region and is covered by the Upper Hunter SRLUP. The plan defines land of strategic agricultural importance, either due to its land capability, productivity or other economic and social value (DPI, 2012).

Mapping of land with unique natural resource characteristics has been undertaken on a regional scale. Mapping of BSAL is based on available land and soil characteristics. Critical Industry Clusters (CICs), such as Viticulture CICs or Equine CICs, are based on based on specific production and economic values.

As per the Upper Hunter SRLUP, BSAL is defined as land with Land and Soil Capability (LSC) Classes 1 or 2 and a moderate to high soil fertility. Land with an LSC Class 3 and moderately high to high soil fertility may also qualify as BSAL. Access to quality agricultural water supply is also a requirement.

CICs are a concentration of industries based on an agricultural product. These productive industries are interrelated and are identified by a unique combination of factors such as location, infrastructure, heritage and natural resources. The industry clusters are of national and/or international importance or are an iconic industry for a region's identity.

The location of BSAL (as mapped by the Upper Hunter SRLUP) within the Project Locality is shown in **Figure 2.1**. There are no CICs located within the Project Locality. Due to large scale mapping associated with the Upper Hunter SRLUP, BSAL verification is required to be carried out on a property scale (OEH and OASFS, 2013).

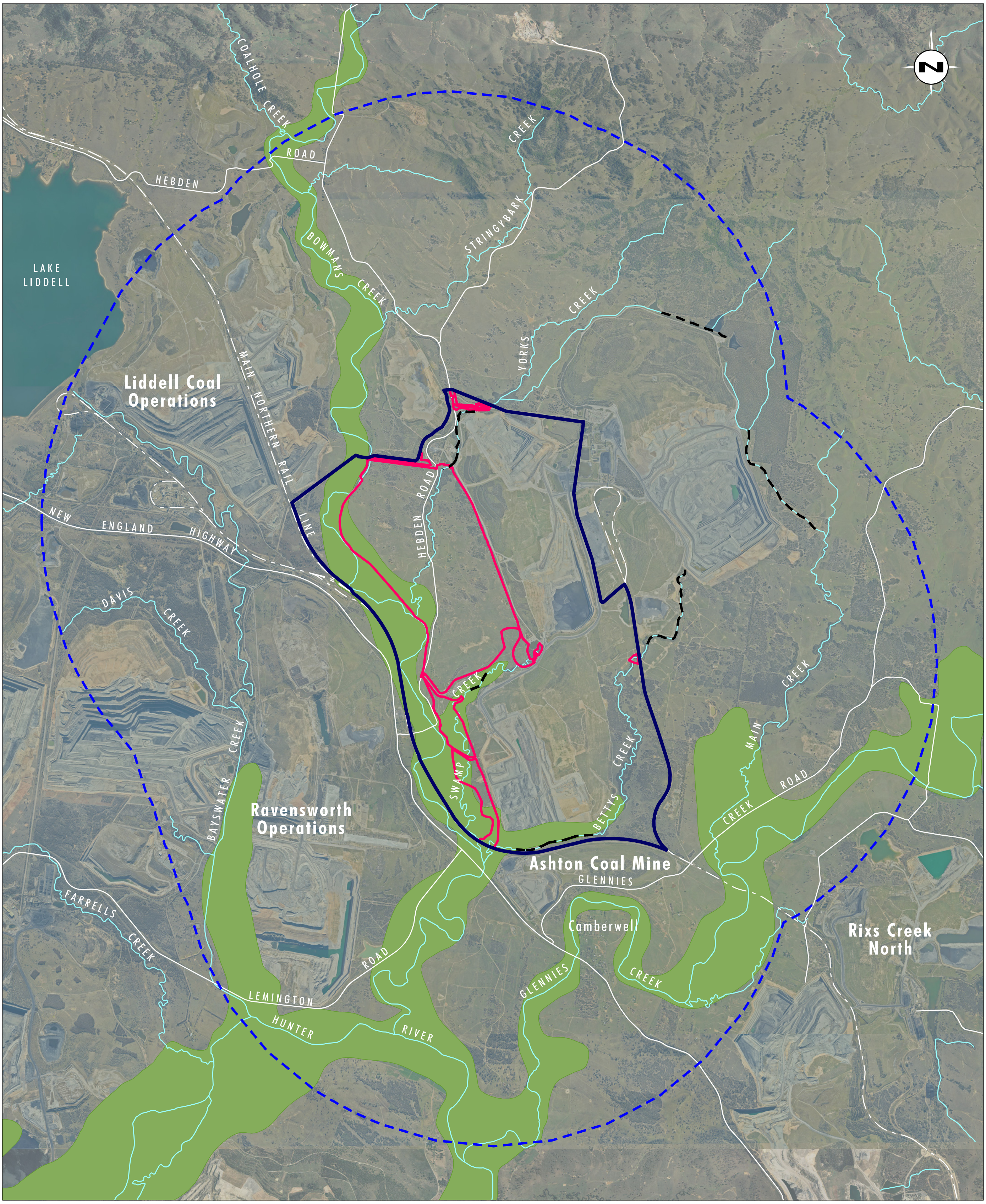

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion
- Mapped Biophysical Strategic Agricultural Land (Upper Hunter SRLUP, 2013)

FIGURE 2.1

Potential Biophysical Strategic Agricultural Land Upper Hunter SRLUP Mapping

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20191202 13.56

2.3 Mining SEPP

The Mining SEPP requires certain types of development to verify whether BSAL is present on a proposed site and whether the Gateway Process applies to the development application. The Mining SEPP does not apply the Upper Hunter SRLUP LSC Classification but instead requires the Secretary of DPIE, when considering a Site Verification Certificate, to *have regard to* the Interim Protocol for Site Verification and Mapping of Biophysical Strategic Land (NSW Government, 2013) (Interim Protocol). This process only applies to land where a new mining lease is required to carry out the Project. Verification is not required where existing mining leases are held for the Project.

A Site Verification Report accompanied the Gateway Application for the Project (Umwelt, 2019). The Site Verification Report was prepared having regard to the Interim Protocol and applies only to parts of the Project Area that will be newly disturbed by the Project and where new mining leases may be required for the activities proposed (Verification Area). Based on the assessment in accordance with the Interim Protocol, there is approximately 34 ha of BSAL within the Verification Area (referred to in this report as Verified BSAL). As a result of the proposed impact ion Verified BSAL, the Project was subject to the Gateway Assessment and a conditional gateway certificate was issued on 24 July 2019. The Gateway Certificate recommendations included:

- further assessment and detail in relation to stockpiling and reconstitution of BSAL.
- consideration of re-routing the re-alignment of Hebden Road to avoid traversing an area of contiguous BSAL.
- groundwater modelling to quantify impacts on nearby water assets (bores, wells and groundwater dependent ecosystems).
- monitoring and reporting of actual mine water inflows and the development of a strategy for complying with Water Sharing Plan rules.

These Gateway Assessment requirements are addressed in the EIS.

2.4 Requirements of the agricultural impact statement technical notes

Specific relevant requirements of the guidelines and technical notes are summarised in **Table 2.1**, which also identifies the relevant section of the AIS where the required information is provided.

Table 2.1 Overview of Assessment Requirements and Relevant AIS Section

Section of AIS Technical Notes	AIS Technical Notes Assessment Requirements	Secretary's Environmental Assessment Requirements	Relevant Section of this AIS
1.0	Project overview • Overview of the project and project description		**Section 1.0**
2.1, 2.2	Assessment of agricultural resources in the project area • Detailed soil assessment and description • Slope and land characteristics identifying agricultural land suitability and land capability classes of the pre-mining landscape		**Section 4.2**
3.1.1, 3.1.2, 3.1.4, 3.1.6, 3.1.7	Agricultural resources within locality • Soil characteristics including soil types and depths • Topography • Water resources and extraction location • Vegetation • Climate and climate variability		**Section 4.0**
2.3, 3.1.3, 3.1.5,3.2	Agricultural land use and production • History of agriculture in the project area for a minimum of 10 years and correlation between history and climatic background. • Management practices of agricultural enterprises in the project area • Agriculture support infrastructure in the locality. • Location and type of agricultural industry in the locality. • Agricultural enterprises in locality.		**Section 3.0**

Section of AIS Technical Notes	AIS Technical Notes Assessment Requirements	Secretary's Environmental Assessment Requirements	Relevant Section of this AIS
2.4, 2.5, 2.6, 2.7, 4.1, 4.2, 4.3	Impact assessment • Land to be temporarily removed from agriculture, including the agricultural usage of the land, agricultural suitability and LSC. • Land to be returned to agriculture post mining, including LCS, evidence of feasibility, management requirements and land use type. • Land that will be permanently removed from agriculture (including offset sites), including expected decrease in LSC. • Agriculture undertaken on buffer or offset zones during life of project • Impacts on agricultural resources • Assessment of impacts on water availability and water movement • Assessment of socio-economic impacts	• An assessment of the likely impacts of the development on the soils and land capability of the site and surrounds • An assessment of the agricultural impacts of the development • An assessment of the compatibility of the development with other land uses in the vicinity of the Development, in accordance with the requirements of Clause 12 of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*, paying particular attention to the agricultural land use in the region	**Section 5.0**
5.1-5.6	Mitigation and management • Project justification • Project alternatives • Monitoring programs to assess predicted versus actual impacts • Trigger response plans and actions taken if required • Appropriateness of remedial actions to address and respond to impacts • Discussion of capacity of rehabilitated land for the intended final land use • Planning for progressive rehabilitation		**Section 6.0**
6.0	Consultation		**Section 2.5.2**

2.5 Method of assessment

In order to assess the potential impacts to agricultural resources within the Project Area the AIS has relied on information provided within the detailed technical studies (detailed below) prepared to support the EIS for the Project. Potential impacts on agricultural resources within the Region and Project Locality have been assessed based on the review of publicly available information, such as information from Bureau of Meteorology (BoM), the Australian Bureau of Statistics (ABS) and the DPIE eSPADE website.

2.5.1 Review of the biophysical, social and economic studies as they relate to agriculture

Productive and sustainable agriculture depends on the interaction of the natural resources of the land, and the availability of suitable infrastructure, skills, investment and market access. The AIS therefore draws together outcomes from multiple, detailed technical reports which have been prepared for the EIS for the Project, including:

- Social Impact Assessment
- Appendix 1 of the Gateway Application – Glendell Continued Operations Project - Biophysical Strategic Agricultural Land Verification Assessment
- Surface Water Impact Assessment
- Groundwater Impact Assessment
- Aboriginal Cultural Heritage Assessment
- Biodiversity Development Assessment Report
- Rehabilitation and Mine Closure Strategy
- Noise Impact Assessment
- Air Quality Impact Assessment
- Blast Impact Assessment
- Traffic and Transport Impact Assessment.

2.5.2 Consultation

Extensive community consultation was carried out as part of the EIS in the form of a Social Impact Assessment (SIA). This included consultation with a wide range of stakeholders as part of the SIA program (refer to Section 6.0 of EIS for further information). Consultation in relation to the Project was undertaken using a range of mechanisms which included meetings, presentations, information sessions, newsletters, face to face interviews, phone discussions and other forms of personal communication (e.g. emails). Direct consultation to inform the AIS was undertaken with Colinta regarding current management of cattle grazing in Mount Owen Complex buffer lands.

Relevant findings from the stakeholder consultation undertaken for the Project were considered in the preparation of this AIS and are discussed further in the EIS and the SIA (Appendix 11 of the EIS).

3.0 Agricultural land use and production

This section provides an overview of the history of agricultural land use and previous and current agricultural production within the Region, Project Locality and Project Area.

3.1 History of agriculture

Changing agricultural focus and rural settlement patterns are a key characteristic of the history of the region surrounding the Project 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 Locality.

Notwithstanding these changes, the general agricultural land use of the Project Locality is low intensity cattle grazing. It should be noted that the broader Upper Hunter Region (north-west of the Project Locality) generally has higher quality soils and a more diverse agricultural sector.

3.1.1 Regional history

Information in this section is based on the Mount Owen Continued Operations Project AIS (Umwelt, 2014) and the Statement of Heritage Impact (LSJ 2019) (refer to Appendix 23 of the EIS) undertaken to support the EIS for the Project.

European settlers occupied the Hunter Valley from the early nineteenth century. Early reports described the land as suitable for agricultural activities resulting in the establishment of large-scale pastoral holdings. In the following years, European settlement expanded rapidly.

Since European settlement of the Hunter Valley, a number of agricultural industries have been significant and then subsequently declined within the region. 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, with crops including wheat, maize, barely and tobacco. Wheat crops grown in the Hunter Valley were prone to disease 'rust', with a severe outbreak occurring in 1857. Disease together with the relatively dry conditions in the Upper Hunter resulted in the decline of wheat production. Following the decline of wheat, barely production, predominantly for stock feed, increased. As the dairy industry began to grow, Lucerne crops became a more viable option for feed.

Dairy farming became an important land use after sheep/wool production began to decrease and by the early twentieth century, dairy farms of up to ~200 ha were present in the Upper Hunter. Dairying further increased after World War l as soldiers were given small holdings and government assistance to establish small agricultural businesses.

A decline of the dairying industry began in the second half of the twentieth century, with the number of dairy farms almost halving between 1970 and 1976. The decline is thought to be the result of changing policies, with Britain joining the European Economic Community resulting in Australia losing its main dairy export market, the reallocation of milk quotas and the eventual deregulation of the industry.

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, but the boom of grape growing 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 22% of workers in the Singleton LGA and 20% of workers in the Muswellbrook LGA (ABS 2019) (refer to **Section 3.2.1**).

3.1.2 Project locality and Project area

The Ravensworth Estate, which is partially located within the Project Area is recognised as an important piece of the agricultural history of the Hunter Valley. Detailed investigations into the history of Ravensworth Estate and the general history of the Project Area have been undertaken to support the EIS for the Project (LSJ 2019). A brief summary of the relevant aspects is provided below.

The agricultural potential of the Project Locality was noted by early surveyors, explorers and settlers. The pastoral industry was the earliest established industry in the Project Locality. In 1823, John Howe was granted permission to graze his stock at Patrick's Plains, agisting 1,000 sheep and 1,200 cattle. Dr James Bowman was the first European to take up land at Ravensworth in 1824, which became the Ravensworth Estate.

The 1828 census reported that Bowman had cleared 500 acres (202 ha), 40 acres (16 ha) under cultivation, and that he owned two horses, 362 cows and 3,715 sheep. Richard Alcorn on a neighbouring property had cleared 12 acres (5 ha) of his 60 acres (24 ha) land, with nine acres (4 ha) under cultivation. He owned one horse and a herd of 90 cattle. James Chilcott, another landholder within the Project Locality cleared 40 acres (16 ha), cultivated 30 acres (12 ha) and owned 10 horses, 100 cattle and 400 sheep.

During the nineteenth century, the Ravensworth Estate was central to local and regional wool production. Later in the nineteenth century, a shift from wool production to mixed farming took place. Dairying and, to a lesser degree grazing, took up a more important role in farming within the Project Locality in the twentieth century. Prior to the commencement of mining operations within the Project Area (at Swamp Creek Mine, now part of the Mount Owen Complex) in the 1960s, the land was predominately used for grazing purposes.

3.2 Agricultural industry and productivity

3.2.1 Singleton and Muswellbrook LGA

The Singleton and Muswellbrook LGAs have an area of approximately 489,285 ha and 340,490 ha, respectively. In the Singleton LGA, 165,986 ha (34% of the total LGA area) are protected areas, in the Muswellbrook LGA protected areas accounted for 144,598 ha (43% of the total LGA area) (ABS, 2018b). In 2015-2016, the area of farm holdings in the Singleton LGA was 100,618 ha (or 21% of the total LGA area), whereas in the Muswellbrook LGA it was 122,674 ha (36% of the total LGA area) (ABS, 2017a) (refer to **Table 3.1**).

The total area of farm holdings for the Muswellbrook LGA was virtually unchanged from 2001 and 2016, with a decrease in area between 2006 and 2011 and a subsequent increase between 2011 and 2016. This decrease could be due to a decrease of farm holdings as a result of the severe Millennium drought which occurred from late 1996 to mid-2010. Farmland, which may not have been viable for faming during the drought years, may have been taken back into operation after the drought broke in mid-2010, which would reflect the increase in farm holdings between 2010-2011 and 2015-2016.

In the Singleton LGA, the area of farm holdings remained stable between 2001 and 2011, but a marked decrease between the 2011 and 2016 census (refer to **Table 3.1**). As this decline occurred after the drought broke in 2010 this is unlikely related to climatic reasons. Similarly, competition for land between mining and agriculture is unlikely the reason for the decline of farm holding areas, as the mining downturn commenced in late 2012.

The number of farms continuously decreased from 2006 to 2016 in both LGAs (refer to **Table 3.1**). This is mirrored by a general decrease of the number of agriculture, forestry and fishing businesses between 2006 (Muswellbrook 372 businesses, Singleton 621 businesses) and 2018 (Muswellbrook 299 businesses, Singleton 542 (2018 data)) (ABS, 2010a, ABS, 2010b, ABS, 2018a, ABS, 2018b). In 2016, in the Singleton and Muswellbrook LGAs 3.8% and 6.9%, respectively, of the workforce were employed in the agricultural sector (ABS, 2018a, ABS, 2018b).

Cropping land increased the Singleton LGA between 2001 and 2011, but a marked decrease between 2011 and 2016 resulted in cropping land falling below the 2001 area. Grazing land on the other hand strongly increased between 2001 and 2011, doubling in size. For the Muswellbrook LGA, the area utilised for cropping remained stable between 2006 and 2011 but decreased by over 50% by 2016. Grazing land increased markedly between 2001 and 2006 and slightly decreased in the period thereafter (refer to **Table 3.1**).

Table 3.1 Land Use by Area for Agriculture in the Singleton and Muswellbrook LGAs, for the 2000-2001, 2005-2006, 2010-2011 and 2015-2016 census data

LGA	Singleton LGA				Muswellbrook LGA			
Census date	2000-2001[a]	2005-2006[b]	2010-2011[c]	2015-2016[d]	2000-2001[a]	2005-2006[b]	2010-2011[c]	2015-2016[d]
LGA Area (ha)	488,425	488,425	488,425	489,283	340,200	340,200	340,200	340,488
Area of farm holdings (ha)	155,707	156,484	148,759	100,618	122,272	121,872	105,548	122,674
Change of area of farm holdings		777	-7,725	-48,141		-400	-16,324	17,126
Number of farms	437	551	454	178	271	314	264	169
Change in number of farms		114	-97	-276		43	-50	-95
Farm holdings as percentage of LGA area	32%	32%	30%	21%	36%	36%	31%	36%
Change farm holdings as percentage of LGA area (%)		0	-2	-10		0	-5	5
Crop and grazing land (ha)	66,012	138,968	135,545	NA	65,013	101,702	94,829	NA
Crop land (ha)	4,511	6,337	8,020	2,794	5,088	6,256	6,653	3,710
Grazing land (ha)	61,501	132,631	127,525	NA	59,925	95,446	88,176	NA
Changes in crop land (ha)		1,826	1,683	-5,226		1,168	397	-2,943
Changes in grazing land (ha)		71,130	-5,106			35,521	-7,270	

*Data sourced from: [a] ABS, 2008a, [b] ABS, 2008b, [c] ABS, 2012a, [d] ABS, 2017a

The Australian Bureau of Statistics (ABS) estimates the value of agricultural commodities as local value (price that would be paid at the farm gate) and gross value (price in the wholesale market). For the purposes of this AIS, gross values have been applied.

In 2015-2016, the Singleton and Muswellbrook LGAs accounted for approximately 11% and 9% of the value of the Hunter Valley (excl Newcastle) agricultural sector, respectively. Their percentage of NSW agricultural sector was less than 1% (refer to **Table 3.2**).

Table 3.2 Estimated Value of Agricultural Products for Singleton and Muswellbrook LGAs, Hunter Valley (excl Newcastle) and NSW in 2015-2016

Location	Estimated Value of Agricultural Products 2015-2016 ($m)
Singleton LGA	41
Muswellbrook LGA	33
Hunter Valley excl Newcastle	362
NSW	13,086

Source: ABS, 2017b

Agriculture in both LGAs encompasses a range of commodities, the most important being livestock, both for slaughter and livestock product. Livestock for slaughter includes cattle and calves, poultry, sheep and lambs, pigs and goats, with the slaughter of cattle and calves making up for over half of the of the gross agricultural product value for both LGAs. Milk production is the central livestock production commodity, with wool and egg production also occurring (refer to **Table 3.3**).

The most important crop production in both LGAs is hay and silage production. Further agricultural commodities are broadacre crops, fruit and nuts, grapes, vegetables for human consumption, as well as nurseries and cut flowers.

Some agricultural commodities have larger percentage at the Hunter Valley (excl Newcastle) agricultural economy. Approximately a third of the Hunter Valley estimated gross value for hay and silage, as well as value from milk production stems from the Singleton LGA. Almost half of the Hunter Valley estimated gross value for fruits and nuts (excluding grapes) is derived in the Muswellbrook LGA, as is almost a quarter of the hay and silage gross value and 22% of the grape value (refer to **Table 3.3**).

While the percentage of the values derived are sizable, the monetary value of these commodities is comparatively small compared to the value derived from farming cattle for slaughter or livestock product (refer to **Table 3.3**).

Table 3.3 Estimated Gross Value for Agricultural Commodities in the Singleton and Muswellbrook LGAs and Hunter Valley (Excl. Newcastle) 2015-2016

Agricultural Commodity	Estimated Value of Agricultural Products Singleton LGA ($m)	Estimated Value of Agricultural Products Muswellbrook LGA ($m)	Estimated Value of Agricultural Products Hunter excl. Newcastle ($m)	Percentage Value Singleton LGA of Hunter excl. Newcastle (%)	Percentage Value Muswellbrook LGA of Hunter excl. Newcastle (%)
Total agriculture	41.8	33.2	362.1	11%	9%
Total value of crops	6.2	5.1	31.5	20%	16%
Broadacre crops	0.60	0.3	7	9%	5%
Hay and silage	5.3	3.9	16.2	33%	24%
Fruit and nuts (excluding grapes)	0.03	0.5	0.9	3%	49%
Fruit and nuts - Grapes	0.2	0.4	1.9	9%	22%
Livestock products - Total	12.7	7.4	74.3	17%	10%
Livestock Products - Wool	0.01	0.9	8.	0%	2%
Livestock products - Milk	12.7	7.2	41.9	30%	17%
Livestock products - Eggs	0.00	0.07	24.4	<1%	0%
Livestock slaughtered - Total	22.3	20.6	256.4	9%	8%
Livestock slaughtered - Sheep and lambs	0.01	0.7	5.2	<1%	3%
Livestock slaughtered - Cattle and calves	22.3	19.9	166.4	13%	12%
Livestock slaughtered - Goats	<0.01	0.00	0.2	1%	1%
Livestock slaughtered - Pigs		0.01	1.3		1%
Livestock slaughtered - Poultry	<0.01	0.6	83.2	<1%	1%

Source ABS, 2017b

Table 3.4 and **Table 3.5** present the estimated gross value for the Singleton and Muswellbrook LGAs from 2005-2015, respectively. As some of the agricultural commodities were not reported on in 2015/2016, data from 2010/2011 have been included as well.

The gross value of the total agriculture in the Singleton LGA has decreased over the 2005-2015 period. Initially, gross value of agriculture increased from 2005/2006 to 2010/2011, even accounting for inflation[1]. In 2015/2016 the gross value of agriculture decreased from $51 M in 2010/2011 to $41 M (refer to **Table 3.4**). According the Reserve Bank of Australia (RBA), due to the rate of inflation the 2015/2016 gross value of $41 M is less than the value of $37 M in 2005/2006, which would amount to $48 M in 2015/2016[2].

The gross value of the total agriculture in the Muswellbrook LGA declined over the 2005-2015 period. In 2005/2006 the gross value of agriculture was $34 M, while ten years later it decreased to $33 M (refer to **Table 3.5**). According to the RBA, $34 M in 2005/2006 is equivalent to approximately $44 M in 2015/2016. The 2010/2011 gross value of the agricultural sector increased almost in line with inflation (actual gross value $38 M, gross value equivalent of 2005/2006 after inflation $39 M)[3].

The overall decrease in gross value of the total agriculture over the last ten years in both LGAs could be due to a strong shift away from livestock products to livestock slaughtering in 2015/2016. This follows a marked decrease in average Australian farm gate milk price in 2008/2009. However, the decrease in farm gate milk price for the NSW market was less pronounced (Rural Bank, 2017).

Over the same time period hay and silage production increased substantially in the Singleton LGA from 14,334 t in 2005/06 to 46,246 t in 2015/16, however its relative contribution to total agriculture only increased by approximately 8%. The production of vegetables for human consumption has decreased in the Singleton LGA over the past ten years with only a production of 3 t being reported in 2015/2016 (refer to **Table 3.4** and **Table 3.6**).

Cattle and calves in the Singleton LGA reduced by almost 30% over the 2005-2015 period. This decrease occurred in both meat and dairy cattle. The importance of gross value derived from milk production remained relatively stable while there was an increase of the percentage contribution of cattle for slaughter in the total agricultural value accounting for over 50% of the total value in 2015/2016. Stud horses were not reported in the 2015/2016 census. Between 2005/2006 and 2010/2011 there was an approximate decrease of stud horses by 30% (refer to **Table 3.4** and **Table 3.6**).

In the Muswellbrook LGA the relative importance of broadacre crops, hay and silage production and fruit and nut production for total agricultural value remained stable over the last 10 years (refer to **Table 3.5**), even though tonnes of silage produced increased by almost 30% (refer to **Table 3.7**).

[1] https://www.rba.gov.au/calculator/annualDecimal.html, accessed 23/10/2018

[2] https://www.rba.gov.au/calculator/annualDecimal.html, accessed 23/10/2018

[3] https://www.rba.gov.au/calculator/annualDecimal.html, accessed 23/10/2018

Table 3.4 Gross Value of Selected Agricultural Commodities in the Singleton LGA in 2005-2006, 2010-2011 and 2015-2016

Agricultural Commodity	2005/2006		2010/2011		2015/2016	
	Gross Value ($m)[a]	% of total agriculture	Gross Value ($m)[b]	% of total agriculture	Gross Value ($m)[c]	% of total agriculture
Total agriculture	37.1		50.9		41.2	
Broadacre crops	0.3	0.9	<0.1	<0.1	0.6	1.5
Hay and silage	2.8	7.6	3.4	6.7	5.3	12.9
Nurseries and cut flowers	0.8	2.2	0.2	0.4	<0.1	0.1
Vegetable for human consumption	2.0	5.4	1.8	3.5	<0.1	<0.1
Fruit and nuts - Grapes	2.1	5.5	0.2	0.4	0.2	0.4
Fruit and nuts - (excluding grapes)	0.3	0.9	1.4	2.8	<0.1	0.1
Livestock products Wool Milk Eggs	11.5 • No data • 11.5 • <0.1	0.9 • No data • 30.9 • <0.1	13.6 • No data • 13.6 • -	26.7 • No data • 26.7 • -	12.7 • <0.1 • 12.7 • <0.1	30.8 • <0.1 • 30.8 • <0.1
Livestock slaughtering Sheep Cattle Poultry Goats	17.4 • <0.1 • 15.4 • 1.8 • <0.1	46.9 • <0.1 • 41.6 • 4.9 • <0.1	30.5 • No data • 17.1 • 13.2 • 0.1	59.9 • No data • 33.6 • 25.9 • 0.2	22.3 • <0.1 • 22.3 • <0.1 • <0.1	54.2 • <0.1 • 54.2 • <0.1 • <0.1

Data source: [a] ABS, 2008c; ABS, 2008d; ABS, 2008e; ABS, 2008f, [b] ABS, 2012b, [c] ABS, 2017b

Table 3.5 Gross Value of Selected Agricultural Commodities in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016

Agricultural Commodity	2005/2006		2010/2011		2015/2016	
	Gross Value ($m)[a]	% of total agriculture	Gross Value ($m)[b]	% of total agriculture	Gross Value ($m)[c]	% of total agriculture
Total agriculture	34.0		38.0		33.2	
Broadacre crops	0.2	0.6	0.3	0.8	0.3	1.0
Hay and silage	4.0	11.6	3.8	10.0	3.9	11.6
Nurseries and cut flowers	0.1	0.3	0.1	0.3	No data	
Fruit and nuts - Grapes	4.2	12.4	0.9	2.4	0.4	1.2
Fruit and nuts - (excluding grapes)	1.1	3.3	1.1	2.9	0.5	1.4
Livestock products	13.1	38.6	16.6	43.7	7.4	22.4
Wool	• 0.1	• 0.2	• No data	• No data	• 0.2	• 0.5
Milk	• 13.1	• 38.4	• 16.6	• 43.7	• 7.2	• 21.7
Eggs	• 0.0	• 0.0	• No data	• No data	• 0.1	• 0.2
Livestock slaughtering	11.3	33.0	15.2	40.0	20.7	62.3
Sheep	• 0.1	• 0.4	• No data	• No data	• 0.2	• 0.5
Cattle	• 11.1	• 32.5	• 15.1	• 39.7	• 19.9	• 59.9
Poultry	• 0.1	• 0.2	• 0.1	• 0.3	• 0.6	• 1.9

Data source: [a] ABS, 2008c; ABS, 2008d; ABS, 2008e; ABS, 2008f, [b] ABS, 2012b, [c] ABS, 2017b

Table 3.6 Annual Yield and Livestock Numbers in the Singleton LGA in 2005-2006, 2010-2011 and 2015-2016

Agricultural Commodity	2005/2006[a]	2010/2011[b]	2015/2016[c]	5 Year Change		10 Year Change
				2005/2006-2010/2011	2010/2011-2015/2016	2005/2006 - 2015/2016
Broadacre crops (t)	669	46	2,614	-553	2,498	1,945
Hay and silage (t)	14,334	12,621	46,245	-1,713	33,624	31,911
Vegetables for human consumption (t)	1,615	913	3	-702	-910	-1,612
Fruit and nuts - Grapes (t)	4,522	1,861	509	-2,661	-1,352	-4,013
Fruit and nuts - (excluding grapes) (t)	127	160	56	33	-104	-71
Sheep and lambs (no.)	206	607	173	401	-434	-33
Total Cattle and calves (no.)	59,555	47,896	43,524	-11,659	-4,372	-16,031
Dairy cattle (no.)	9,345	6,629	7,464	-2,716	835	-1,881
Meat cattle (no.)	50,211	46,685	36,060	-3,526	-10,625	-14,151
Pigs (no.)	232	125	-	-107		
Goats (no.)	215	348	66	33		
Horses – Stud (no.)	932	651	-	-281	-651	-932
Horses – Other (no.)	857	806	-	-51		

Data source: [a] ABS, 2008f, ABS, 2008g, ABS, 2008h, [b] ABS, 2012a, [c] ABS, 2017b

Table 3.7 Annual Yield and Livestock Numbers in the Muswellbrook LGA in 2005-2006, 2010-2011 and 2015-2016

Agricultural Commodity	2005/2006[a]	2010/2011[b]	2015/2016[c]	5 Year Change 2005/2006-2010/2011	5 Year Change 2010/2011-2015/2016	10 Year Change 2005/2006 - 2015/2016
Broadacre crops (t)	417	835	1,247	418	412	830
Hay and silage (t)	19,976	16,707	29,215	-3,269	12,508	9,239
Vegetables for human consumption (t)	138	35		-103		
Fruit and nuts - Grapes (t)	9,330	2,819	1,229	-6,511	-1,590	-8,101
Fruit and nuts - (excluding grapes) (t)	233	444		211		
Sheep and lambs (no.)	2,517	2,957	5,006	440	2,049	2,489
Total Cattle and calves (no.)	46,166	45,046	38,748	-1,120	-6,298	-7,418
Dairy cattle (no.)	10,421	10,546	3,484	125	-7,062	-6,937
Meat cattle (no.)	35,745	34,500	35,264	-1,245	764	-481
Pigs (no.)	1,211	16	16	-1,195		-1,195
Goats (no.)	374	128	43	-246	-85	-331
Horses – Stud (No.)	2,630	3546		916		
Horses – Other (No)	605	517		-88		

Data source: [a] ABS,2008g; ABS, 2008h, [b] ABS, 2012a, [c] ABS, 2017c

Grape production and income generated through viticulture decreased markedly over the 2005 – 2015 period in both the Singleton and Muswellbrook LGAs. In the Singleton LGA in 2005/06 grape production contributed to 6% of total agriculture production of 4,522 t and a yield of 5.2 t/ha. In 2010/11 this markedly decreased to less than 1% of the total agriculture industry, yielding 1,861 t and 3.4 t/ha productivity. The annual yield decreased further in 2015/16 to 509 t whilst continuing to contribute to the total agriculture by less than 1% (refer to **Table 3.8**).

In the Muswellbrook LGA in 2005/2006 a total of 9,330 t of grapes were produced with an average yield of 6.5 t/ha. Grape production decreased by approximately 70% in 2010/2011 to 2,819 t with an average yield of 3.2 t/ha and by a further 56% in grape production in 2015/2016 (refer to **Table 3.8**). Gross value generated from grapes decreased from $4 M to $0.4 M over the 2005-2015 time period.

The reduction in grapes across the two LGAs may partly be caused by the grape oversupply between 2000 and 2008, which coincided with a high Australian dollar impacting export market demands (DPI, 2013b).

Table 3.8 Grape Production in the Singleton and Muswellbrook LGAs

Census Year	Singleton LGA			Muswellbrook LGA		
	Grape Production (t)	Grape Growing Area (ha)	Grape Yield (t/ha)	Grape Production (t)	Grape Growing Area (ha)	Grape Yield (t/ha)
2005/2006[a]	4,522	864	5.2	9,330	1,446	6.5
2010/2011[b]	1,861	547	3.4	2,819	883	3.2
2015/2016[c]	509	158	3.2	1,229	190	6.4

[a] ABS,2008g, [b] ABS, 2012a, [c] ABS, 2017c

In the Singleton LGA, 78% of the total agriculture gross value was produced by livestock in 2005/2006 which increased to 85% in 2015/2016. Generally, livestock for slaughter had a higher significance in generating value, with over 50% of the total agriculture gross value being generated by cattle for slaughter alone in 2015/2016. The relative importance of gross generated by milk production remained stable at approximately 30% of the total gross value. The total gross value increased from $12 M in 2005/2006 to $13 M in 2015/2016, which is a decrease in value generated by this sector if inflation in taken into account (refer to **Table 3.4**). The number of dairy cattle in the Singleton LGA decreased by approximately 20% over the 2005-2015 period (refer to **Table 3.6**).

In the Muswellbrook LGA, the importance of livestock, both for product and for slaughter, for agriculture has increased from a combined 72% in 2005/2006 to 86% in 2015/2016. In 2005/2006 and 2010/2011, livestock product and livestock for slaughter had a similar share of the agricultural gross value, whereas in the latest survey, the importance has shifted towards livestock for slaughtering (refer to **Table 3.5**)**.**The number of dairy cattle has decreased by over 60% in the last decade, which was accompanied by a strong decrease in gross value of milk production (refer to **Table 3.5**).

3.2.2 Agricultural communities

Farm holdings make up 21% of the Singleton LGA, while the agricultural sector employed 4% of the workforce in 2011. Mining on the other hand employed 25% of the workforce[4]. Data for agricultural employment from the 2016 census was not available. Coal mining employed 17% in 2006 and 22% of the workforce in 2016[5].

For the Muswellbrook LGA, 36% of the LGA is taken up by farm holdings but only 7% of the working population was employed in the agricultural sector in 2011. Of this, 3% were working in the horse farming industry[6]. The working population employed by the agricultural sector remained steady at 7% in 2016. Coal mining on the other hand accounted for 20% of the working population in 2016, which has increased from 14% in 2006[7] and 19% in 2011[8].

Table 3.9 presents farm demographics in the Singleton and Muswellbrook LGAs (region plus town) in 2015/2016. There are approximately 132 and 145 people who work on the farm they own in Singleton and Muswellbrook LGAs, respectively. However, only 14 employees or contractors are working on farms in the Muswellbrook LGA and five in the Singleton LGA. A total of 10 workers were neither the owner nor an employee on the farm they worked for both LGAs combined. The majority of the income of the farm workers is derived from farming.

The average age of the farm worker in Muswellbrook region and town is 59 and 61 years respectively. In Singleton this is 62 years in the region and 60 in Singleton town. This indicates an aging workforce. This is consistent with the average age of farm workers in the Hunter Valley (excl. Newcastle) (60 years) and NSW (59 years). In the Muswellbrook region, 20% of the income is generated by employment or activities outside of the farm, which is also found to be the case in Singleton region and town (19%), in the Hunter Valley (excl. Newcastle) (19%) and slightly above the percentage recorded for NSW (13%) (refer to **Table 3.9**).

It is noted that the 2016 census was undertaken in May, and as a result many seasonal picking and pruning employment options are not captured by the data presented.

[4] http://stat.abs.gov.au/itt/r.jsp?RegionSummary&region=17000&dataset=ABS_REGIONAL_LGA&geoconcept=REGION&datasetASGS=ABS_REGIONAL_ASGS&datasetLGA=ABS_NRP9_LGA&regionLGA=REGION&regionASGS=REGION, accessed 19/12/2018

[5] http://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA17000?opendocument#employment, accessed 19/12/2018

[6] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA15650?opendocument, accessed 19/12/2018

[7] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2006/quickstat/LGA15650?opendocument, accessed 19/12/2018

[8] http://www.censusdata.abs.gov.au/census_services/getproduct/census/2011/quickstat/LGA15650?opendocument, accessed 19/12/2018

Table 3.9 Farm Demographics in the Singleton and Muswellbrook LGAs

Description	Singleton Region	Singleton Town	Muswellbrook Region	Muswellbrook Town	Hunter Valley (excl. Newcastle)	NSW
Owner operator (no.)	132	np	129	16	973	23,216
Contractor/employee (no.)	5		14	np	79	917
Other relationship to business (no.)	6	np	4	np	48	832
Males (no.)	107	21	106	12	820	19,718
Females (no.)	37	6	37	7	292	5,512
Average age - all persons (yrs)	62	60	59	61	59	57
Age of male provider - Average age (yrs)	63	59	61	60	60	58
Age of female provider - Average age (yrs)	63	68	52	62	57	56
Years involved in farming - Average years (yrs)	40	39	36	43	36	36
Income generated by agricultural production on holding - Average percentage (%)	72	67	75	82	75	82
Income through grants, government transfers, relief funding - Average percentage (%)	np	0	np	0	1	<1
Income generated by off-farm employment/business activities - Average percentage (%)	19	19	20	np	19	13
Other funding sources - Average percentage (%)	7	14	np	np	5	4
Income source not stated - Average percentage (%)	np	0	0	0	1	<1

np – not available for publication

Data source: ABS, 2017d

3.2.3 Supporting infrastructure

Both the Muswellbrook and Singleton LGAs have a well-developed road network that connects the agricultural industry to markets, services and suppliers. Road services range from the New England Highway and Golden Highway to local unsealed and sealed roads. The Main Northern Railway also provides connections to northern and southern centres for freight and passengers. The main agricultural service centres are Singleton and Muswellbrook.

Livestock farming for slaughter has the highest importance for agriculture in the Singleton and Muswellbrook LGAs, whereas farming of livestock for product, such as dairy, has been declining (refer to **Table 3.5** and **Table 3.6**).

Regional livestock saleyards are located in Singleton, Maitland, Scone and Mudgee. Abattoirs are located in Scone and Singleton. Additional abattoirs can be found in Dubbo, Tamworth and Sydney. A further abattoir and a feedlot facility is proposed to be developed near Denman (Yarraman Abattoir and Feedlot). This facility is intended to process 500,000 head of cattle and 1,000,000 head of sheep per year (KMH, 2016).

In 2013, the majority (90%) of dairy produced in the Upper Hunter Region was processed in Sydney, with the remainder being processed in Hexham and on the North Coast (DPI, 2013e). This reinforces the importance of a high-quality road network for the dairy industry.

3.2.4 Agriculture in the Project locality

Large areas within the Project Locality are owned by various mining companies and used for mining activities. The prevailing agricultural land use is cattle grazing, predominantly on areas cleared of vegetation as a result of historic agricultural use.

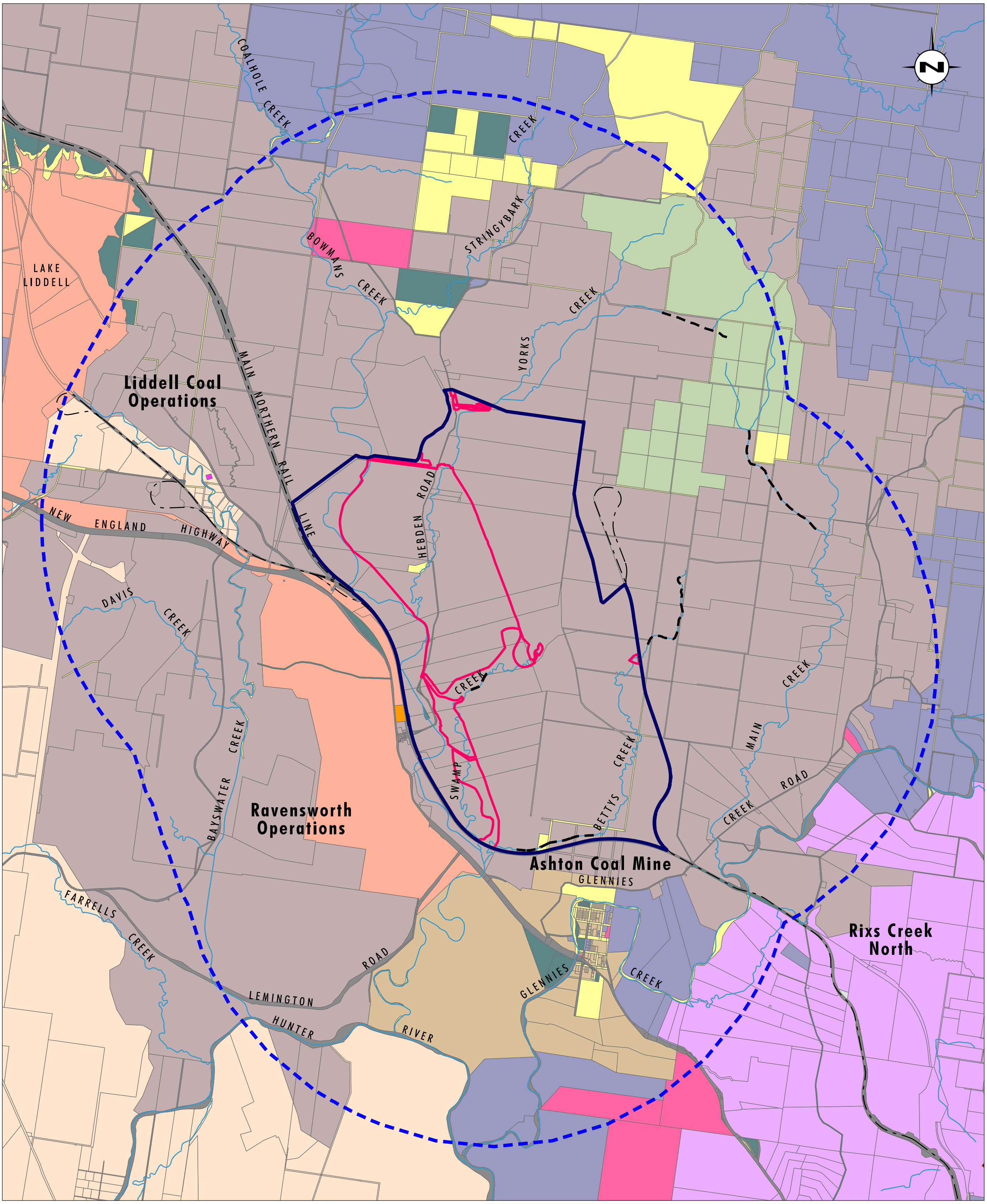
Small areas on the eastern and western side of Bowmans Creek have historically been used for cropping. However, the area is now used for cattle grazing.

There is approximately 2,920 ha of BSAL mapped (as per the regional Upper Hunter SRLUP mapping) within the Project Locality along parts of the floodplains of Glennies Creek, Bowmans Creek, Swamp Creek, Bettys Creek, Main Creek and the Hunter River. Some of the mapped BSAL occurs on areas currently disturbed by active mining operations within the Project Locality. There are no viticulture or equine CICs mapped in the Project Locality. There are no vineyards or horse studs within or in the vicinity of the Project Locality.

Some areas of higher soil quality are used for grazing on modified pastures. Cropping is carried out in scattered locations along the floodplains of Glennies Creek and the Hunter River. A disused olive grove is located in the eastern part of the Project Locality on Glencore owned land.

The majority of the land in the Project Locality is owned by Glencore and other mining operations (refer to **Figure 3.1**). Private landowners are located in the south, southeast and north, associated with the communities of Camberwell, Glennies Creek, Middle Fallbrook and Hebden. Further, there are several Crown land parcels and roads in the Project Locality as well as the Ravensworth State Forest.

umwelt



Data Source: Glencore (2019), OEH (2018)

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion
- AGL Macquarie
- Ashton Coal
- Bloomfield Collieries
- Crown Land
- Daracon
- Ausgrid
- Glencore
- Government Authority
- Hunter Valley Operations
- Private
- State Forest
- Private Vacant Land (Acquisition Rights)
- Telstra

FIGURE 3.1

Land Ownership in the Project Locality and Project Area

File Name (A4): R10/4166_291.dgn
20191126 15.34

3.2.5 Agriculture in the Project Area

Land within the Project Area not utilised for mining operations are currently utilised for cattle grazing. Colinta manages the buffer land surrounding the Mount Owen Complex used for agricultural purposes, including the Project Area. The Project Area has been destocked to 40 head of cattle to accommodate for the current drought conditions (during non-drought conditions up to 100 head of cattle are run within the Project Area). The cattle are watered through surface dams or pumped groundwater. No additional feeding is carried out.

Currently, the Project Area is not fertilised, and no other land improvement strategies are carried out. Erosion does occur on steeper slopes as well as on some floodplains where sodic soils are present (refer to **Plates 3.1** and **3.2**).

Cattle turned off from the Project Area are sold as feeders or re-stock at the Singleton saleyard. In non-drought years, approximately 50 weaners (300-350 kg on average) are turned off from the Project Area. **Table 3.10** shows average sale prices for yearling cattle (280-330 kg) at the Singleton saleyard for feeders and re-stock. The three year average price per head is clearly driven by a drop in price due to drought conditions. Drought conditions were declared in the Project Area in April 2018, which is reflected in sale prices. Based on the 2016/2017 average sale price the 50 cattle turned off would be sold for a maximum of $55,495 (50 vealer steer feeder) and a minimum of $51,520 (50 vealer heifer feeder). In 2017/2018 period, average prices have decreased to a maximum of $42,275 (50 vealer steer feeder) and a minimum of $36,490 (50 vealer heifer feeder).

Plate 3.1 Gully erosion on hillslope

Plate 3.2 Yorks Creek gully erosion in floodplain

Table 3.10 Average Price Per Head for Vealer Cattle Sold at the Singleton Saleyard[9]

Category	Type	Time period	$/head	Number of Cattle Sold
Vealer Steer (280-330 kg)	Feeder	3 year average	911	664
		August 16 - June 17	1,110	124
		August 17 - June 18	921	154
		June 18 - June 19	845	386
	Re-stocker	3 year average	938	2,850
		June 16 - June 17	1,103	1,467
		June 17 - June 18	915	862
		June 18 - June 19	778	521
Vealer Heifer (280-330 kg)	Feeder	3 year average	814	372
		August 16 - June 17	1,030	49
		July 17 - July 18	791	56
		August 18 - June 19	730	267
	Re-stocker	3 year average	889	1,038
		June 16 - June 17	1,036	571
		June 17 - June 18	811	298
		June 18 - June 19	703	169

[9] https://www.mla.com.au/prices-markets/market-reports-prices/, accessed 30/05/2019

4.0 Agricultural resources

The following section discusses the agricultural resources in the Project Locality and more specifically within the Project Area as defined in **Section 1.2** and shown in **Figure 1.2**. The data used in this section has been sourced from publicly available and site-specific information.

4.1 Agricultural resources within the Project locality

At a 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). (2017). Land and Soil Capability Mapping
- Contour mapping at 1:25,000
- Rainfall and climate statistics released by Bureau of Meteorology (BoM)
- Water Sharing Plan for the Hunter Regulated River Water Source 2003 and Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009.

This section discusses how these regional studies apply to the context of the Project Locality. Further site-specific data collected during the preparation of the EIS for the Project relevant to the agricultural resources of the Project Area is also discussed.

4.1.1 Climate

Climate measurements including monthly rainfall distribution, evaporation, as well as maximum and minimum temperatures provide a key determinant of the agricultural potential of a locality. Temperature data has been obtained from the BoM maintained Singleton STP from the period 2002 to 2019 and rainfall and evaporation data has been obtained from the Scientific Information for Landowners (SILO) database of historical climate records for Australia (DSITI, 2015). A summary of the mean climate statistics for the Mount Owen Complex (rainfall and evaporation) and Singleton (temperature) is shown in **Table 4.1**.

Table 4.1 Mean Climate Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C) (Singleton STP (BOM 2002 – 2019)													
Mean Max	32.1	30.7	28.3	24.9	21.6	18.1	18.0	20.0	23.5	26.3	28.8	30.3	25.2
Mean Min	17.9	17.5	15.2	11.3	6.9	6.0	4.3	4.3	7.2	10.4	13.9	16.1	10.9
Rainfall and Evaporation (SILO 1900 – 2018)													
Mean rainfall (mm)	78.1	74.8	65.9	53.2	44.3	52.1	43.1	37.3	41.3	50.9	60.9	69.1	671.0
Mean evaporation (mm)	204.5	161.4	142.9	103.6	72.5	55.2	63.9	89.4	119.6	156.1	177.0	210.0	1,556.2
Evap minus rainfall	126.4	86.6	77.1	50.4	28.2	3.1	20.8	52.1	78.3	105.2	116.2	140.9	885.1

The rainfall of the Upper Hunter is summer dominant with 33% of rainfall occurring in the three months December to February, compared with 18% falling in the three months June to August. 61% of rain falls from October to March inclusive.

The prevailing winds are from the northwest direction during the winter months, and then predominantly from the southeast during the summer months. Generally, wind speed is greatest from late winter through the spring with lighter winds occurring in autumn.

The climate of the central parts of the Hunter region is variable year on year and decade to decade. Inter-decadal variability is associated with the Southern Oscillation Index (La Niña-like and El Niño-like periods). Examples of extended periods within the Hunter region 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 Hunter region is affected by extreme rainfall and temperature events. These events can have major impacts 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. The majority of the extreme rainfall events have occurred during the summer months (24-hour rainfall events) the top five events at the Singleton STP station during the 2002 to 2019 timeframe occurred in April 2015 (130 mm), February 2013 (85 mm), February 2009 (96 mm), June 2007 (101 mm) and February 2004 (84 mm). As previously discussed, the Hunter region is currently subject to drought conditions with daily rainfall not exceeding 50 mm during the summer months in 2017 and 2018 and 10 mm during the winter months.

Despite recent drought conditions, 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 continue to rely on irrigation to provide consistent productivity in this climate (particularly during drought conditions) where there can be significant gaps between rainfall events and the evaporation rate is relatively high.

4.1.1.1 Potential impact of climate change

The NSW Government modelled climate change for the near future (2020-2039) and the far future (2060-2079) across NSW[10]. Climate change modelling for the Project Locality and Project Region predict that in the near future average temperatures will increase by less than 1°C. In the far future, this increase is predicted to be approximately 2°C. In the near future, more than seven additional days exceeding 35°C are expected. This will increase to an additional 20 days in the far future. Nights with less than 2°C are anticipated to decrease by two to three days per year in the near future. This decrease of cold nights is expected to increase to five nights in the far future.

[10] https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Interactive-map, accessed 05/06/2019

Annual daily average rainfall has been modelled to increase by approximately 2% in the near future. The increase of precipitation is modelled to occur in autumn (13% increase of average daily precipitation). Average daily precipitation is expected to decrease by 3% in both summer and winter, while spring precipitation may decrease or increase by less than 1%.

In the far future, annual daily average precipitation is expected to increase by 7%. Seasonally, average daily winter precipitation is modelled to decrease by approximately 3%. Average daily spring precipitation is predicted to slightly increase by 2%, in summer this increase grows to 8% and in autumn the largest increase to the average daily precipitation is anticipated (13%).

Days with a Forest Fire Index (FFDI) >50 are predicted to increase by less than one day in both the near future and far future.

The increase in temperature, specifically the increase in days over 35°C, in addition to predicated increase of average daily precipitation in summer in the far future may lead to an increase of heat stress in cattle.

The decrease of nights with less than 2°C may cause an increase of crop pathogens as fewer frost events may not be sufficient to reduce pests and pathogens.

4.1.2 Topography

The topography of the Project Locality is characterised by an undulating hilly landscape, gently sloping alluvial plains associated with stream floodplains and large areas of manmade disturbance to the natural topography due to agricultural land uses and more recently coal mining.

Highest elevations and steepest slopes are situated in the north eastern extent of the Project Locality associated with the Ravensworth State Forest. Elevations in this part of the Project Locality range from approximately 460 m to 170 m. A distinctive ridgeline runs approximately from north to south in this area.

The southern part of the Project Locality is defined by the Hunter River, Bowmans Creek and Glennies Creek floodplains, with elevations ranging from approximately 110 m to 60 m along the waterways. Slopes in this area are gently sloping to flat.

Large areas of the Project Locality have been disturbed by mining operations, creating artificial low points associated with voids and high points relating to overburden dumps.

4.1.3 Soil and land resources

The following publicly available soil information for the Project Locality was reviewed for this section

- Australian Soil Classification (ASC) soil mapping (1: 250,000 scale) (OEH, 2012)
- Land and Soil Capability Mapping for NSW (1: 250,000 scale) (OEH, 2017)
- Soil landscapes of the Singleton 1: 250,000 scale sheet (Kovac and Lawrie, 1991)
- Soil and Land Resources of Central and Eastern NSW (1: 100,000 scale) (OEH, 2018).

The majority of the Project Locality is covered by the Bayswater and the Liddell soil landscapes, which have the Land and Soil Capability (LSC) Class 6 and Class 5, respectively. Areas associated with the Bowmans Creek, Glennies Creek and Hunter River floodplains have been mapped as Hunter soil landscape, which has the LSC Class 3 (refer to **Table 4.2 , Table 4.3, Figure 4.1** and **Figure 4.2**). Based on the mapping, the majority of the Project Locality has severe to very severe limitations to high impact. The Bayswater soil landscape (LSC Class 6) is suited to lower impact land uses, such as grazing. The Liddell soil landscape (LSC Class 5) can only be used for low intensity grazing due to the higher limitation of the land.

The soil landscape mapping was undertaken prior to the disturbance associated with some of the mining operations within in the Project Locality. As such some limitations, mining and mine rehabilitation are not captured.

Large areas of LSC Class 5 and LSC Class 6 land is currently used for mining purposes, either active mining or mine rehabilitation. Additional land uses are grazing or forestry. Small areas along Glennies Creek and Hunter River (LSC Class 3) are used for cropping.

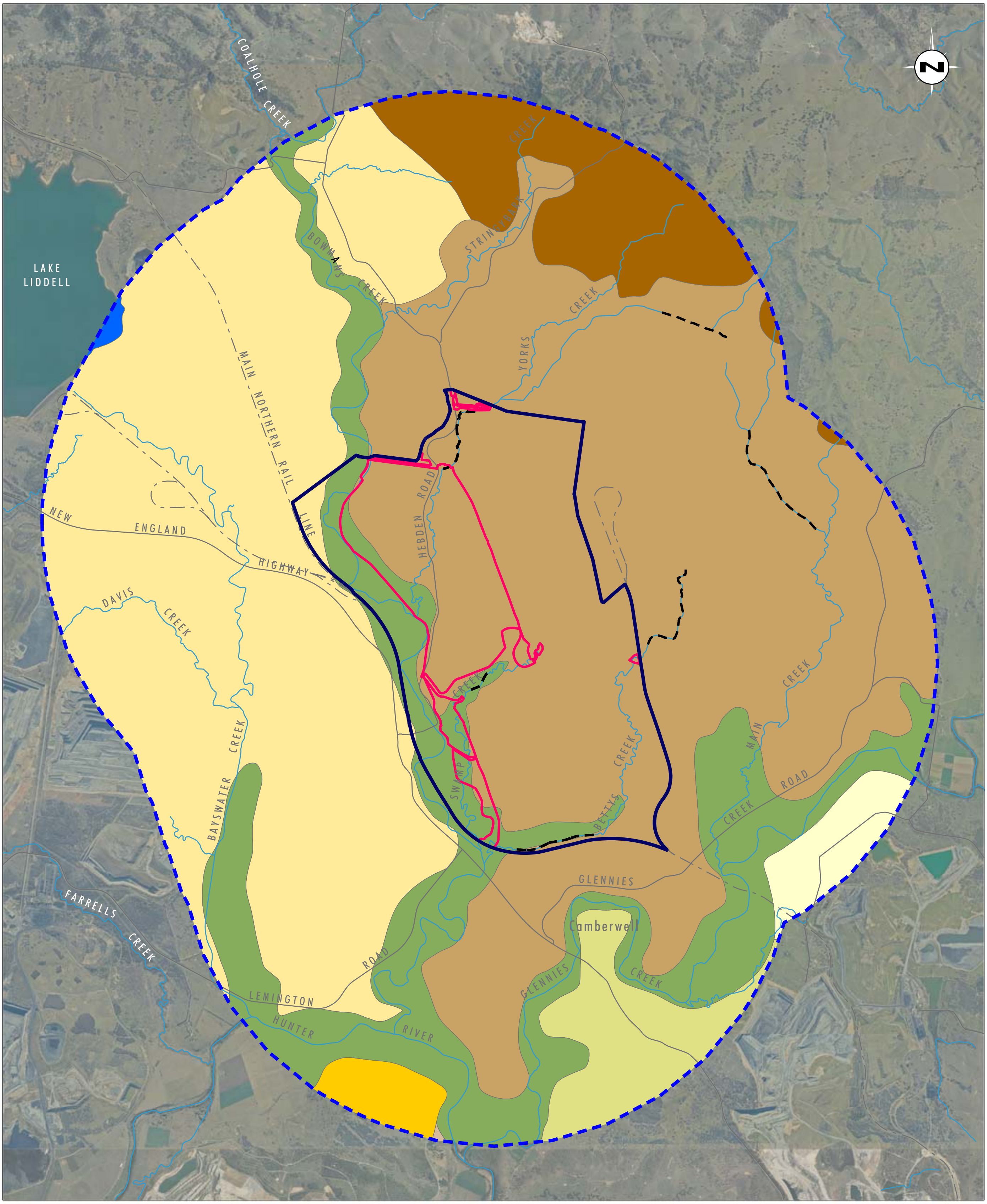


Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), NSW Department of Planning and Infrastructure (2013)

0 1 2 4km

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion

Soil Landscapes:

- Hunter Soil Landscape
- Branxton Soil Landscape
- Greenland Soil Landscape
- Liddell Soil Landscape
- Roxburgh Soil Landscape
- Sedgefield Soil Landscape
- Jerrys Plains Soil Landscape
- Bayswater Soil Landscape
- Rosevale Soil Landscape

FIGURE 4.1

Soil Landscapes in the Project Locality

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20191001 9.39

Table 4.2 Soil Landscapes, Great Soil Group, Australian Soil Classification and Land and Soil Capabilities in the Project Locality

Soil Landscapes[1]	Landform[1]	Great Soil Group[1]	Limitations of Soil Landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Rosevale	Rolling hills ranging with moderately inclined to steep slopes, 100-400 m in length, and high relief. Elevation from 180 – 600 m.	• Red and brown podzolic soils are the main soils are on upper to lower slopes and on the steeper sections of footslopes. • Euchrozems occur on upper slopes. • Yellow Soloths can be found on midslopes on dacitic ignimbrite. • Chocolate Soils are present on slopes of Woolooma Formation. • Lithosols (shallow clays and sands) can be found on upper slopes of the Isismurra Formation. • Brown Earths occur on mid to lower slopes of the Isismurra Formation.	• moderate to very high erosion hazard • low to high structural degradation hazard • moderate to high mass movement hazard • shallow to very deep soil depth • rock outcrop is common in some areas.	Dermosol	7
Liddell	Undulating low hills with a few undulating hills (elevation from 140 – 220 m) and low to high local relief. Slopes are gently and have long slope lengths. Local relief is 60 – 120 m.	• Yellow Soloths are the main soils on slopes. • Some Yellow Solodic Soils can occur on concave slopes. • Earthy and Siliceous Sands can be found on mid to lower slopes where the parent material is sandier. • Some Red Soloths, Red Solodic Soils and Red Podzolic Soils also occur.	• high to very high erosion hazard • moderate to high structural degradation hazard • low mass movement hazard • moderate to very deep soil depth.	Kurosol, natric	5

Soil Landscapes[1]	Landform[1]	Great Soil Group[1]	Limitations of Soil Landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Hunter	Plains, 200 - 3200 m wide, and river terraces of the Hunter River with elevations of 20 - 60 m. Slopes are level to very gently inclined (0 - 3%). Local relief is extremely low.	• Brown Clays and Black Earths on prior stream channels and on tributary flats. • Chernozems can be located on prior stream channels. • Alluvial Soils occur on levees and flats adjacent to the present river channel. • Red Podzolic Soils and Lateritic Podzolic Soils are located on old terraces. • Non-calcic Brown Soils and Yellow Solodic Soils are present in some drainage lines.	• moderate to high erosion hazard • moderate to high structural degradation hazard • nil to low mass movement hazard • moderate to very deep soil depth.	Tenosol (Alluvial)	3
Bayswater	Undulating low hills, between 140 - 220 m high, with gently inclined slopes (3 - 10%) and low relief (40 - 60 m). Slope lengths averaging 1,200 m.	• Yellow Solodic Soils are the main soils on slopes. • Alluvial Soils occur in drainage lines. • Brown and Yellow Earths and Prairie Soils are present in some drainage lines. • Red and Yellow podzolic soils and Brown Podzolic Soils occur on slopes. • Yellow Solodic Soil - Red-brown Earth intergrades can also occur.	• moderate to extreme erosion hazard • moderate to high structural degradation hazard • low mass movement hazard • shallow to very deep soil depth.	Sodosol	6
Branxton	Undulating rises to low hills and creek flats. Gently included slopes with slope lengths up to 600 m. Elevations range from 50 - 80 m, Local relief is very low to low.	• The main soils are Yellow Podzolic Soils on midslopes. • Red Podzolic Soils occur on crests. • Yellow Soloths occur on lower slopes and in drainage lines. • Alluvial Soils can be found in some creeks. • Siliceous Sands can be present on flats within large valleys.	• high erosion hazard • moderate to high structural degradation hazard • nil mass movement hazard • moderate to deep soil depth • Some acid topsoil problems are encountered in the area.	Kurosol, natric	4

Soil Landscapes[1]	Landform[1]	Great Soil Group[1]	Limitations of Soil Landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Roxburgh	Undulating low hills and undulating hills (elevations 80 – 370 m) with level to gently inclined slopes and medium to long slope lengths. Local relief is low to high.	• Yellow podzolic soils occur on upper to midslopes. • Red solodic soils can be present on more rounded hills. • Lithosols occur on crests. • Brown podzolic soils occur on slopes on conglomerate with associated flat pavements. • Yellow soloths have been recorded in some gullies.	• moderate to high erosion hazard • high structural degradation hazard • low mass movement hazard • shallow to very deep soil depths.	Kurosol	5
Sedgefield	Undulating low hills with gently inclined slopes and medium slope lengths. Elevations range from 60 – 170 m and local relief is low.	• Yellow Soloths can be found on upper to midslopes. • Yellow Solodic Soils occur on lower slopes and in drainage lines. • Black Soloths may also occur in area of seepage on the slopes.	• high to extreme erosion hazard • moderate to high structural degradation hazard • nil mass movement hazard • moderate to deep soil depths • salting is evident in some of the drainage lines.	Kurosol, natric	5

Soil Landscapes[1]	Landform[1]	Great Soil Group[1]	Limitations of Soil Landscape[1]	Australian Soil Classification[2]	Land and Soil Capability Class[3]
Jerrys Plains	Undulating low hills (elevation 80 - 180 m) with very gently inclined to gently inclined slopes. Slope lengths are moderate to long and the local relief is low.	• Soloths are the main soils occurring on on the crests to midslopes. • Solodic Soils can be found on the lower slopes and in drainage depressions. • Brown Clays occur in midslope depressions. • Solodised Solonetz occur on slopes where drainage is severely impeded by bedrock. • Red Earths can be found on upper slopes with some Euchrozem - Yellow Solodic Soil intergrades. • Areas of severe salting can occur in many of the drainage lines	• moderate to very high erosion hazard • moderate to high structural degradation hazard • low mass movement hazard • moderate to very deep soil depths • salting is evident in some of the drainage lines.	Sodosol	5

[1] Kovac and Lawrie, 1991, [2]OEH, 2013, [3] OEH, 2012

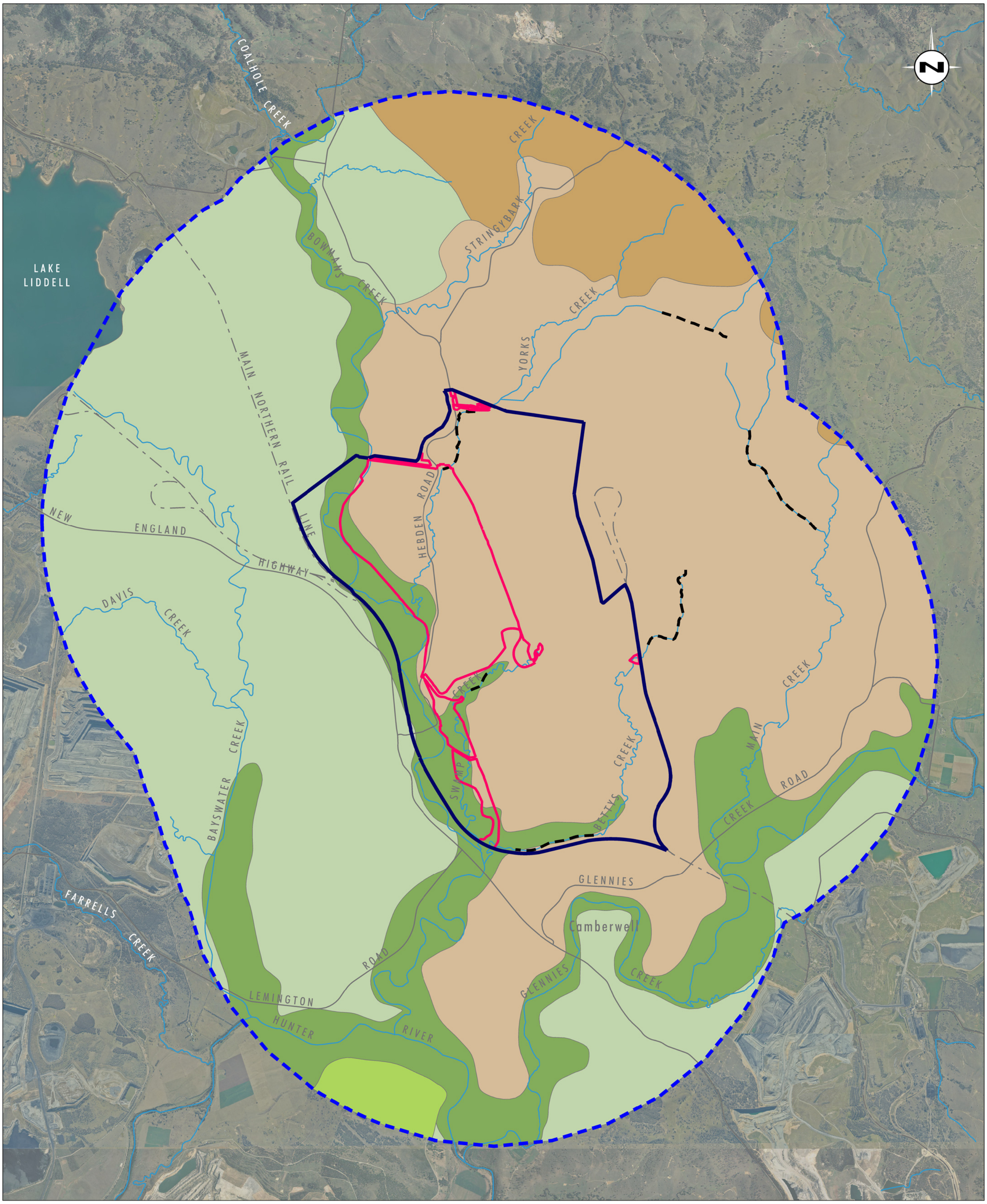

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), OEH (2019)

0 1 2 4km

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion

Soil and Land Capability:

- Class 3
- Class 4
- Class 5
- Class 6
- Class 7

FIGURE 4.2

Land and Soil Capability Classes in the Project Locality (Pre Mining)

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20190802 13.24

Table 4.3 Land and Soil Capability Classes and Size in Project Locality

Land and Soil Capability Class[1]	LSC Definition	Area in Project Locality (ha)
1	Extremely high capability land: Land has no limitations and is capable of all rural land uses and land management practices. No special land management practices required.	0
2	Very high capability land: Land has slight limitations and is capable of most land uses and land management practices. Limitations can be managed by easily implemented management practices.	0
3	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, if more intensive and widely accepted management practices are in place. Careful management of limitations is required for cropping and intensive grazing to avoid degradation.	2,916
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. Limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.	188
5	Moderate–low capability land: Land has high limitations for high-impact land uses. Land use is restricted to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.	6,965
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.	7,868
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.	1,096
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.	0
9	Water	23

[1]OEH, 2012a

In 2018 OEH undertook reconnaissance soil landscape assessment mapping at 1:100,000 scale (OEH, 2018). This, more detailed, mapping identified 13 Soil and Land Resource (SLR) units and one variant in the Project Locality, refer to **Figure 4.3**.

Over a third of the Project Locality (6,769 ha, 36%) has been identified as land disturbed by active mining or mine rehabilitated land. Almost a third of the Project Locality has been mapped as the Ravensworth SLR unit (30%). Limitations to cultivation for most SLR units are high to extreme. Only the Foy Brook and Singleton SLR units have slight to high limitations to cultivation and the Paterson River SLR unit has moderate limitations. These SLR units are associated with the Bowmans Creek, Glennies Creek and Hunter River floodplains. If it is assumed that the complete SLR units would be used for cropping, a conservative estimate as they include the streams and stream banks, 2,401 ha (13%) of the Project Locality is suitable for cropping. The majority of the Project Locality (11,165 ha, 59%) is best suited for grazing, with the main limitation to grazing being erosion and salinity. A total of 29% of the Project Locality is unsuitable for agricultural purposes (refer to **Table 4.4**).

Table 4.4 Summary of Soil and Land Resource (SLR) Units in the Project Locality and Limitations to land Use Practices (based on OEH, 2018)

SLR unit	Limitation to Cultivation	Limitation to Grazing	Area (ha)
Foy Brook	Slight to high	Slight to moderate	1,160
Singleton	Slight to high	Slight to moderate	340
Paterson River	Moderate	Slight to moderate	900
Isis	Moderate to high	Low to moderate	518
Gundy Gundy	High	Low	285
Waverly	High	Moderate	33
Donalds Gully	High to very high	Moderate to high	1,236
Ravensworth	High to very high	Moderate to high	5,692
Warkworth	High to very high	Moderate to high	71
Goorangoola	Very high	Moderate	194
Disturbed Terrain variant a	Very high to extreme	Moderate to high	2,220
Granbalang	Very high to extreme	Moderate to high	916
Foy Pinnacle	Extreme	High	894
Disturbed Terrain	Not assessed	Not assessed	4,549

A brief summary of each SLR unit is provided in **Table 4.5**.

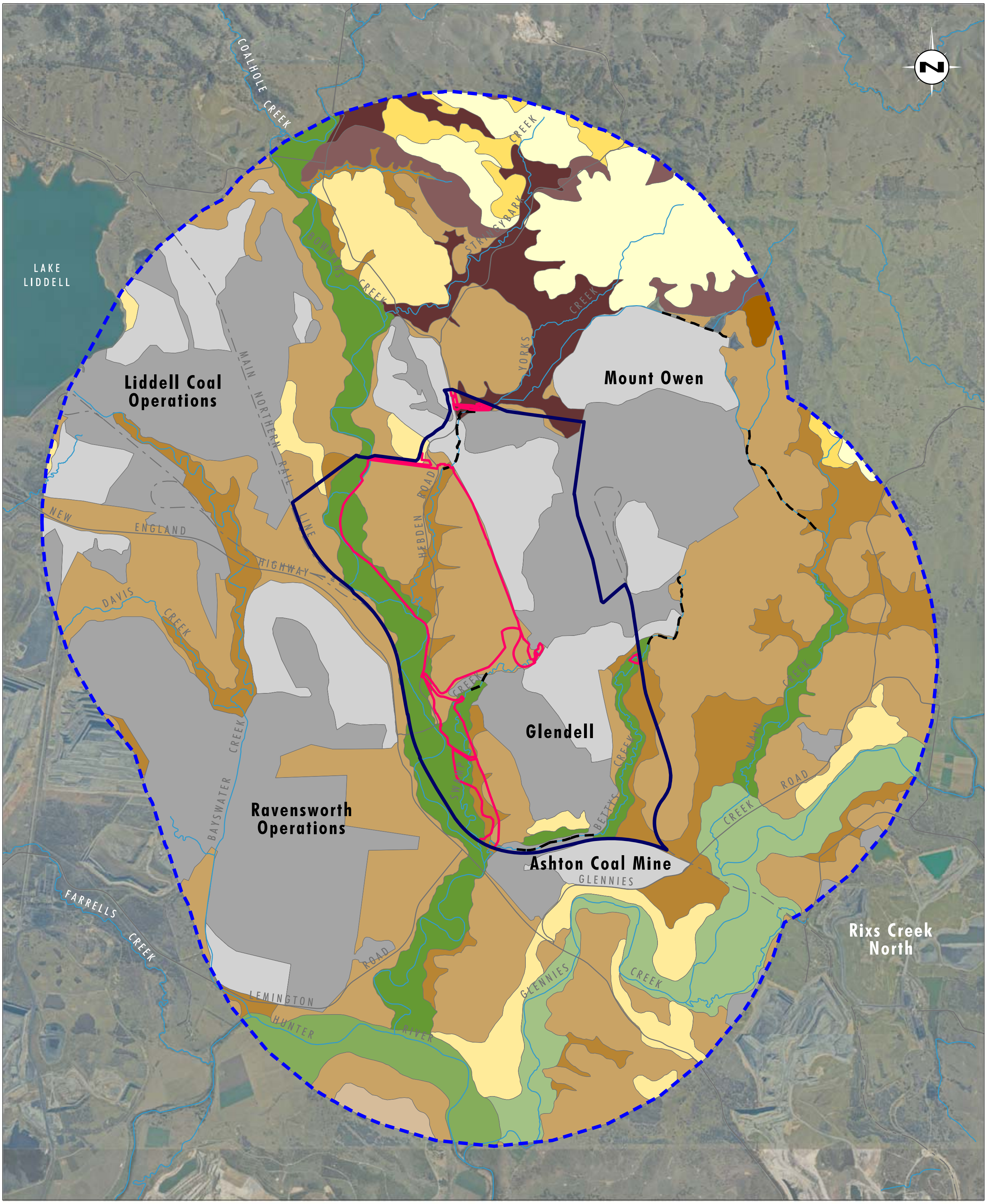

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), OEH (2018)

0 1 2 4 km

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion

Soil and Land Resource:

- Foy Brook
- Singleton
- Paterson River
- Disturbed
- Disturbed Terrain Variant a
- Isis
- Gundy Gundy
- Waverly
- Donalds Gully
- Ravensworth
- Warkworth
- Goorangoola
- Granbalang
- Foy Pinnacle

FIGURE 4.3

Soil and Land Resources in the Project Locality

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Table 4.5 Soil and Land Resource (SLR) Unit Description Summaries

SLR unit	Description
Disturbed Terrain and Disturbed Terrain variant A	In the Project Locality Disturbed Terrain relates to areas disturbed by coal mining, Disturbed Terrain variant A are areas of reshaped and revegetated land associated with mine spoil. Slopes and local relief vary depending on operation and stage of mine. Soils of the Disturbed Terrain variant A are Spolic Anthroposols and Scalpic Anthroposols. For the Disturbed Terrain variant A the limitations to grazing are rated as moderate to high and limitations to cultivation are rated as very high to extreme. This SLR unit takes up 4,549 ha (24%) and variant A 2,220 ha (12%) of the Project Locality.
Donalds Gully	Donalds Gully is associated with gently undulating plain to undulating rises comprising footslopes, drainage plains and alluvial fans on Permian Wittingham Coal Measures. Slopes are gentle (1-5%) and local relief is low. Soils in the SLR unit are moderately deep to deep, imperfectly to poorly drained Brown, Yellow and Grey Sodosols and Natric Kurosols, moderately deep to very deep, imperfectly drained Chromosols. Soil with higher fertility may occur on some slopes due to the influence of calcareous or carbonaceous sediments or basalt. These soil types range between moderately deep to deep, moderately well-drained to imperfectly drained Red Dermosols and Chromosols, Hypocalcic Calcarosols, Red and Brown Vertosols and Black Dermosols. This SLR unit is mostly used for grazing of beef, sheep and horses on native pasture. Land degradation included extensive, minor sheet erosion, rare occurrences of moderate sheet and gully erosion and localised saline outbreaks. Limitations to grazing are rated moderate to high and limitations to cultivation are rated high to very high. This SLR unit takes up 1,236 ha (6%) of the locality.
Foy Brook	Foy Brook occurs level to gently undulating plains (100 - 500 m wide), terraced plains and open depressions derived from of Quaternary alluvial sand, silt and clay. Slopes are level (0 - 3%), local relief is extremely low. Soils of this SLR unit are moderately deep to deep, moderately well-drained to well-drained Brown Kandosols and Brown Dermosols; deep to very deep, moderately-well drained Brown Dermosols and Kandosols and deep to very deep, poorly drained Brown Sodosols and imperfectly drained Brown Kurosols. Foy Brook is used for grazing on native and improved pastures on floodplains and terraces. The gravelly channel bars are unused. Streambank erosion is common, flood scour and sediment deposition occur on some inset floodplain surfaces. Limitations to grazing are slight to moderate and limitations to cultivation are rated slight to high. This SLR unit takes up 6% or 1,160 ha of the Project Locality.
Foy Pinnacle	Foy Pinnacele is associated with steep to very steep hills on Carboniferous sediments. Slopes are moderately inclined to steep, local relief is high and elevation ranges from 200 – 700 m. Abundant rock outcrop is common and talus slopes beneath cliffs can occur occasionally. The soils found on this SLR unit are shallow, well-drained stony Lithosolic Clastic Rudosols and Paralithic Chernic-Leptic Tenosols and shallow to moderately deep, moderately well-drained Brown Kurosols, Brown Dermosols and Red Dermosols. Foy Pinnacle is partly cleared for grazing, but sheet erosion is evident on cleared and overgrazed slopes. Rockslides and landslips can be present. Limitations to grazing are rated high and limitations to cultivation extreme. This SLR unit takes up 5% or 894 ha of the Project Locality.

SLR unit	Description
Goorangoola	Goorangoola is linked to rolling hills on Carboniferous sediments in the central part of the Hunter Region. Slopes are moderately inclined and local relief is high. Associated soils are shallow, well-drained stony Inceptic Brown-Orthic Tenosols, Lithosolic Clastic Rudosols and Brown Dermosol, moderately deep, well-drained Brown Chromosols and Dermosols and Red Chromosols, Dermosols and Kandosols and moderately deep, imperfectly drained Bleached and/or Mottled Brown and Yellow Chromosols. The SLR unit is extensively cleared and used for grazing on unimproved pastures. Sheet erosion is evident on cleared and over-grazed slopes and minor discontinuous gully erosion can occur on lower slopes. Terracettes have been observed on cleared upper slopes. Limitations to grazing are moderate and limitations to cultivation are very high. This SLR unit takes up 1% or 194 ha of the Project Locality.
Granbalang	Granbalang is present on rolling low hills to rolling hills on Permian Wittingham Coal Measures. Slopes are moderately inclined, local relief is low to high, with elevation ranging between 30 - 350 m. Soils are shallow to deep, imperfectly to poorly drained Red and Brown Sodosols and Red and Brown Kurosols, shallow to deep, well to moderately well-drained Brown Kurosols and Red and Brown Chromosols. Land use is dominated by grazing on native and improved pastures with some localised areas remaining mostly uncleared under native vegetation. Sheet erosion is extensive, gully and rill erosion are also present on cleared slopes and drainage depressions. Subsoils are often dispersible and erodible. Limitations to grazing are moderate to high and limitations to cultivation are very high to extreme. This SLR unit takes up 5% or 916 ha of the Project Locality.
Gundy Gundy	Gundy Gundy is associated with undulating low hills to rolling hills on Carboniferous sediments, with gently to moderately inclined slopes and low to high local relief. The soils of this SLR unit are moderately deep to deep, moderately well-drained Brown Chromosols, Dermosols and Kurosols and Yellow Chromosols, shallow to moderately deep stony Lithic or Paralithic Leptic Rudosols and Tenosols and Lithosolic Clastic Rudosols, minimal Brown Chromosols and Red Chromosols, and moderately deep to deep, imperfectly drained Brown and Red Sodosols and Grey Sodosols. The land has been extensively cleared for grazing on native pastures. Contour banks are used in some areas to control runoff. Sheet erosion is common on areas with insufficient ground cover, and minor gully erosion where run-on is concentrated especially on lower slopes. Limitations to grazing are low and limitations to cultivation are high. This SLR unit takes up 1% or 285 ha of the Project Locality.
Isis	The Isis SLR unit occurs on gently undulating plains to undulating plain of lower slopes and drainage plains on colluvial clays and silts derived from Devonian to Carboniferous sediments. Slopes are level to gently inclined and local relief is extremely low. Soils of this unit are moderately deep to deep, moderately well-drained Brown and Red Chromosols, Brown Sodosols and Red Sodosols, moderately deep, imperfectly drained Brown Chromosols, Bleached and/or Mottled Grey, Brown Chromosols and Sodosols. The SLR unit is predominantly used for unimproved pastures, with occasional cropping of lucerne. Contour banks are commonly used to slow runoff. Sheet erosion is common where ground cover is insufficient, and gully erosion is evident where drainage is concentrated. Compaction and surface poaching by cattle and machinery is also evident. Limitations to grazing are low to moderate and limitations to cultivation are moderate to high. This SLR unit takes up 3% or 518 ha of the Project Locality.

SLR unit	Description
Paterson River	This SLR unit can be found on level to gently undulating alluvial floodplains on Quaternary alluvium. Slopes are level and the local relief is extremely low. The soils of the Paterson River SLR unit are very deep, moderately permeable and well-drained Basic Lutic Rudosols, deep, highly permeable and rapidly drained Basic Stratic Rudosols, and very deep, moderately permeable and well-drained Humose Eutrophic Brown Dermosols. The SLR unit is generally used for pasture and grazing. Minor to moderate streambank erosion. Structural degradation due to over cultivation is evident in soils that have been under long-term cultivation. Limitations to grazing are slight to moderate and limitations to cultivation are moderate. This SLR unit takes up 5% or 900 ha of the Project Locality
Ravensworth	The Ravensworth SLR unit is associated with undulating rises to undulating low hills on Permian Wittingham Coal Measures. The slopes of these rises and hills are gently inclined but can locally be moderately inclined (20%). The local relief is low. Soils present in this SLR are moderately deep to deep, imperfectly to poorly drained Brown and Yellow Natric Kurosols and Brown and Yellow Sodosols, as well as moderately deep to deep, well-drained to imperfectly drained Red, Brown and Yellow Kurosols and Chromosols. The area has been extensively cleared and the land use of this SLR unit is mainly grazing but some parts of this soil landscape are being used for mining related activities. Sheet erosion is extensive on many hillslopes in cleared areas and gully and rill erosion also occur on cleared slopes and in drainage depressions. Subsoils are often dispersible and erodible and salt can be present in drainage lines and lower slopes. Limitations to grazing are moderate to high and limitations to cultivation are high to very high. This SLR unit takes up 30% or 5,692 ha of the Project Locality.
Singleton	This SLR unit occurs on level plains to gently undulating plains on Quaternary alluvium. Slopes are level and the local relief is extremely low. The soils of the Singleton SLR unit are deep, moderately well-drained Brown and Black Dermosols and deep, well-drained Red and Brown Kandosols, deep, imperfectly drained Haplic Epipedal Black Vertosols, deep, well-drained Bleached Red Chromosols and deep, imperfectly to well-drained Stratic Rudosols. The Singleton SLR unit is extensively used for agriculture including vegetable and lucerne production, viticulture, dairying and other grazing on improved pastures. Land degradation for this SLR unit is minor apart from some streambank erosion and gully erosion has been observed within the prominent terrace surface. Limitations to grazing are slight to moderate and limitations to cultivation are slight to high. This SLR unit takes up 2% or 340 ha of the Project Locality.
Warkworth	This SLR unit can be found on level to rolling plains comprised of thin sand sheets and linear sand dunes 1 - 3 m high formed of Quaternary fluviatile sands from the Hunter River. Slopes exceed 25% and local relief is extremely low. Soils of the Warkworth SLR unit are deep, rapidly drained Basic Lutic Rudosols. The Warkworth SLR unit has some occurrence of grazing but is mainly unused for agricultural purposes. Minor wind erosion occurs when the soil is disturbed. Limitations to grazing are moderate to high and limitations to cultivation are high to very high. This SLR unit takes up less than 1% or 71 ha of the Project Locality.

SLR unit	Description
Waverly	The Waverly SLR unit is present on rolling hills on Devonian and Carboniferous sediments and volcanics with moderately inclined slopes and a low to high local relief. Soils in this SLR unit are shallow, well-drained stony Inceptic Bleached-Orthic, Yellow-Orthic and Red-Orthic Tenosols (and Brown Chromosols and Dermosols, moderately deep, moderately well-drained Brown Chromosols, Dermosols and Kandosols and Yellow Chromosols with well-drained Red Dermosols and Red Kandosols, and moderately deep, imperfectly drained Bleached/Haplic Brown Chromosols. The land of this SLR unit is extensively cleared for grazing on native pastures. Sheet erosion occurs on slopes with insufficient ground cover, minor gully erosion is present where runoff is concentrated on lower slopes. Terracettes occur on cleared steep slopes. Limitations to grazing are moderate and limitations to cultivation are high. This SLR unit takes up less than 1% or 33 ha of the Project Locality.

4.1.4 Water resources

4.1.4.1 Surface water

This surface water description is largely based on the Surface Water Impact Assessment (GHD, 2019) undertaken to support the EIS for the Project. The complete study is presented as Appendix 17 of the EIS. Watercourses located within and close proximity to the Project Locality are shown on **Figure 4.4**.

There are several creeks present in the Project Locality which ultimately join the Hunter River in the southern extent. Note, only a small reach of the Hunter River itself is located within the south-west of the Project Locality.

Bowmans Creek is the main drainage line, flowing generally in a southerly direction. It has several tributaries in the Project Locality, being Stringybark Creek, Yorks Creek, Swamp Creek and Bettys Creek. Historically, Bowmans Creek has maintained flows under most climate conditions, however has not flowed in the Project Area for approximately 18 months prior to the writing of this report due to drought conditions.

Glennies Creek is another major drainage line, running from north-east to south-west until it joins with the Hunter River. The upper section (45%) of this catchment area is regulated by Glennies Creek Dam, an ungated earth and rockfill embankment dam. The dam is located 17 km upstream of the confluence of Main Creek. The dam is used for environmental, irrigation, stock and domestic, town water and water conservation usages.

Yorks Creek is an ephemeral creek with a defined channel and is generally dry between rainfall events. The creek varies from highly vegetated to some sections that are hydraulically steep with limited vegetation. An approximately 1.5 km section of Yorks Creek has previously been diverted around the Ravensworth East MIA as part of the former Swamp Creek Mine/Ravensworth East mining operations (in the late 1970s, early 1980s) (known as the Yorks Creek Diversion). The catchment of Yorks Creek is also highly modified with parts of the upper catchments of Swamp Creek diverted into Yorks Creek (known as the Swamp Creek Diversion).

Swamp Creek was is an ephemeral creek which has been significantly modified by approved mining projects. The central areas of the former Swamp Creek catchment are located within the existing approved disturbance area for Mount Owen Complex and is managed as part of the water management system. A section of the lower reach of Swamp Creek has been diverted around the Glendell MIA (known as the Glendell MIA Diversion). Downstream of the Glendell MIA, the Swamp Creek floodplain merges with the Bowmans Creek floodplain.

Bettys Creek is an ephemeral creek and is generally dry between rainfall events. Pools of standing water are often present in the downstream reaches, but the water of these pools can be highly saline. Parts of the upper catchment of this creek have been diverted to the east of the Mount Owen Mine into Main Creek (known as the Upper Bettys Creek Diversion). The middle reaches of Bettys Creek have been diverted around the southern end of the Eastern Rail Pit (known as the Middle Bettys Creek Diversion). Bettys Creek has also previously been diverted around the southern end of the Glendell Pit (known as the Lower Bettys Creek Diversion).

Main Creek flows into Glennies Creek approximately 6.5 km upstream of the confluence of Glennies Creek and the Hunter River.

Major drainage patterns to the east of Bowmans Creek are from the north-east to the south and south-west. The area to the west of Bowmans Creek has been disturbed by existing mining operations but drainage flows approximately from the west to east. Due to extensive mining in the area, most of the creeks have been affected by mining either directly through diversions or indirectly through changes in creek catchments.

The Mount Owen Complex surface water monitoring program includes 19 surface water monitoring locations along Bowmans Creek, Bettys Creek, Swamp Creek, Yorks Creek and Main Creek. The 2017 Annual Review[11] found that the stream health, based on the Rapid Appraisal of Riparian Condition method, of Bowmans Creek was very poor, of Yorks Creek was very poor to average, of Swamp Creek was very poor to poor, of Bettys Creek was good to poor and of Main Creek was poor. During 2018 stream condition on Bowmans Creek had decreased at one monitoring point but increased at another, at Yorks Creek stream condition remained the same or improved, on Bettys Creek and Main Creek stream health remain the same at one monitoring point and decreased at the other.

The dominant limitation for agricultural use of the surface water is water flow. As such, Bowmans Creek and Glennies Creek have, aside from the Hunter River, the highest importance to agriculture in the Project Locality.

[11] Mount Owen Complex Annual Review 2017, http://www.mtowencomplex.com.au/en/publications/AEMR/MOC_Annual_Review_2017.pdf, accessed 08/11/2018

umwelt

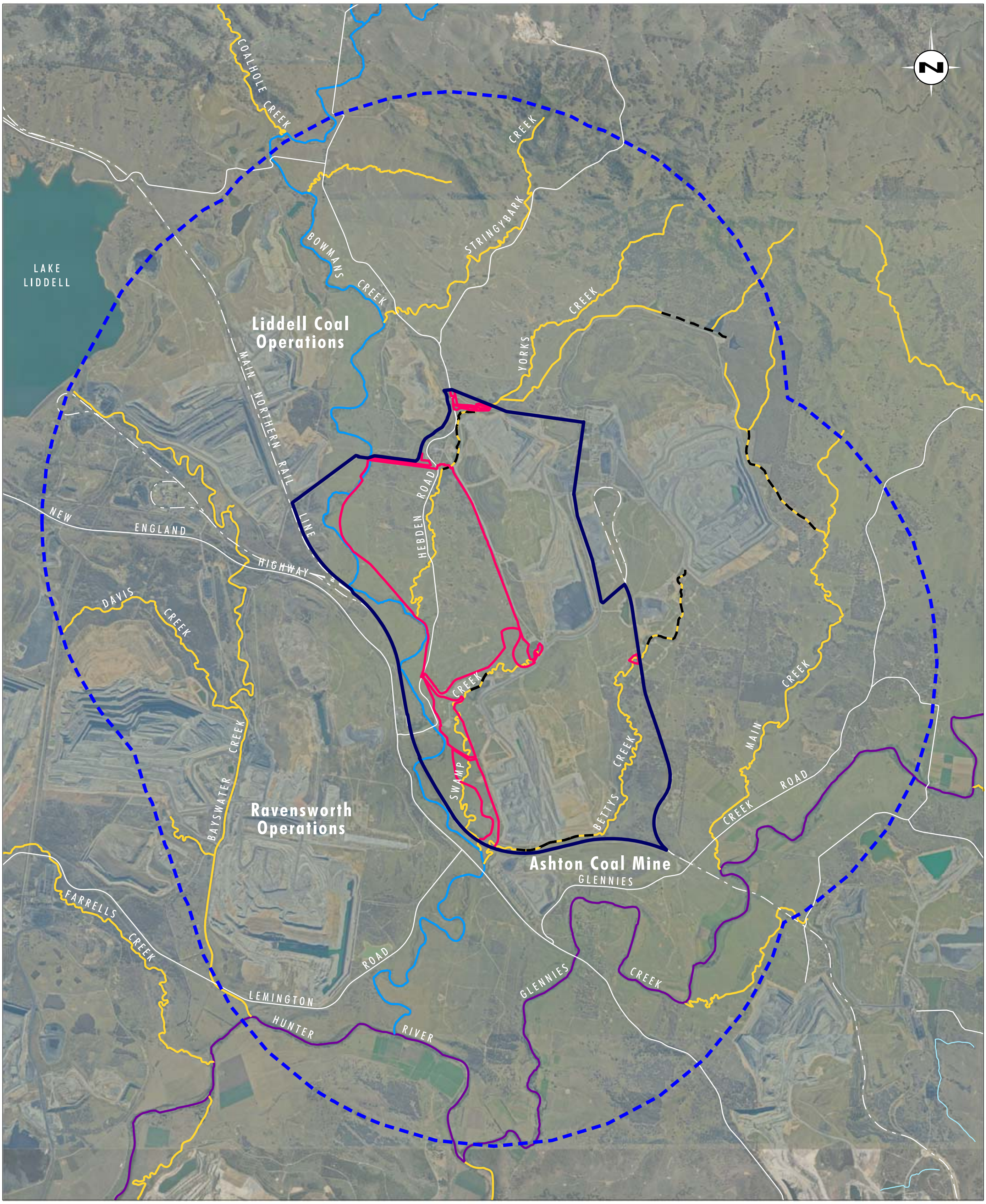

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), OEH (2018)

Legend

- Project Area
- Project Locality
- Additional Disturbance Area
- Existing Creek Diversion
- Ephemeral
- Semi Permanant
- Permanant/Regulated

FIGURE 4.4

Surface Water in the Project Locality

File Name (A4): R10/4166_286.dgn
20191126 15.37

4.1.4.2 Groundwater

Information presented in this section is based on the Groundwater Impact Assessment (AGE, 2019) prepared to support the EIS for the Project. The complete study is presented as Appendix 16 of the EIS.

The alluvium forms a relatively thin aquifer along the major creeks and rivers. In the Project Locality, flow of this groundwater system generally follows the topography, flowing roughly from north to south towards the Hunter River. The alluvium levels fluctuate between 1 m to 4 m, driven by climatic factors, current mining activities seem not to have disrupted the flow of alluvium derived groundwater.

Bowmans Creek alluvium forms a significant aquifer system in the Project Locality, which is thickest closer to the creek and thins out towards the edges of the alluvium. The Bowmans Creek alluvium is classed as a highly productive groundwater source. Alluvium along Bettys Creek, Yorks Creek and Swamp Creek has a limited saturated thickness or is dry and is classed as a less productive groundwater source.

Groundwater flow within the Permian strata has only a weak relationship with the surface topography. Existing mining operations have depressurised the Permian groundwater system and groundwater flows are towards the existing open cut and underground options in the Project Locality. Saturation of the Permian strata occurs in the coal seams and interburden. The ability to yield water is limited to the coal seams. The interburden does not transmit significant volumes of groundwater and acts as an aquitard confining the coal seams. The Permian aquifers are considered a less productive groundwater source.

Salinity of the Bowmans Creek alluvium varies from fresh to brackish, depending on the location. The Glennies Creek alluvium in the south of the Project Locality indicates a relatively fresh groundwater system. Salinity in Bettys Creek, Swamp Creek and Yorks Creek varies between fresh to highly saline waters. The salinity of Permian derived groundwater ranges from fresh to highly saline.

Water sampling in the Project Locality indicates that the groundwater from both the alluvium and Permian groundwater systems is not suitable for potable or irrigation uses due to salinity. Groundwater from some areas within the alluvium and Permian could be used for stock, but this use is variable and generally controlled by the salinity.

4.1.4.3 Private water users

There are two privately owned licenced water bores in the Project Locality and several mine-owned bores. The private bores are located on private property along Bowmans Creek on land that is currently managed by Daracon, the land is not presently used for agricultural or residential purposes. As per the NSW State Government groundwater bore database intended use for the bores is for stock and domestic purposes and have a depth of 16.2 m and 6.2 m, respectively.

4.1.4.4 Water sharing plans

Water sharing plans (WSPs) regulate sharing of water between environmental needs and water users. Rules are also established to manage requirements of different water uses such as town supply, rural domestic supply, stock watering, industry and irrigation. WSPs have been established for groundwater as well as for surface water resources.

Three WSPs apply to the Project Locality, these are

- Hunter Regulated River Water Source 2016 (Hunter Regulated WSP)
- Hunter Unregulated and Alluvial Water Sources 2009 (Hunter Unregulated WSP), and

- North Coast Fractured and Porous Rock Groundwater Sources 2016 (North Coast Fractured and Porous Rock WSP).

Management Zone 3A is the relevant zone for the Hunter Regulated WSP. The Hunter Unregulated WSP is subdivided into water sources. The majority of the Project Locality is situated in the Jerrys Water Source, while some parts in the east of the area are located in the Glennies Water Source. The Hunter Regulated River Alluvium Water Source applies to alluvial aquifers associated with regulated sections of the Hunter River; this includes alluvium adjacent to Glennies Creek.

4.1.5 Vegetation communities

The Hunter Valley, like most areas of Australia, has been extensively cleared for agricultural and industrial land uses. In case of the Project Locality, historic clearing has been carried out for grazing and cropping, and more recently for coal mining and infrastructure purposes. The majority of the existing fragmented remnant vegetation within areas subject to historical clearance within the Project Locality occurs as a result of extensive re-growth over the past 30 years (Umwelt, 2019). Forested areas associated with the Ravensworth State Forest and the Glencore biodiversity offset areas are located within the Project Locality. Note there will be no disturbance to vegetation outside of the Project Area, site specific flora surveys have been undertaken within the Project Area to assess the direct impacts of the Project to vegetation, this is discussed further in **Section 4.2**.

4.2 Agricultural resources within the Project Area

Detailed soil and ecological assessment undertaken within the Project Area to support the EIS for the Project has been undertaken and is summarised in the following sections. Detailed assessment has been undertaken within the Additional Disturbance Area only, from an agricultural impact assessment perspective the impacts within the Additional Disturbance Area are considered to be direct impacts. Areas within the Project Area that will not be disturbed will also not be available for agricultural purposes due to the proximity of the proposed mining operations within these areas, these areas will therefore be subject to indirect impacts.

4.2.1 Soil

4.2.1.1 Soil landscapes and soil and land resources

The Additional Disturbance Area has been mapped at a regional scale with two soil landscapes, namely the Bayswater soil landscape (629 ha, 84%) and the Hunter soil landscape (121 ha, 15%). As discussed in **Section 4.1.4**, the Bayswater soil landscape is LSC Class 6 and is equivalent to the ASC order sodosol. The Hunter soil landscape is LSC Class 3 and is equivalent to the ASC order tenosol. The Hunter soil landscape is associated with the floodplains of Bowmans Creek, Swamp Creek and Bettys Creek (refer to **Figure 4.3**).

The following SLR units occur in the Additional Disturbance Area (refer to **Figure 4.3**):

- Disturbed Terrain (1 ha, <1%)
- Donalds Gully (99 ha, 13%)
- Foy Brook (97 ha, 12%)
- Granbalang (2 ha, <1%)
- Isis (3.7 ha, <1%)

- Ravensworth (548 ha, 73%).

A discussion of the SLR units has been provided in **Section 4.1.4**. The majority of the Additional Disturbance Area, not disturbed by mining to date, has high to very high limitations to cultivation and moderate to high limitations to grazing (Ravensworth and Donalds Gully SLR units). Areas associated with the floodplains (Foy Brook SLR unit) have a slight to high limitation to cultivation and a slight to moderate limitation to grazing (refer to **Table 4.4**).

4.2.1.2 Australian soil classification

Extensive soil investigations have been carried out in the Additional Disturbance Area to assess the soils of the area and the occurrence of BSAL. For details of the soil survey design and profile descriptions please refer to Appendix 1 of the Gateway Application.

The soil survey identified six Australian Soil Classification (ASC) soil orders within the Additional Disturbance Area (refer to **Figure 4.5**), namely

- Sodosol (approximately 620 ha, 82%)
- Tenosol (approximately 58 ha, 8%)
- Chromosol (approximately 18 ha, 2%)
- Dermosol (approximately 11 ha, 1%)
- Rudosol (approximately 7 ha, <1%)
- Kandosol (approximately 6 ha, <1%).

The remainder of the Additional Disturbance Area consists of disturbed land (approximately 17 ha, 2%) or creek line landscapes (approximately 15 ha, 2%). An overview of each ASC order is supplied in **Table 4.6**. The interpretation of the laboratory results is based on values provided by Hazelwood and Murphy (2016).

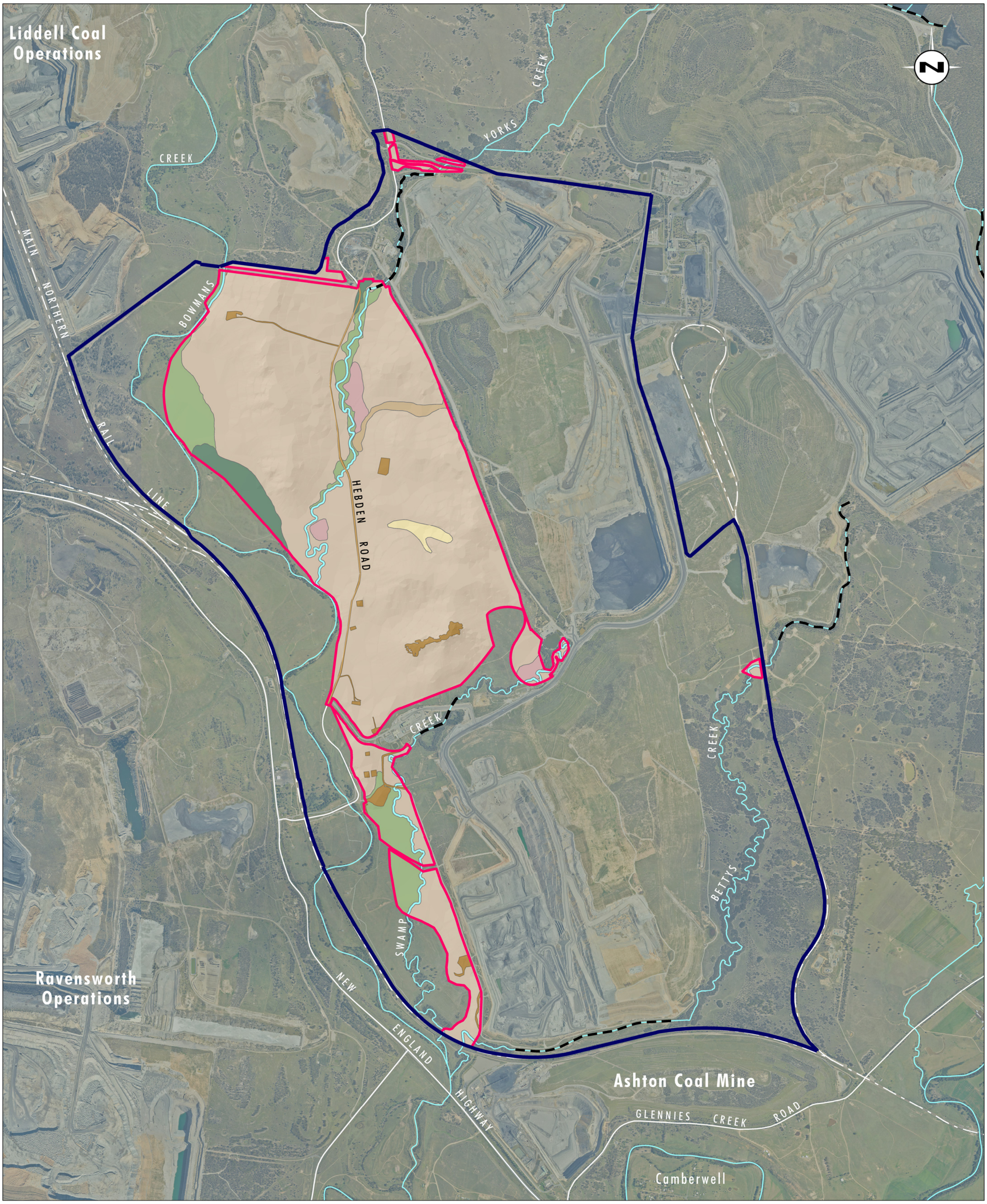

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- Creek
- Disturbed

Soils:

- Chromosol
- Tenosol
- Rudosol
- Sodosol
- Kandosol
- Dermosol

FIGURE 4.5

Soil Mapping in the Additional Disturbance Area

Table 4.6 Soil Classification within Additional Disturbance Area

Classification	Description
Sodosol	Sodosols are the dominant ASC Order in the Additional Disturbance Area, making up approximately 620 ha (82%) of the area. Brown, Red, Yellow, Grey or Black Sodosols, either Mesonatric or Subnatric, occur on the hillslope and footslope of the rolling hills in the Project Area. This ASC Order is associated with sandstone or mudstone bedrock or deposited material derived from this geology. Sandstone rock outcrop and surface rocks are scattered throughout the hillslopes, however the densities of these are low and occurrences are random. Rock outcrops are predominantly flat. Sodosols in the Additional Disturbance Area commonly had A horizons with a Silty or Sandy Loam to Silty or Sandy Clay Loam texture overlying a B2 horizon with a Light Medium to Medium Heavy Clay texture. Many of the surveyed Sodosols showed a conspicuously bleached A2 horizon and sub-rounded, medium pebbles were often present in this horizon. The structure of the A horizon typically ranged from apedal massive to moderate sub-angular blocky while the structure of the B horizon generally was moderate to strong sub-angular to angular blocky. Some profiles showed columnar and prismatic structures, breaking to angular blocky. Mottling of the B horizon was frequently observed. The laboratory pH for all analysed Sodosol soil samples ranged from strongly acidic (pH 4.8) to moderately alkaline (pH 8.8), with pH increasing with increasing depth. A horizon pH ranged from pH 4.8 to pH 7.7, while B horizon pH was between pH 6.3 and pH 8.8. Salinity ranged from non-saline to moderately saline, with saturated paste electrical conductivity (ECe) between 0.05 dS/m and 4.33 dS/m. The Cation Exchange Capacity (CEC) of many profiles is moderate to high, but this is most likely the result of a high sodium content, which is reflected in high Exchangeable Sodium Percentage (ESP) values. Most samples are deficient in exchangeable Potassium (K) (values <0.5 meq/100g) and exchangeable Calcium (Ca) (values <5 meq/100g). Further, almost all samples had exchangeable Sodium (Na) exceeding the desirable level of <0.1 meq/100g. The ESP ranged from non-sodic (ESP 0.9) to highly sodic and hypernatric (ESP 35.2). With the exception of one analysed profile, the soils displayed an increase of sodicity in the B2 horizon with depth. The Ca:Mg ratio for all analysed Sodosols showed a calcium deficiency, with the majority of samples having a ration below one and a maximum Ca:Mg ratio of 2.9. This indicates a strong tendency for clay dispersion underlining the unstable nature of the Sodosols in the Additional Disturbance Area. The Emerson aggregate class for analysed B Horizon samples ranged from moderate to slight dispersion (Class 3) to complete dispersion (Class 1). Phosphorous values (Colwell phosphorous) of analysed samples showed that phosphorous was deficient, with phosphorous values of the A Horizons ranging from less than 5 mg/kg to 17 mg/kg. One sample (site GN80, 0-50 mm depth) had a value of 167 mg/kg, however, it is likely that this is an outlier, especially in the light phosphorous in the following depth (50-150 mm) decreased to 17 mg/kg. B Horizon values were between 25 mg/kg and less than 5 mg/kg, further confirming the phosphorous deficiency of the soil order. Organic carbon in the upper 0-50 mm of analysed samples were extremely high (4.2%) and very high (2.4%), however below 50 mm organic carbon content rapidly decreased with values in the A2 ranging from 0.4% (extremely low) to 0.9% (low). In light of the fact that sheet erosion has stripped large areas of the A1 Horizon, the Sodosols are considered to be low in organic carbon. This ASC Order has severe limitations for agricultural use due to its dispersion risk and gully erosion is observed within the Additional Disturbance Area on midslopes as well as footslopes. Further, bleached A2 horizons and mottling of B horizons were present at many sites, indicating additional limitations to agriculture through imperfect drainage and water logging. Based on the laboratory analysis particularly the deficiencies in Ca, K P and organic carbon, as described above, the fertility ranking of the Sodosol soil order is moderately low. This is in line with the fertility ranking provided in the Interim Protocol.

Classification	Description
Tenosol	Tenosols in the Project Area occur as Brown-Orthic and are associated with the floodplains of Yorks, Bowmans and Swamp Creeks. Due to the lower flow capacity of Yorks and Swamp Creek, their floodplains and associated Tenosols have a relatively narrow distribution and are absent in some reaches of the creeks. The total area of this ASC order in the Additional Disturbance Area is 58 ha (8%). The Bowmans Creek floodplain consists of a lower and an upper terrace. Soil sampling sites located on the lower terrace of the Bowmans Creek floodplain have a band of large pebbles at 650 mm to 800 mm. The textures of the sites on the lower terrace were Sandy Clay Loams, Sandy Loams and Sand. On the upper terrace, Sandy to Silty Clay Loams were the dominant soil textures. Soil structures for all Tenosols were mainly apedal to weak sub-angular blocky. Aside from the mentioned band of large pebbles, very few coarse fragments were present in the profiles. The A horizon pH of sampled Tenosols ranged from strongly acidic to moderately acidic. The pH of the B horizons was slightly alkaline. The Tenosols in the Additional Disturbance Area are non-saline and predominantly non-sodic throughout the profile. One site in the upper terrace had a sodicity increase with depth, making it sodic below 300 mm. The measured CEC for all profiles was low to moderate in the upper 300 mm. Below this, the CEC of one profile remained moderate, decreased to low for one profile and was high for one site. The high CEC is most likely due to a high amount of sodium, which is reflected in the sites elevated ESP. Exchangeable K was within desirable levels in the upper 200 to 300 mm for all sites and deficient thereafter. Exchangeable Ca and Mg was deficient in the lower terrace and in the upper 500 mm of one site in the upper terrace. The site to the north of Bowmans Creek showed sufficient exchangeable Ca levels but was deficient in exchangeable Mg. Phosphorous values in the upper 50 mm were within the desirable range for wheat (89 mg/kg) and pasture (30 mg/kg). P values decreased below this depth, but generally were above 10 mg/kg and thus higher than for some other soil orders in the Additional Disturbance Area. Organic carbon in the upper 0-50 mm of analysed samples was extremely high and decreased to low and extremely low thereafter. The fertility of this ASC order is ranked as moderate. Tenosols on the upper floodplain terrace may be well suited for agriculture. The coarse fragments recorded on the lower floodplain terrace, restrict root growth and thus are an impediment to agriculture. Further, the risk of frequent flooding on this lower landscape poses a limitation to agriculture as well. Tenosols associated with Yorks Creek and Swamp Creek, are narrow and have a high flood risk as well.

Classification	Description
Chromosol	Brown or Black Chromosols occur on the upper terrace of the creek floodplains and in one occasion on the midslope of the rolling hills. The Chromosols in the floodplain are derived from ex situ material, the midslope Chromosol profile is situated in a drainage line, therefore the underlying sandstone or mudstone bedrock as well as ex situ material will have contributed to the soil formation. Chromosols cover 18 ha (2%) of the Additional Disturbance Area. The Chromosols found on the had A Horizons with textures ranging from Sandy Loam, Sandy Clay Loam and Silty Clay Loam to Clay Loam with a weak to moderate, granular to sub-angular blocky structure. The upper B textures were Coarse Sandy Light Medium Clay, Medium Clay and Medium Heavy Clay, with predominantly moderate sub-angular and angular blocky structures. Coarse fragments were only recorded in one profile and mottling occurred in the lower B horizons of some of the other profiles and in one case in the upper B horizon. Few manganiferous soft segregations were recorded in the lower depth sporadically. Laboratory analysis showed that A horizon pH ranged from strongly acidic to slightly alkaline and B horizon from slightly acidic to strongly alkaline. The analysed Chromosol samples were non-saline and non-sodic, with the exception of the Yorks Creek site, which was slightly saline and strongly sodic (ESP 36) below 500 mm. This indicates that the underlying geology strongly influenced the soil formation for this site below 500 mm. The CEC of the A horizons was moderate for all sites, with the exception of the A2 horizon of the Yorks Creek site, which had a low CEC. This may be a result of the slight bleach in this horizon which indicates lateral leaching of nutrients, however, the CEC rating of this site's B horizon was low as well. The other analysed sites had a high CEC rating for the upper B horizon, which may be a result of increased clay contents, and a moderate to low value in the lower B horizon. Exchangeable K was only deficient in the Yorks Creek site and the complete B horizon of one site and the lower B Horizon of all other sites. All sites were generally deficient of exchangeable Ca and Mg. Exchangeable Na exceeded desired values at the Yorks Creek site and B horizon of one Bowmans Creek site. The Ca:Mg ratios showed that the sites are predominantly Ca deficient, however ratios generally exceeded 1, thus clay dispersion should not be enhanced. Emerson aggregate class for analysed A horizon samples were Class 4, Negligible dispersion. B horizon samples in the Bowmans Creek floodplain were Class 3, moderate to slight dispersion, while the Yorks Creek site was Class 1, complete dispersion. Phosphorous values (Colwell phosphorous) of analysed samples showed that phosphorous was deficient, in the Yorks Creek site (P values <5 mg/kg). P of the analysed A horizons of the Bowmans Creek sites were within the critical values for wheat and pasture. One site had all analysed depth within the critical value for pasture and the upper 300 mm within the critical value for wheat. Organic carbon in the upper 0-50 mm of analysed samples ranged from extremely high (7.3%) to moderate (1.8%). Below 50 mm the organic carbon content was low and extremely low. Chromosols on the Bowmans Creek floodplain may be well suited for agricultural use, however the Chromosol mapped near Yorks Creek has imperfect drainage and rooting restrictions due to high sodicity. As the Yorks Creek Chromosol makes up a small portion of the Chromosols in the Additional Disturbance Area, the fertility of this ASC Order is rated as moderate.

Classification	Description
Dermosol	Red, Black and Brown Dermosols were found in isolation in floodplain areas and to a limited extent on a mid to lower slope site. This ASC order is only encountered in 11 ha (1%) of the Additional Disturbance Area. Dermosols on the floodplains are formed from *ex-situ* material, while on the mid to lower slope it may be a result of a slight variation of the underlying sedimentary (mudstone) geology. The A horizon of the observed Dermosols had a Light Clay texture with a moderate granular structure. On the midslope, B horizons had a Medium Heavy Clay texture which decreased to a Light Clay with depth, with strong, angular blocky structure and 10-20 mm peds. Few fine, faint mottles were observed, increasing to many with depths. Many angular small mudstone pebbles occurred between 600-700 mm and mudstone bedrock was encountered at 700 mm. On the floodplain, B horizon texture increased from Medium Clay to Heavy Clay with depth, with the occurrence of slickensides in the profile. Soil structure was strong angular blocky with 5-20 mm peds. Few, faint orange mottles were observed in the B horizon. Vertic properties were observed in the B21 and B22 but cracks did not connect to the surface. Analysed soil samples showed a moderately acidic soil pH in the A and upper B horizon, which increased to moderately alkaline with depth. The mid-slope profile was non saline throughout the profile, while the site in the floodplain was slightly saline below 600 mm. Both sites had non sodic A horizons, but had a sodic B horizon, with maximum ESPs of 24 and 19 below 600 mm. The floodplain site has a low CEC rating throughout the profile, while the CEC of the midslope site was moderate to high, decreasing to low below 600 mm. The midslope site was deficient in exchangeable K and exchangeable Ca but had sufficient levels of exchangeable Mg. The latter was also true for the floodplain site, with desirable levels of exchangeable K in the upper 300 mm of the profile and sufficient exchangeable Ca levels between 50 to 300 mm. The Ca:Mg levels for both sites were below 1 throughout the profiles, indicating a strong clay dispersion risk. Emerson aggregate class for the upper 50 mm was Class 3, moderate to slight dispersion. Below this, the floodplain site had a Class 1, complete dispersion, score, while the midslope site remained Class 3. Phosphorous values (Colwell phosphorous) of analysed samples showed that phosphorous was deficient with P values of 7 and 24 mg/kg in the upper 50 mm, decreasing to less than 5 mg/kg below this. Organic carbon in the upper 0-50 mm of analysed samples was extremely high, decreasing to low. For Dermosols, imperfect drainage is a limitation to agriculture. At the midslope site, coarse fragments and bedrock at 700 mm further impede agricultural land use. Both analysed profiles were highly sodic below 600 mm, and thus restrict rooting depth. The fertility rating of this ASC order is moderately low.

Classification	Description
Rudosol	Clastic Rudosols occur on hill crests where weathering of parent material is insufficient to form a more mature soil profile. Stratic Rudosols are found where repeated fluvial depositions have occurred without further soil profile development. The Clastic Rudosol is derived from the underlying sandstone, whereas the Stratic Rudosol was formed by *ex-situ* material deposition. Rudosols covered 7 ha (<1%) of the Additional Disturbance Area. The Clastic Rudosol had a Sandy Clay Loam texture with a weak granular to strong sub-angular blocky structure and few coarse fragments throughout the profile. Soil depth of the Clastic Rudosol was 250 to 600 mm. Soil textures of the Stratic Rudosols ranged from Loamy Coarse Sand to Silty Clay Loam, the profiles showed an apedal to weak, granular and sub-angular blocky structure. The pH of analysed soil samples was moderately acidic to slightly acidic. All samples are classed as non-saline. The Clastic Rudosol was non-sodic, while the spordic horizons of Stratic Rudosol were sodic. The CEC for all samples was low to moderate, with the topsoil of one Stratic Rudosol showing a high CEC. The Clastic Rudosol was deficient in exchangeable Ca and Mg but had sufficient exchangeable K levels. Stratic Rudosols varied in the level of exchangeable cations, due to differing fluvial source material. Each profile was deficient in two exchangeable cations for most horizons. Ca:Mg levels of two profiles were below 1 or close to 1, indicating structural instability of the profiles. Emerson aggregate classes for the Clastic Rudosol showed that it has a negligible dispersion risk (Classes 4 and 8). Stratic Rudosols had Emerson aggregate classes of 3 and 4, indication a moderate to low dispersion risk. Phosphorous values (Colwell phosphorous) of analysed samples showed that phosphorous was deficient in the upper 50 mm. One Stratic Rudosol profile had P values above the critical value for wheat. P values for all analysed sites decreased to less than 5 mg/kg below 50 mm. Organic carbon in the upper 0-50 mm of analysed samples was extremely high, decreasing to very low below 50 mm. The lack of soil formation is a limitation for agricultural use, especially for Clastic Rudosols. The fertility for this ASC Order is ranked as low.

Classification	Description
Kandosol	Brown Kandosols occur isolated on hillslopes, footslopes and on a lower alluvial terrace. The occurrence of Kandosols may be a result of the weathering of isolated, coarser grained sandstones or sandstone conglomerates. The hillslope profile is located in a drainage depression, and as a result accumulation of *ex-situ* derived material may have contributed to all sites. Kandosols are found on 6 ha (<1%) of the Additional Disturbance Area. Sites have a Clay Loam texture grading into Light Clay or a Sandy Loam with apedal massive to moderate sub-angular blocky structures. Common to many mottles were evident in the B horizon of all profiles. The hillslope profile showed few to common rounded pebbles throughout the profile. The pH of the Kandosols is moderately acid to slightly acid, both in the A and B horizons of the analysed sites. Profiles are non-saline and the floodplain profile is non sodic, while the hillslope site is sodic below 250 mm and highly sodic below 600 mm, which may be a result of the influence of the underlying sandstone. The floodplain Kandosol has a moderate CEC throughout the profile, while the hillslope profile has a very low CEC in the upper 600 mm and a moderate CEC below this. The floodplain site had sufficient levels of exchangeable Ca and Mg throughout the profile and sufficient exchangeable K in the upper 150 mm. The hillslope site was deficient in exchangeable Ca and K throughout the profile and deficient in exchangeable Mg above 250 mm. Ca:Mg Ratios for both sites were Ca deficient, with ratios between 0.1 and 1.4 indicating instable soil aggregates. Phosphorous values (Colwell phosphorous) of analysed samples showed that phosphorous was deficient in the upper 150 mm. P values measured a maximum of 20 mg/kg and a minimum of less than 5 mg/kg. Organic carbon in the upper 0-50 mm of analysed samples was moderate, decreasing to low below 50 mm. The water logging of the Kandosols in the Additional Disturbance Area, evident through mottling, is a limitation to agriculture for all sites. In addition, the presence of coarse fragments and a shallow rooting depth on the hillslope further impedes agricultural land use in this location. The fertility rating of this ASC order is moderately low.

4.2.1.3 Land and soil capability class

The Additional Disturbance Area has been mapped at a regional scale as LSC Class 3 along the floodplains (approximately 121 ha) and LSC Class 6 in the rolling hills (approximately 667 ha) (refer to **Figure 4.2**). As this assessment is based on large scale mapping, the LSC of the Additional Disturbance Area has been reassessed based on soil physical and chemical data obtained during the soil survey, slope criteria obtained from LiDAR analysis and OEH guidelines (OEH, 2012a).

Detailed information about the score of each detailed site against the 10 LSC assessment criteria is presented in **Appendix 1**. It is further noted, that the soil survey was designed to identify potential BSAL. As a result, no detailed sites were located in areas with slope exceeding 10% or where aerial imagery showed the occurrence of gully erosion. Areas with mass movement hazards were mapped based on slope and aerial imagery.

LSC classes and ASC soil orders in the Additional Disturbance Area are discussed below:

- Chromosol – Chromosols have a LSC Class between 3 and 6. The higher LSC Class (Class 6) was driven by waterlogging and was recorded in the north–east of the Additional Disturbance Area.

- Dermosol – Dermosols have a LSC Class of 5 and 6. The former is due to subsoil sodicity and the latter to mass movement, which is likely caused by subsoil sodicity.

- Kandosol – Kandosols generally have an LSC Class of 5. Small areas showed signs of waterlogging and have an LSC Class of 6.

- Rudosol – Rudosols have a LSC Class between 3 and 6. The clastic Rudosol on the hillcrest has a LSC Class 6 due to the shallowness of the soil. One analysed stratic Rudosol has a LSC Class of 3 and is located on a lower floodplain of Yorks Creek. The remaining stratic Rudosols have a LSC Class 5 due to waterlogging and acidification.

- Sodosol – Sodosols have a LSC Class of 5 in areas where no mass movement is present and an LSC Class of 6 where mass movement occurs and a LSC Class 6 where mass movement is obvious from aerial photography.

- Tenosol – Tenosols on the lower floodplain have a LSC Class 5 due to rooting restrictions, whereas areas on the upper floodplain have a LSC Class 3 or LSC Class 4 where acidification is a limiting factor.

In relation to the Additional Disturbance Area, based on the LSC classes of the detailed survey sites as well as aerial imagery, the areas of each LSC within the Additional Disturbance Area has been mapped (refer to **Figure 4.6**) and corresponding description provided in **Table 4.7**.

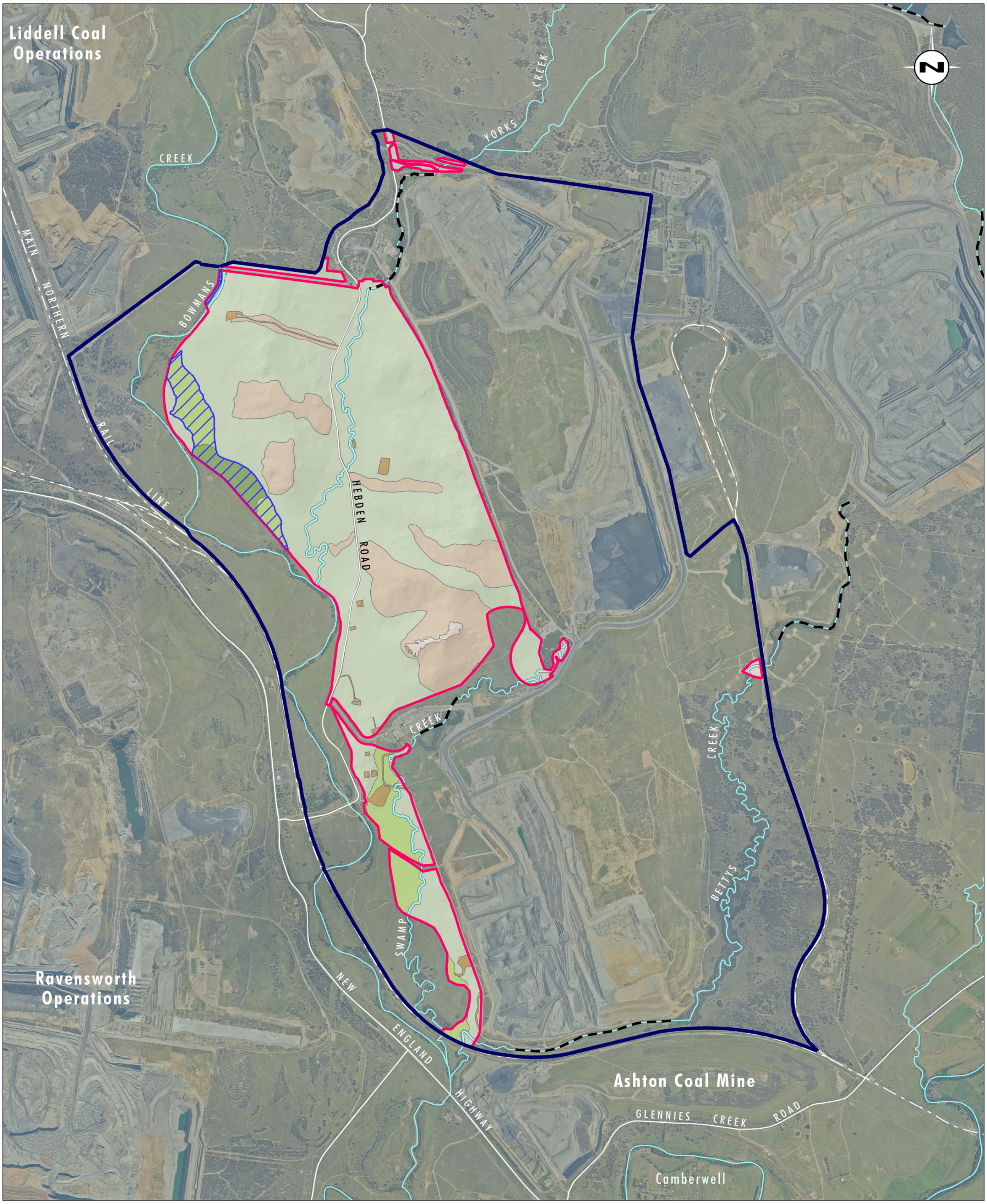

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- Verified BSAL
- Creek
- Disturbed

Verified Land and Soil Capability:

- Class 3
- Class 4
- Class 5
- Class 6
- Class 8

FIGURE 4.6

Land and Soil Capability in the Additional Disturbance Area

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20191126 16.21

Table 4.7 Mapped LSC within the Additional Disturbance Area

LSC Class	LSC Class General Description (OEH 2012a)	Extent (ha)
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.	13
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.	50
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.	523
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	131
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.	0
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	33

The site specific LSC assessment confirmed that the majority of the Additional Disturbance Area (approximately 91%) would only be suited to low intensity grazing. Areas on the floodplain may be suitable to higher intensity grazing or cropping (approximately 9%).

4.2.1.4 Biophysical strategic agricultural land

The Upper Hunter SRLUP maps 121 ha of BSAL across the Project Area (refer to **Figure 2.1**). For land to qualify as BSAL in accordance with the Interim Protocol, it must have access to a reliable water supply, meet all of the 12 BSAL criteria, as defined by the Interim Protocol, and be a contiguous area of at least 20 ha (OEH and OASFS, 2013).The Interim Protocol defines that all of the Upper Hunter, which includes the Project Area, has access to reliable water (OEH and OASFS, 2013). All soil survey sites that were analysed in the laboratory were assessed against the 12 Interim Protocol BSAL criteria.

Several Chromosol sites and some Tenosol sites meet all 12 BSAL criteria and thus are considered BSAL as per the Interim Protocol. All assessed BSAL sites are located on the Bowmans Creek upper floodplain terrace. The total area of Verified BSAL (as mapped in accordance with the Interim Protocol within the Verification Area is approximately 34 ha (refer to **Figure 4.6**). The majority of this is situated to the east of Bowmans Creek, with a small, BSAL parcel located to the north of the creek. This northern area is approximately 0.7 ha, and thus does not comply with the minimum size criterion of 20 ha as per the Interim Protocol. However, it is expected that BSAL continues in the adjacent area (refer to **Figure 4.6**). Contiguous BSAL in the area outside of the Verification Area has been estimated based on the regional Upper Hunter SRLUP mapping, slope analysis and previous mapping by GSSE (2013).

The LSC assessment has identified that just 13 ha of the Additional Disturbance Area is LSC Class 3 land with all of this being within the Verified BSAL area assessed using the Interim Protocol. The remaining 21 ha of the Verified BSAL assessed in accordance with the Interim Protocol has been assessed as being LSC Class 4 land. LSC Class 4 land is identified as being moderate capability land which has moderate to high limitations to high impact land uses. The soils within the LCS Class 3 and Class 4 land in the Verified BSAL area is identified as being either tenosols or chromosols that have moderately high fertility. Based on the LSC classification and soil fertility, these soils, while technically meeting the criteria for BSAL when assessed in accordance with the Interim Protocol, are considered to be lower value land relative to the types of land that can be assessed as being BSAL. All other areas within the Verification Area have been assessed as LSC Class 5, 6 and 8 land.

4.2.2 Water resources

The main surface water resources within the Additional Disturbance Area are Yorks Creek and Swamp Creek. As discussed in **Section 4.1.5**, these creeks have limited potential as an agricultural resource, mainly due to their ephemeral nature. Smaller areas of Bowmans Creek and Bettys Creek are also located in the Project Area.

There are a number of dams located within the Additional Disturbance Area that capture runoff from gully areas. These are the primary source of water for stock. The Bowmans Creek, Yorks Creek and Swamp Creek alluvium extend into the Additional Disturbance Area. The cumulative impacts of mining operations in the area (in the absence of the Project) are predicted to result in the further lowering of the water table in the Bowmans Creek alluvium before recovering following the cessation of mining (AGE, 2019).

The Additional Disturbance Area includes paddock areas that extend to Bowmans Creek, which is subject to water quality and flow constraints, both Bowmans Creek and the associated alluvial systems provide potential opportunities for supplying water for stock and, potentially, irrigation purposes. There are currently no works licensed for the extraction of water for irrigation purposes from Bowmans Creek adjacent to the Additional Disturbance Area. Groundwater resources are discussed in **Section 4.1.5**.

4.2.3 Topography

The topography of the Additional Disturbance Area is defined by rolling hills and gently sloping to flat alluvial areas associated with Bowmans Creek, Yorks Creek and Swamp Creek. Elevations range from approximately 130 m on the hill crest to 80 m along the creeks. Hill crests between Bowmans and York Creeks run in a north-southerly direction.

Overall, approximately 41% of the Additional Disturbance Area has a slope between 0 to 5%, and slopes between 5 to 10% occur on approximately 44% of the area. Steeper sections, with slopes exceeding 10% are present on approximately 16% of the Additional Disturbance Area (refer to **Figure 4.7**).

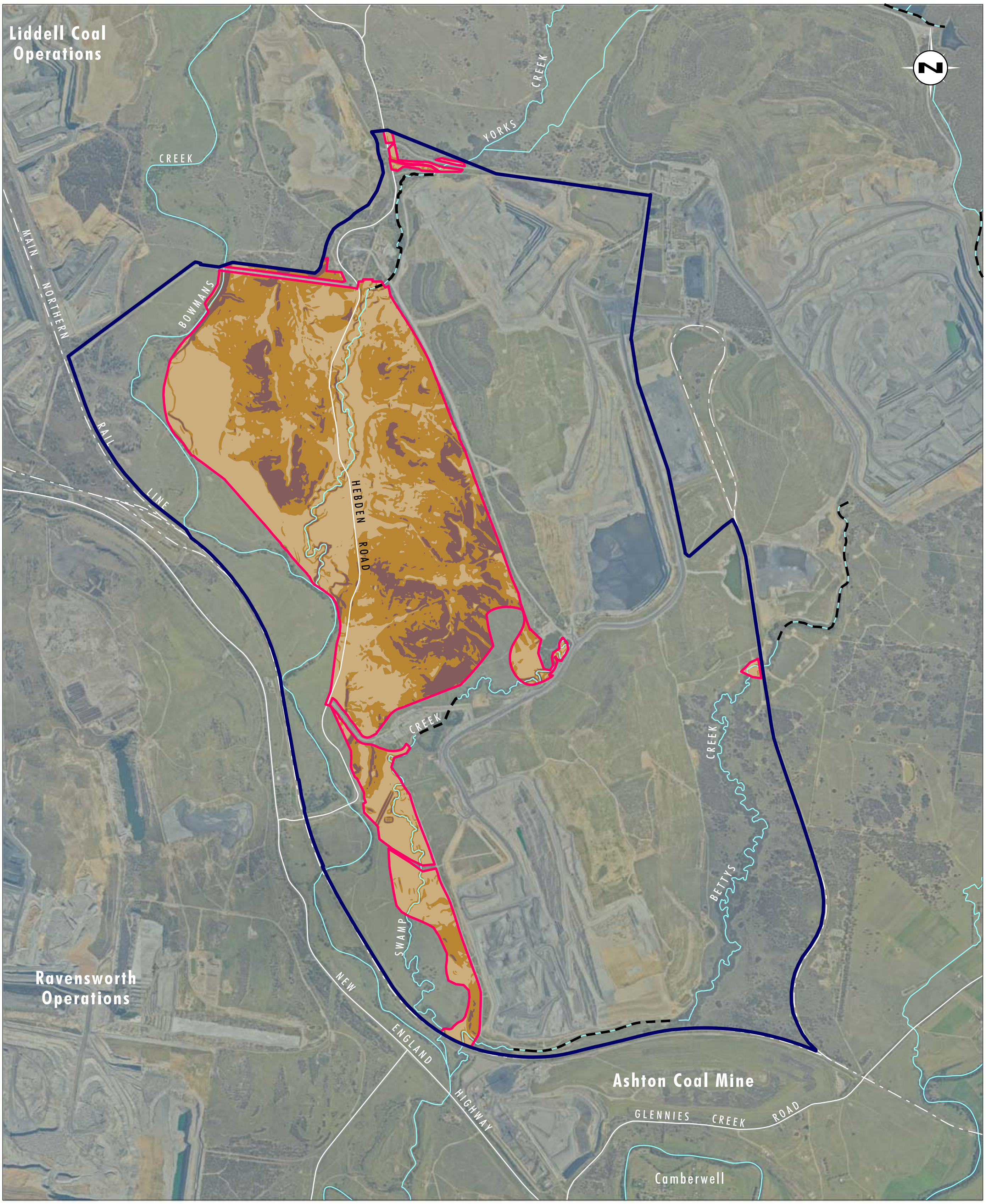

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- 0 - 5% Slope
- 5 -10% Slope
- >10% Slope

FIGURE 4.7

Slope Analysis of Additional Disturbance Area

4.2.4 Vegetation

The Additional Disturbance Area has been extensively impacted by past agricultural activities including cultivation on alluvial flats and lower slopes and clearing in most other areas. Large areas were modified with contour banks and/or ploughing in the 1960s and 1970s to mitigate erosion risks associated with past clearing and agricultural activities.

The Additional Disturbance Area is approximately 750 ha. The majority of the existing vegetation within the Additional Disturbance Area exists as a result of extensive re-growth over the past 30 years**.** The extant woodland/forest vegetation in the Additional Disturbance Area is majority 'regrowth' or logged vegetation, that is, it has been previously cleared and its present extent is based entirely on natural regeneration or on targeted planting of canopy species (refer to Appendix 20 of the EIS). The area of different vegetation types within the Additional Disturbance Area is presented in **Table 4.8.** Mapping of the native vegetation within the Additional Disturbance Area is shown on **Figure 4.8** and detailed mapping of all vegetation communities in the Additional Disturbance Area is shown on **Figure 4.9**.

Further detail relating to the vegetation within the Additional Disturbance Area is provided in the EIS.

Table 4.8 Vegetation in the Project Area

Feature	Area (ha)
Project Area	2900.5
Glendell Project Disturbance Area	1827.1
Additional Disturbance Area	749.8
Category 1 – exempt land	135.8
Development Footprint	614.3
Disturbed	19
Exotic Vegetation	54.8
Native Vegetation – Derived Grassland	386.0
Native Vegetation – Woodland/Forest (including rehabilitation)	154.5

+

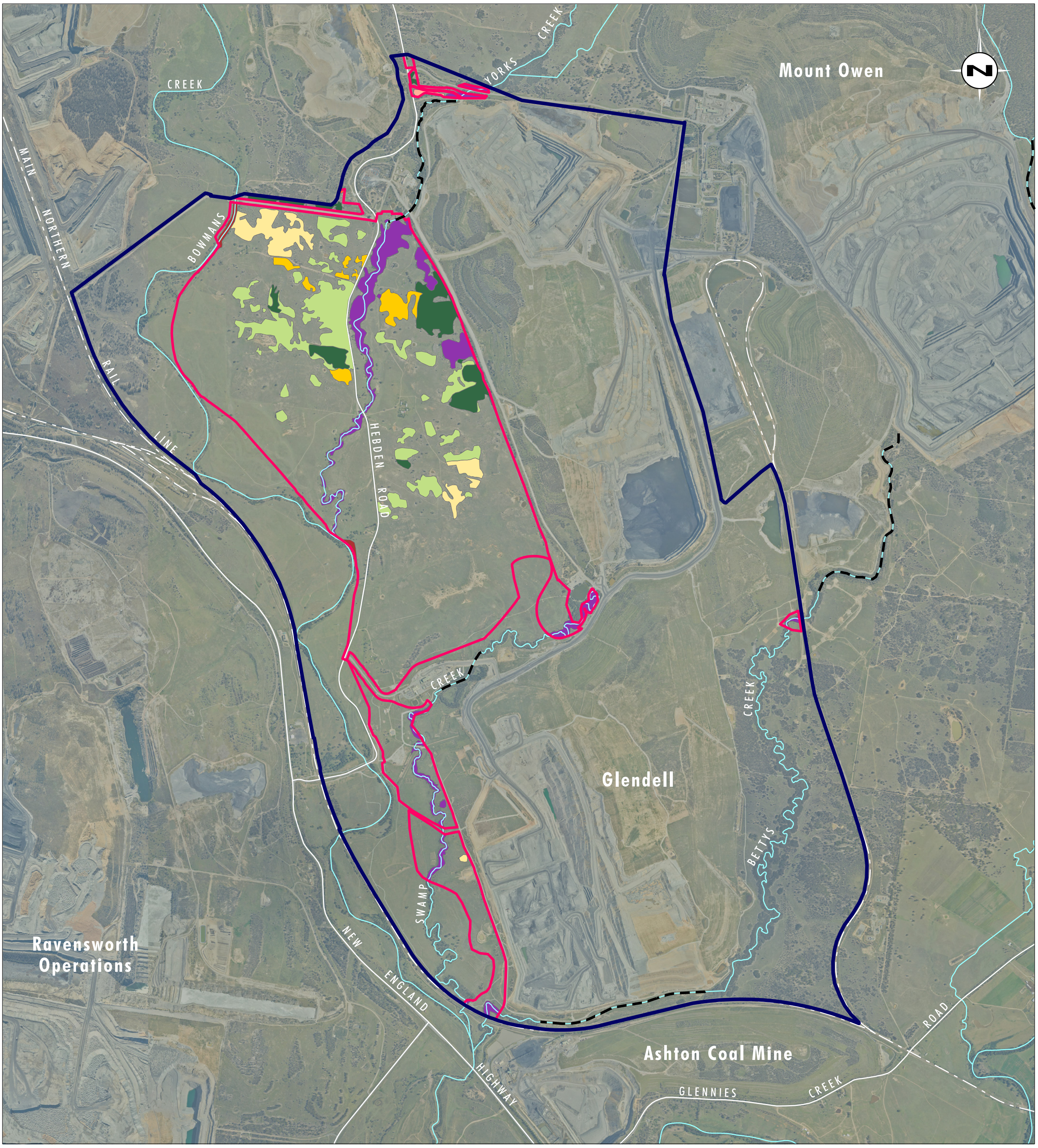

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- 485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Moderate to Good Condition
- 1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good Condition
- 1603 - Regeneration
- 1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central And Lower Hunter - Plantation
- 1604 - Woody Rehab
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition
- 1692 - Regeneration
- 1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good Condition

FIGURE 4.8

Native Vegetation in the Additional Disturbance Area

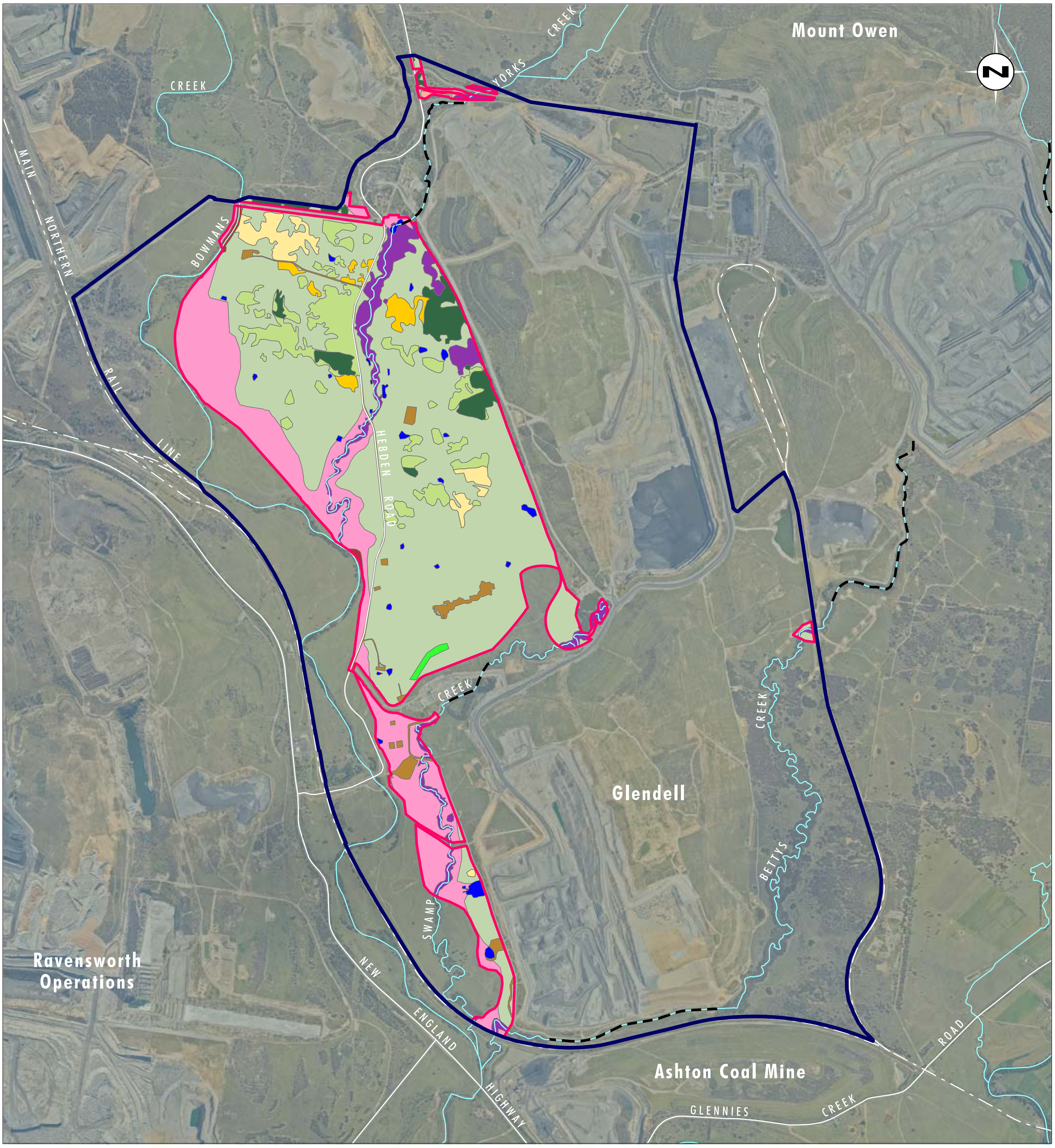

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- 485 - River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Moderate to Good Condition
- 1603 - Narrow-leaved Ironbark - Bull Oak - Grey Box Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good Condition
- 1603 - Plantation
- 1603 - Regeneration
- 1603 - Derived Native Grassland
- 1604 - Narrow-Leaved Ironbark - Grey Box - Spotted Gum Shrub - Grass Woodland of the Central And Lower Hunter - Plantation
- 1604 - Woody Rehab
- 1692 - Bull Oak Grassy Woodland of the Central Hunter Valley - Moderate to Good Condition
- 1692 - Regeneration
- 1731 - Swamp Oak - Weeping Grass Grassy Riparian Forest of the Hunter Valley - Moderate to Good Condition
- Exotic Grassland
- Dam
- Disturbed Land

FIGURE 4.9

Vegetation Communities in the Additional Disturbance Area

5.0 Agricultural impacts

The impacts from mining activities on the land resources and agricultural productivity can vary from short term temporary impact to long term and permanent impacts. Temporary impacts can include the construction of access tracks or storage of soil resources, as well as operational impacts such as noise and air quality. Long term impacts may include changes to water availability and the future land and soil capability of reshaped overburden placement areas. Permanent impacts are irreversible and do not allow the reinstatement of the pre-mining land and soil capability or agricultural uses. They can include final voids and significant changes to the pre-mining landform, drainage patterns or groundwater quality and quantity.

5.1 Rehabilitation and post mining land use

A Rehabilitation and Mine Closure Strategy has been prepared for the Project (refer to Appendix 24 of the EIS), this section summaries the rehabilitation objectives that will be implemented at the Mount Owen Complex.

The overarching rehabilitation objective for the Project is to create a safe, stable and non-polluting post-mining landscape which is suitable to sustain the final land use. The conceptual final landform will predominantly consist of an undulating landform generally reflecting the dominant features of the existing environment. Consistent with the proposed rehabilitation objectives, natural landform design elements will be developed in all parts of the final landform above natural ground level developed under the Glendell Continued Operations Consent and as part of the Project.

The proposed Rehabilitation and Mine Closure Strategy for Mount Owen Complex has been developed in consideration of a number of factors including site opportunities (i.e. proximity to remnant native vegetation areas) and constraints (i.e. slope, substrate quality etc.), ecological and rural land use values and existing strategic land use objectives.

The overall objectives of the conceptual post-mining land use design of Mount Owen Complex include:

- the development regional vegetation corridors that promote fauna movements between Mount Owen Complex, Ravensworth Operations, Liddell Coal Operations, Lake Liddell, Ravensworth State Forest, biodiversity offset areas and Bowmans Creek
- maintain and provide additional suitable habitat for a range of threatened fauna species including the spotted-tailed quoll (*Dasyurus maculatus maculatus*)
- provide opportunities for future agricultural activities such as sustainable grazing in appropriates parts of the terrain
- improve the visual amenity of the area
- not preclude other potential post mining land use should they be determined to be viable and preferable as part of the detailed mine closure planning process that will commence at least five years prior to the planned cessation of mining.

The final land uses are nature conservation and low intensity grazing. A final void will remain in the Glendell Pit Extension. Portions of the final landform will be revegetated with open grassland with pockets of native vegetation. It is the intent that these areas could be used for sustainable agricultural purposes such as grazing (subject to final land use planning to be developed as part of the closure process). As such, revegetation may involve the use of both native and suitable exotic pasture species for the establishment of grasslands in these areas. Pockets of native vegetation may be established in these grassland areas as shelter belts to support grazing activities.

The overburden emplacement areas will generally be battered to an average of 10° in order to reduce erosion risk. The implementation of natural landform design principles, however, may result in localised sections of slopes exceeding 18° in order to conform with the surrounding natural landform. It is expected that steeper slopes would only occur in the upper portions of catchment areas. The maximum proposed Glendell emplacement area height will be approximately 200 mAHD, the currently approved height is approximately 160 mAHD.

The final void will include a pit lake which will naturally recover over time, the void will be designed to be a hydraulic sink such that the pit lake and level of saturation within the spoil does not decant to downstream catchments. Highwalls will be maintained in the void to minimise the associated catchment area. However, where necessary, the highwalls surrounding the void will be battered back to improve stability. This will result in a slight increase in overall void footprint, but also provide opportunity for selective plantings. Highwall benches and battered lowwalls will be revegetated with native vegetation however growing medium depth on benches may limit the ability to successfully grow trees in these highwall bench areas.

Rehabilitation will be undertaken progressively in accordance with the Mining Operations Plan (MOP)/Rehabilitation Management Plan (RMP). The MOP/RMP will be developed in accordance with the Rehabilitation Strategy and will include the detailed measures and schedules for all required rehabilitation activities. The ongoing review and refinement of rehabilitation completion criteria will be undertaken as part of the MOP/RMP process and the monitoring of rehabilitation performance against the completion criteria will be reported in the Annual Review.

As previously discussed, the Project will impact approximately 34 ha of Verified BSAL. This area contains LSC Class 3 (approximately 13 ha) and Class 4 (approximately 21 ha) land and is impacted by the following Project components:

- Hebden Road realignment
- new MIA
- Heavy Vehicle Access Road
- relocated telecommunications and electricity infrastructure and
- water management infrastructure.

The Hebden Road realignment and relocated telecommunications and electricity infrastructure will remain in the final landform however the Heavy Vehicle Access Road, new MIA and associated water management infrastructure will be removed unless required for another approved land use in the final landform.

Following removal of the Heavy Vehicle Access Road and MIA, the areas of verified BSAL not impacted by the permanently relocated infrastructure or areas where landform shaping is required for final landform development and/or drainage purposes will be rehabilitated to LSC Class 4 land (approximately 21 ha).

The proposed rehabilitation strategies and relevant management measures applicable to the Project are detailed in the Rehabilitation and Mine Closure Strategy, refer to Appendix 24 of the EIS.

5.2 Impacts on Agricultural Resources in the Project Area

5.2.1 Impact on Soils

The Project will have a direct permanent impact on the majority of the Additional Disturbance Area. Small areas to the west of the Hebden Road realignment may not be disturbed, and impacts to the area to the north-west of the final void and to the south-west of the overburden emplacement area are anticipated to be low (refer to **Figure 5.1**). The pre and post soil impact soil orders within the Additional Disturbance Area are provided in **Table 5.1**.

Soil orders within the Additional Disturbance Area may change from the pre-mining soil order to Anthroposol, depending on the severity of the disturbance. Areas with limited disturbance may retain the original soil order as Anthroposols require anthropic materials of more than 0.3 m (Isbell, 2002).

Table 5.1 Change in ASC Soil Orders within the Additional Disturbance Area

Anticipated Impact Type	Pre-impact Soil Order	Fertility	Area (ha)	Post-impact Soil Order
Potentially no impact	Chromosol	Moderate	6	Chromosol
	Tenosol	Moderate	6	Tenosol
	Sodosol	Moderately low	12	Sodosol
Low impact	Chromosol	Moderate	5	Chromosol
	Tenosol	Moderate	14	Tenosol
	Sodosol	Moderately low	123	Sodosol
Medium to high impact	Chromosol	Moderate	5	Anthroposol
	Disturbed	NA	12	
	Kandosol	Moderately low	6	
	Rudosol	Low	6	
	Dermosol	Moderately low	8	
	Tenosol	Moderate	34	
	Sodosol	Moderately low	451	
Very high impact	Disturbed	NA	1	Disturbed land such as final void, Hebden road realignment, Yorks Creek Realignment
	Rudosol	Low	1	
	Tenosol	Moderate	3	
	Dermosol	Moderately low	3	
	Chromosol	Moderate	3	
	Sodosol	Moderately low	34	

Tenosols and Chromosols, which may not be impacted include areas mapped as BSAL in accordance with the Interim Protocol. Additionally, approximately 5 ha of the Chromosol in the low impact area also falls within theVerified BSAL area. As a result, approximately 17 ha of the area mapped as Verified BSAL (approximately 34 ha) may not be impacted or only in a low manner.

Tenosols subject to high impact (approximately 34 ha) or very high impact (approximately 3 ha) are largely situated in a narrow band along Yorks Creek thus limiting agricultural use of this soil order due to their spatial extent.

Sodosols are the soil order experiencing the largest impact with approximately 485 ha of the soil order either being converted to an Antroposol (approximately 451 ha) or disturbed land (approximately 34 ha). Sodosols are a common soil order of NSW and pose large limitations to agriculture due to their sodic and therefore unstable nature. The Sodosols in the Additional Disturbance Area are in poor condition. They have a moderately low fertility, the topsoil (A1 horizon) has in many cases been eroded and ESP values in the B horizons range from ESP 6 to ESP 35. Gully erosion due to soil instability is evident in several areas within the Additional Disturbance Area. These limitations restrict the agricultural use and also need to be taken into consideration when pre-disturbance soil stripping, soil stockpiling and when carrying out rehabilitation.

In total, approximately 65% of the soils in the Additional Disturbance Area will either be converted to Anthroposols or permanently disturbed. Therefore, the impact on soils within the Additional Disturbance Area is considered high.

However, the associated quality of the majority of the soil within the Additional Disturbance Area that will be disturbed is considered low. The majority of the impacted soils have a moderately low (approximately 502 ha) or low (approximately 7 ha) fertility or were disturbed prior to mining (approximately 14 ha). Therefore, the existing limitations to agricultural use by the soil orders within the Additional Disturbance Area is already considerable.

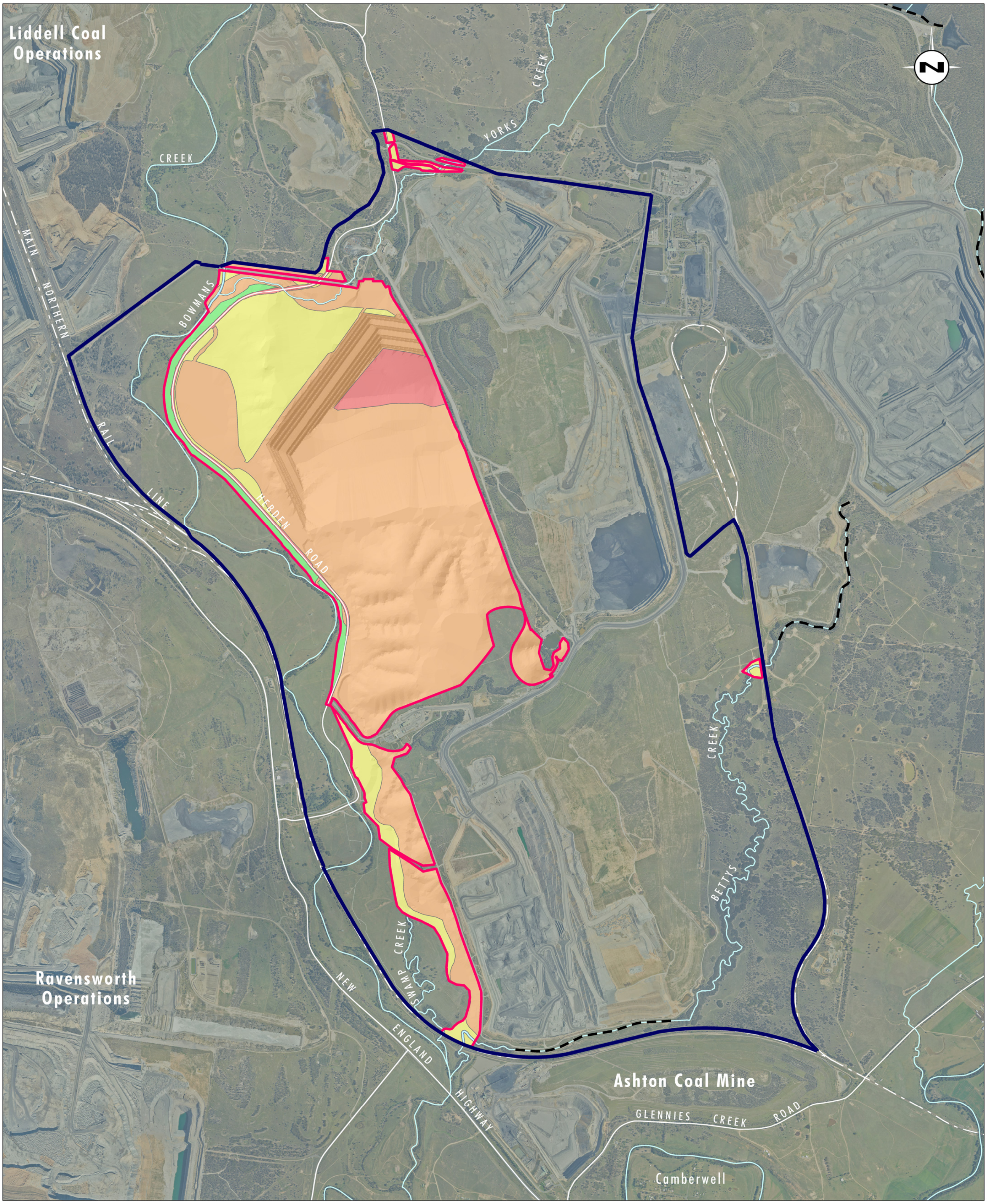

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion
- Potentially No Impact
- Creek

Forecasted Impact:

- Very High Impact
- High Impact
- Low Impact

FIGURE 5.1

Forecasted Impact Types (Long Term)

File Name (A4): R10/4166_292.dgn
20191202 13.55

5.2.2 Impacts to land capability

Disturbance associated with the Project will lead to changes in LSC classes due to a change in landform and soil resource. Some areas within the Additional Disturbance Area that will be directly impacted will be permanently removed from future agricultural use, other areas directly impacted will only be temporarily removed. The majority of the land directly impacted within the Additional Disturbance Area is owned by Glencore with the exception of two small lots, one owned by Ausgrid the other is Crown Land, and the road reserve for Hebden Road which Singleton Council is the Road Authority. The Additional Disturbance Area is currently utilised as buffer land for mining operations or dryland cattle grazing. A summary of the land and soil resources, expressed as LSC Class, of all directly impacted areas is presented in **Table 5.2**.

Table 5.2 Change in Land and Soil Capability within the Additional Disturbance Area

<table>
<tr><th>LSC Class</th><th>Existing (ha)</th><th>Post Mining (ha)</th><th>Change (ha)</th></tr>
<tr><td>Class 3 High Capability</td><td>13</td><td>0</td><td>-13</td></tr>
<tr><td>Class 4 Moderate Capability</td><td>50</td><td>21</td><td>-29</td></tr>
<tr><td>Class 5 Moderate – Low Capability</td><td>523</td><td rowspan="2">616</td><td rowspan="2">-38</td></tr>
<tr><td>Class 6 Low Capability</td><td>131</td></tr>
<tr><td>Class 8 Extremely Low Capability</td><td>33[#]</td><td>113*</td><td>+80</td></tr>
</table>

[#] Includes creeklines, disturbed areas and Hebden Road

*Includes creeklines, disturbed areas, final void and realigned Hebden Road

Direct Permanent Impact

The Hebden Road realignment, the Yorks Creek realignment, general infrastructure areas and the final void will result in direct impacts which will permanently change the existing land use away from agriculture. These areas will form approximately 113 ha of the post mining landform with a LSC Class 8 (Extremely Low Capability). The remainder of the post mining landform will be rehabilitated to LSC Class 4 or Class 6 land. The indicative soils capability classes in the Additional Disturbance Area in the rehabilitated post-mining landform are shown in **Figure 5.2**

umwelt

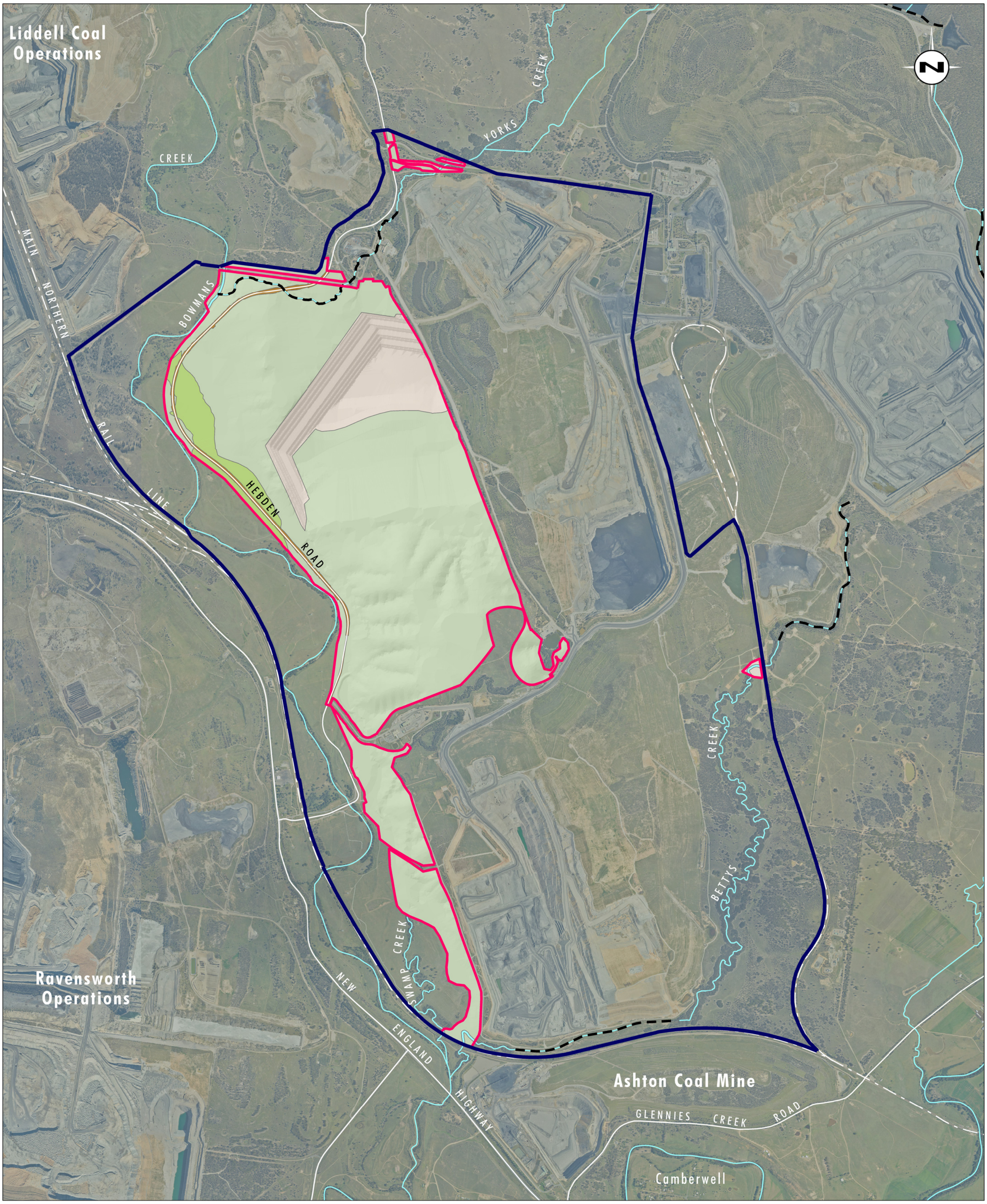

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019)

Legend

- Project Area
- Additional Disturbance Area
- Existing and Proposed Creek Diversions

Land and Soil Capability:

- Class 4
- Class 6
- Class 8
- Creek
- Disturbed

FIGURE 5.2

Conceptual Final Landform Indicative Soil Capability Classes in the Additional Disturbance Area

File Name (A4): R10/4166_342.dgn
20191128 15.18

Direct Temporary Impact

Aside from the Hebden Road reserve, areas currently disturbed and the existing creek lines (approximately 4% of the Additional Disturbance Area), the remainder of the land within the Additional Disturbance Area is currently suitable for low intensity grazing.

The majority of the post mining landform will form LSC Class 6 (approximately 80% of the Additional Disturbance Area). As per the Rehabilitation and Mine Closure Strategy (Appendix 24 of the EIS), the conceptual final land uses are native vegetation and low intensity grazing. The Additional Disturbance Area will be rehabilitated with a combination of native vegetation and open grassland communities that would have historically occurred in the area. Dryland grazing has been proposed as a potential post mining land use for the areas of open grassland.

The Project will directly impact on approximately 63 ha of Class 3 and Class 4 land which may be suitable for cropping (noting Class 4 land is only suited for occasional cropping) of which approximately 34 ha has been verified as BSAL in accordance with the Interim Protocol. With the exception of the areas of Verified BSAL not impacted by the permanently relocated infrastructure (Hebden Road, telecommunications and electricity) or areas where landform shaping is required for final landform development and/or drainage purposes, the land within the verified BSAL area will be returned to LSC Class 4 land in the post mining landform (approximately 21 ha). The small area of LSC Class 4 land located in the south of the Additional Disturbance Area adjacent to Swamp Creek may also be suitable for cropping however the alignment of Swamp Creek and localised terrain features constrain the ability to effectively crop the entire area. This area may be directly impacted by water management infrastructure and overburden emplacement for the establishment of the final landform with parts of this area identified as being returned to grazing land in the final landform.

The reduced size of paddocks in the alluvial areas east of Bowmans Creek and the presence of the Hebden Road realignment through these paddocks has the potential to reduce the viability of some potential broad-acre cropping options (e.g. grains) that this area could also be utilised for. It is noted however that there is very little support infrastructure for this cropping system in the Hunter Valley and other cropping uses (such as hay or silage) are more likely to be suited to this area. The reduced paddock size and layout and the fragmentation caused by the realigned Hebden Road is unlikely to result in a significant constraint to this area being used for these production purposes in the future. The availability of water for irrigation purposes is considered to be a larger constraint of this potential production system and this is unaffected by the Project.

It is not anticipated that the Project will have any material impact on long term cropping options in the Project Area. The overall reduction in BSAL in the Project Locality (approximately 1% reduction) is not considered to be significant and this is considered to be a negligible impact on the overall extent of BSAL within the Upper Hunter SRLUP area.

Indirect Impact

The floodplain area (LSC Class 3 and Class 4) making up approximately 8.5% of the Additional Disturbance Area, has fewest limitations to grazing and may also be suitable for cropping. The rolling hills within the Project Area are suitable for grazing but steeper areas are prone to erosion and mass movement, which stocking rates have to take into consideration.

For the purposes of the AIS, it has been assumed that the entire Additional Disturbance Area will be removed from agriculture. However, in reality some of the northern areas may continue to be utilised for grazing until the Glendell Pit Extension necessitates the exclusion of stock from this area, as mining progressively extends to the north. Additionally, areas between the Additional Disturbance Area and the Main Northern Railway on the western side of the Project Area will also become unviable for continued grazing, due to indirect impacts associated with access restrictions and close proximity of active mining operations (refer to **Figure 5.3**).

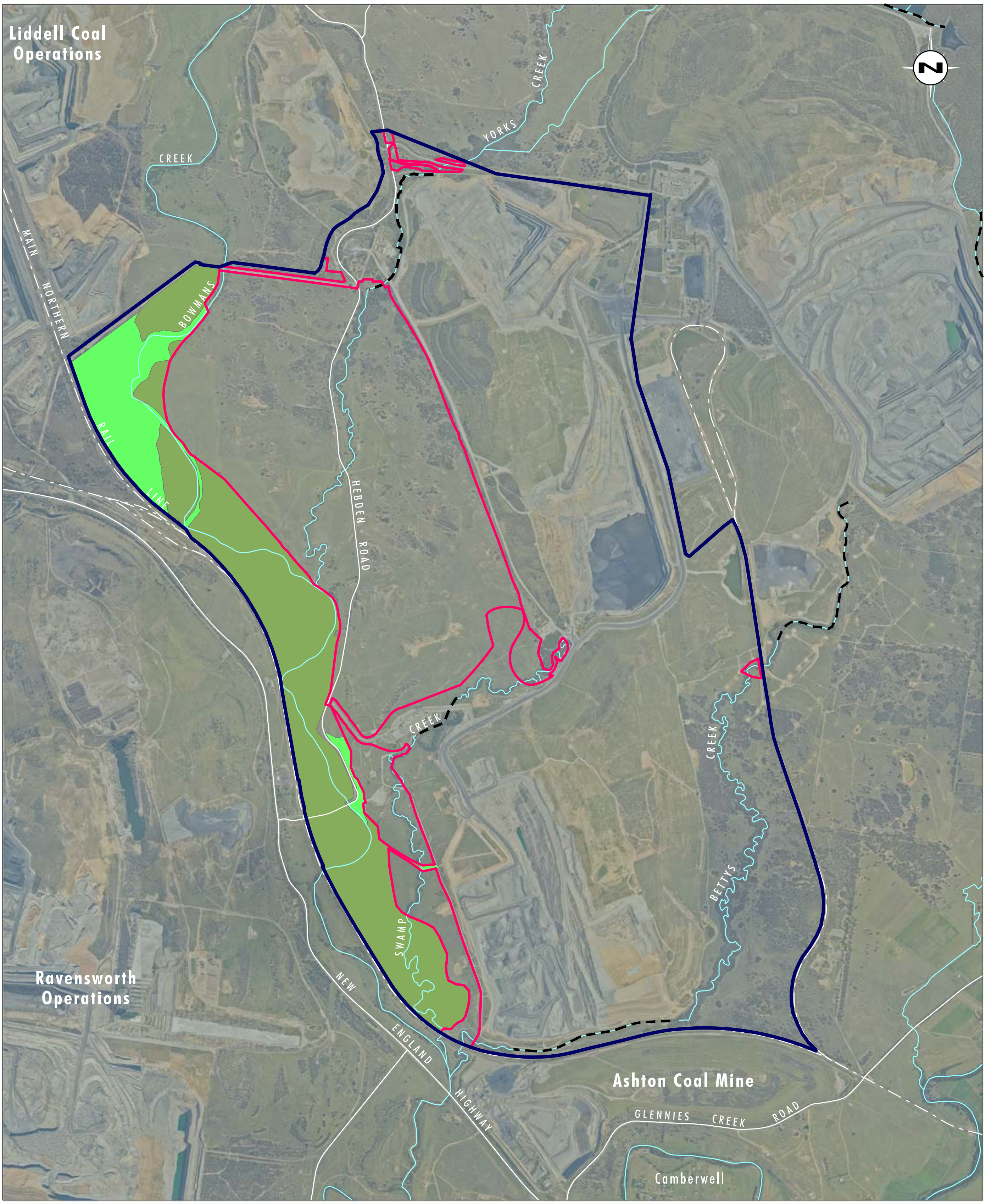

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

Legend

- Project Area
- Additional Disturbance Area
- Existing Creek Diversion

Potential Impact:

- Improved Pasture
- Native Unimproved Pasture

FIGURE 5.3

Project Area Potentially Indirectly Impacted

5.3 Impacts on agricultural resources in the project locality

5.3.1 Agricultural resources

The Project Locality is dominated by mining operations and features rural and rural residential properties. The Project is considered to have low impact on the agricultural resources in the Project locality as:

- There will be minimal impacts on the availability of water resources for agriculture outside the Project Area. The Project is not predicted to impact surface water quality.
- There will be minimal additional impact on groundwater quantity and quality. The majority of the cumulative drawdown on all surrounding groundwater sources is due to the existing approved operations at Glendell Mine and the other surrounding mining operations.
- There will be no direct or indirect impact to the landforms of the Project Locality, outside of the Additional Disturbance Area.

There will be no direct or indirect impacts to the soil resources of the Project Locality (outside of the Additional Disturbance Area). While a small area of BSAL will be impacted within the Additional Disturbance Area, no impact to BSAL outside of the Additional Disturbance Area is expected. LSC Classes in the Project Locality (outside of the Additional Disturbance Area) will not be changed as a result of the Project.

5.3.1.1 Blasting, noise and air quality

Modelling indicates air quality, noise and blasting impacts are consistent with the impacts associated with the approved Glendell Mine, with a slight increase in air quality and noise impacts within the Hebden area however levels remain within relevant criteria. Indirect impacts associated with air quality, noise and blasting are unlikely to have any impact on agricultural production outside the area being assessed.

There are no horticultural, aquaculture or intensive agricultural operations located within the Project Locality that could be adversely affected by particulate matter or dust deposition impacts. Further details with regard to noise and air quality modelling results are provided in the EIS.

An assessment of the rock strata between Bowmans Creek and the Glendell Pit Extension anticipates that blasting induced cracks would not be readily transmitted through the strata and that an increase in permeability would be limited to less than 30 m from the blast face (ESC, 2019).

Noise and vibration impacts from blasting have potential to startle livestock, however, previous studies undertaken by Glencore in relation to the Mount Owen Mine indicate that these blasting impacts do not have any significant impacts on the safety of livestock.

Investigations undertaken by Neil Nelson Advice Pty Limited (Agriculture Consultancy Service) in 2011 included observations made at a Colinta Holdings feedlot, located on Falbrook Road approximately 2 km south of the North Pit.

Observations were made during four separate blasts with no disturbance of the livestock observed within the feedlot or within the paddocks adjoining the feedlot during blasting activities. The report concludes that while blasting can result in immediate noise disruption, so does that of passing traffic and general farming equipment. Given the history of mining activities within the area, blast noise associated with the Glendell Pit Extension would not be an additional noise source to the area and livestock and other animals are likely to be accustomed to blast noise.

Previous studies undertaken by SLR in relation to the Albion Park Quarry, NSW, indicate peak particle component velocity levels for blasting should not exceed 200 mm/s (vibration) and 135 dBL (airblast) to protect livestock.

In 2018 an investigation was undertaken by SLR consulting in relation to blasting at Mount Owen Mine. SLR were involved in a previous confidential study involving cattle that grazed as close as approximately 1 km from open-cut mine blasts (airblast in excess of 110 dBL and vibration in excess of 4 mm/s). The study concluded that there was no statistically relevant difference in weight gain (over multiple periods) between the cattle grazed in proximity to the mine when compared to other cattle grazed on a control site exposed to much lower blasting levels.

SLR then compared the blasting levels the cattle were exposed to during this confidential study to the monitoring data from monitoring point MOC4 (approximately 4 km from the Mount Owen Mine) which is the closest monitoring point to an existing feedlot (approximately 5 km from the Mount Owen Mine). The measured blasting levels from the monitoring point are lower than the acceptable level and significantly lower than the levels recorded during the confidential study. A comparison of the maximum measured level from MOC4 compared to the acceptable level (Albion Park Quarry Study) is provided below:

- Vibration – maximum measured level of 1.93 mm/s (acceptable level 200 mm/s)
- Airblast – maximum measure level of 99.9 dBL (acceptable level 135 dBL)

Colinta currently successfully operate a grazing enterprise within the buffer areas around the Mount Owen Complex in closer proximity to the existing operations than any adjoining neighbours. There is no apparent evidence of stress in the Colinta livestock grazed in close proximity to the existing operations. Accordingly, impacts on grazing and other livestock enterprises located further afield are not anticipated.

Potential impacts to livestock related to flyrock will be managed as part of pre-blast inspection activities, with the clearing of all livestock from within the blast exclusion zone if required. Currently the closest private grazing land is approximately 4 km from the Project Area.

5.3.2 Agricultural use

As discussed in **Section 4.1**, the majority of land within the Project Locality is owned by mining operations. As such, existing agricultural uses are largely dryland grazing either carried out by mining operations, associated subsidiary companies or a third party leasing the land. The agricultural use of land owned by the mining companies will not be impacted by the Project as other drivers will determine land uses of these areas.

Agricultural use of privately-owned land within the Project Locality is unlikely to be affected by the Project as the associated agricultural resources will not be affected. More generally, the main potential impacts on agricultural enterprises are associated with:

- changes to accessibility or services, which can include road access between properties or a property and supplier
- other impacts on social and economic conditions such as competing demands for skilled labour
- visual amenity.

5.3.2.1 Impacts on services and infrastructure

The Project will have a minimal impact on local and regional agricultural services and infrastructure. Changes to the supply and viability of agricultural support services are generally driven by social trends exceeding the scale of the Project Locality.

The Project is predicted to result in a small change in the number of cattle sent to the market (this is discussed further in **Section 5.3.3**). During the life of the Project, based on the current Colinta land management practice, the Project would remove a total of 140 breeders through direct and indirect impacts. This accounts for approximately 3% of the Colinta NSW herd, less than 1% of Colinta's Australian herd and 0.2% of all cattle sold at the local saleyards. The Project is not predicted to result in a significant impact on Colinta's operations or the local saleyards.

It is proposed that Hebden Road will be realigned to the west around the Glendell Pit Extension and the proposed new MIA (refer to **Figure 1.2**). This realignment would extend the trip distance for some road users travelling on Hebden Road by approximately 1.2 km. The realignment will also include a crossing of the proposed Yorks Creeks Realignment.

The road is proposed to be constructed to a design speed of 80 km per hour, consistent with current conditions and in accordance with the NSW Roads and Traffic Authority's (now RMS) Road Design Guide (1993) and Singleton Council's Development Control Plan (2014). In order to minimise disruptions to traffic, where possible, the realigned section of Hebden Road will be largely constructed prior to decommissioning of the existing section (anticipated to be completed by the end of Year 2). This minor change to the distance and travel time along Hebden Road is unlikely to significantly impact on agricultural services and infrastructure.

5.3.2.2 Visual amenity

Visual amenity is an important value in rural areas for landowners 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, however there are no CIC areas within 10 km of the Project Area and mining operations form part of the existing landscape within the Project Locality.

In the case of the Project:

- the Project Locality and surrounding area is dominated by existing mining operations with associated extensive areas of disturbance which are an established part of the existing view of the rural landscape from the properties to the east, south-east and west of the Project Area.
- existing active mining and overburden emplacement areas are currently visible from public viewing points, although the Project will increase the visibility of the mining operations at Glendell Mine, these views are not considered to be significantly different to current views of the approved operations within the Mount Owen Complex and the surrounding mining operations within the Project Locality.
- there are no established tourism operations within the Project Locality.

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 Project 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 local and regional context. Further detail in relation to the social impacts associated with the Project are detailed in the EIS.

5.3.2.3 Impact on agricultural employment

The Project will not impact any existing agricultural enterprise outside of the Project Area, therefore there will be no direct impact to any associated employment. The operational workforce at Glendell will progressively increase from approximately 300 FTE to approximately 690 FTE positions when production rates are higher. However, the increasing workforce at Glendell coincides with a reduced workforce requirement at Mount Owen as operations at Bayswater North Pit and North Pit decline resulting in ongoing workforce requirements which are not predicted to impact local or regional agricultural employment.

5.3.3 Agricultural Use within the Project Area

The NSW Department of Primary Industry Guidelines "Beef stocking rates and farm size – Hunter Region' (DPI, 2006) (DPI Stocking Guidelines) have been used to assess the direct and indirect impacts on stock numbers and production. **Table 5.3** provides an overview of the Project's potential direct and indirect impacts on grazing production in the Project Area. This assessment has assumed that LSC Class 3 and 4 areas are improved pastures which have a higher production capacity and would be used for vealer production; the Class 5 and 6 are assumed to be native pasture and only suitable for weaner production.

Table 5.3 Assessment of Impacts on Cattle Production

Scenario		Production Units*		
		Additional Disturbance Area	Indirect Impact Area	Total (units)*
Existing Landscape	Vealer production on improved pastures (Units)	35	150	185
	Weaner production on unimproved pastures (Unit)	81	13	94
	Total Units	116	163	279
During Operations	Vealer Production on Improved Pastures (units)	0	0	0
	Weaner Production on Unimproved Pastures (units)	0	0	0
	Total Units	0	0	0
Post-mining landscape	Vealer production on improved pastures (Units)	17	150	167
	Weaner production on unimproved pastures (Unit)	42	13	55
	Total Units	59	163	222

*A production unit is a cow and calf with the calf being sold as either a vealer or weaner depending on land capability

DPI (2006) recommends a herd of a minimum of 40 breeding cows to cover direct costs and to justify the effort of running a grazing operation. Based on this recommendation, the area indirectly impacted by the Project would be able to sustain sufficient production levels to cover production costs even with the unavailability of the Additional Disturbance Area. Accordingly, the assumption that the Project would also result in the loss of production from this area is considered conservative.

Assuming that all of the area indirectly impacted by the Project are unavailable for agricultural production during operations, the Project will remove land that can carry approximately 279 production units per annum during operations and until the grassland areas in the Additional Disturbance Area have been rehabilitated after mining has finished. In the post mining landscape, under the assumption that the areas indirectly impacted can return to production with no changes to LSC Classes, a total of 299 production units could be returned to the landscape, 59 units in the Additional Disturbance Area and 163 units in the areas indirectly impacted. The projected carrying capacity of 42 production units would suggest that the rehabilitated landscape would provide enough land, by itself, to cover the costs associated with a grazing operation.

Glencore and its subsidiary companies own approximately 285,000 ha of agricultural land in Australia, which includes about 28,000 ha in NSW. While this land is not exclusively managed for cattle, cattle grazing is the dominant form of agricultural use. A large proportion of the agricultural land is occupied by Colinta, which on average maintain between 40,000 and 50,000 cattle across Australia at any one time. Approximately 5,000 cattle are run in NSW (Glencore, 2017).

During operation based on the current land management practice, the Project would remove a total of 285 breeders through direct and indirect impacts. This accounts for approximately 6% of the Colinta NSW herd and less than 1% of the Australian herd. The areas indirectly impacted are assumed to be able to return to agricultural production and the post mining landscape will be able to sustain a reduced cattle grazing herd. As a result, the Project is not predicted to result in a significant impact on Colinta's operations.

As discussed in the **Section 5.2**, the Project will temporarily restrict the use of the Additional Disturbance Area for grazing and cropping. However, the post mining landform will provide for areas suitable for grazing and to a lesser extent broad-acre cropping. While areas suitable for broad-acre cropping will be restricted, this use is also restricted within the existing landscape and there is little support infrastructure for this cropping system in the Hunter Valley and other cropping uses (such as hay or silage) are more likely to be suited to this area. The reduced paddock size and layout and the fragmentation caused by the realigned Hebden Road is unlikely to result in a significant constraint to this area being used for these production purposes in the future with the availability of water for irrigation purposes considered to be a larger constraint of this potential production system and this is unaffected by the Project.

The Project is predicted to reduce the overall area of land potentially suited to cropping by approximately 33 ha of which the majority is LSC Class 4 land (approximately 23 ha) and only suited for occasional cropping. Low-intensity grazing is the most viable agricultural use for the land, consistent with the existing use.

5.4 Potential physical movement of water away from agriculture

5.4.1 Groundwater

The Project proposes to remove alluvium associated with Yorks Creek and Swamp Creek. The alluvium associated with these creeks is classed as a less productive groundwater source and as an aquifer system it is relatively thin, comprised of less permeable sediments and is of limited saturation or dry. The only potentially highly productive aquifer in the Project Area is the Bowmans Creek alluvium, which is relatively thin but contains a permeable sand and gravel base that readily transmits fresh to slightly brackish groundwater. Bowmans Creek meanders through the flood plain adjacent to the Glendell Pit Extension and includes some pools.

Groundwater modelling indicates that the Project will further depressurise the coal seams proposed to be mined. Localised areas of drawdown are predicted to occur within the Bowmans Creek alluvium in proximity to the areas where Yorks Creek and Swamp Creek will be removed. The predicted drawdown is up to 2 m in isolated areas. There are no known operating private water supply bores in the area where the numerical modelling indicated the potential for drawdown.

Groundwater quality changes are not expected as a result of the Project. Due to salinity, groundwater in the vicinity of the Project Area can be used for stock watering but is not suitable for irrigation. Groundwater levels and quality will continue to be monitored in accordance with the approved Water Management Plan.

Post mining drawdown to the agriculturally valuable alluvium groundwater source by the Project is limited to a small area of the Swamp Creek alluvium at the western interface with the Glendell Pit Extension. The Swamp Creek alluvium is classed as a less productive groundwater source due to its limited saturated thickness and thus has limited agricultural value.

The overall recovery of the alluvium post mining is modelled to take approximately 500 years due to the extensive mining activities in the area, and a new flux equilibrium will develop with lower fluxes than encountered during pre-mining conditions. Overall, impacts to the agriculturally valuable groundwater in the Project Area is negligible. Impacts to downstream agricultural water users due to the Project are not anticipated.

Refer to the Groundwater Impact Assessment (AGE 2019), for further detail, Appendix 16 of the EIS.

5.4.2 Surface Water

Impacts to surface water as a result of the Project are considered negligible as:

- no measurable impacts to the flow of Bowmans Creek, Glennies Creek and the Hunter River are expected
- the flood impacts due to the Yorks Creek Realignment are low and limited to the area of Bowmans Creek between the existing confluence and the proposed confluence approximately 4 km upstream
- the final void will remain a self-contained system as it has approximately 136 m of freeboard
- no impacts to surface water quality are expected.

As a result, no impacts to agricultural surface water users in the Project Locality are expected.

Refer to the Surface Water Impact Assessment (GHD, 2019) for further detail, Appendix 17 of the EIS.

6.0 Risks, risk management and mitigation

6.1 Project alternatives

Glencore has completed detailed environmental and social constraints studies to inform the proposed conceptual design for the Project. As part of these studies, a range of different alternatives for mine design were considered and reviewed including mine disturbance areas, overburden emplacement areas, infrastructure design, fleet numbers, equipment type and location, and scheduling.

Technical mining constraints considered in determining the mineable coal reserve include:

- location of past mine workings such as the former Liddell underground mine to the north and Ravensworth East open cut mine to the east of the target area (refer to **Section 2.1**)
- faulting and other geological structures in the area including the location of the Camberwell anticline and block fault zone
- variations in the thickness and depths of the different coal seams and differing thicknesses of overburden and interburden material in the area
- variability of the quality of the coal in the different seams.

In addition to the technical mining constraints identified above, the consideration of mine plan alternatives had regard to key environmental and social constraints, including:

- impacts on surface water and groundwater systems and water resources, such as Bowmans Creek, Yorks Creek, Swamp Creek, Bettys Creek and associated alluvial aquifers
- heritage impacts, particularly impacts in relation to Ravensworth Homestead and Aboriginal cultural heritage
- impacts on surrounding residents such as:
  - noise impacts
  - air quality impacts
  - visual impacts
- traffic impacts and additional travel distance associated with a realignment of a section of Hebden Road and temporary road closures due to blasting along Hebden Road
- potential cumulative amenity impacts (particularly air quality, noise and visual)
- impacts on agricultural land including assessment of any Biophysical Strategic Agricultural Land (BSAL)
- impacts on biodiversity values.

Other considerations in developing the Project mine plan include:

- requirement to realign part of Yorks Creek and a section of Hebden Road
- location of high voltage transmission lines and other utilities
- location of existing Glendell MIA

- access to adjacent existing operations
- capacity of Mount Owen CHPP and other existing infrastructure
- final landform design, final void configuration and post mining land use options.

The above factors were considered and evaluated in an iterative design and review process, to refine the sequence of mining required to enable the quality and quantity of coal extracted to be managed to meet market specifications and maximise production and operational efficiencies across the life of the Project while mitigating environmental and social impacts.

Project alternatives considered include:

- not undertaking the Project
- underground mining
- different open cut mine design layouts (both larger and smaller in extent to the Project)
- different mine infrastructure area options
- different Hebden Road and Yorks Creek Realignment options.

Details regarding the various conceptual design options and other alternatives considered during the iterative project design phase are discussed in detail in the Mine Planning Options Report, (refer to Appendix 1 of the EIS).

6.2 Management and mitigation of impacts

All current operations at the Mount Owen Complex, including the Glendell Mine, are undertaken in accordance with approved Environmental Management Plans and Strategies. The management plans include detailed environmental monitoring programs. Glencore continually monitors environmental performance and legislative compliance of the existing operations. Mining operations are managed through the existing Environmental Management System (EMS) to minimise impacts on the surrounding environment and community. The EMS provides for the monitoring and reporting of all key environmental aspects of the current operations.

Key management plans currently in effect that assist in managing impacts on agricultural land include:

- Rehabilitation and Mine Closure Strategy
- Mining Operations Plan / Rehabilitation Management Plan
- Air Quality and Greenhouse Gas Management Plan
- Noise Management Plan
- Blast Management Plan
- Water Management Plan (including Water and Salt Balance, Erosion and Sediment Control Plan, Surface Water Management and Monitoring Plan, Groundwater Management and Monitoring Plan, Surface and Groundwater Response Plan, Creek Diversions Plan)
- Biodiversity and Offset Management Plan

- Road Closure Management Plan
- Pollution Incident Response Management Plan.

These management plans will be reviewed and revised where necessary to incorporate the requirements associated with the Project.

The current approved environmental management plans are available on the Mount Owen Complex website (www.mtowencomplex.com.au).

The proposed rehabilitation strategy for the land disturbed by the Project includes a commitment to rehabilitate areas of Verified BSAL not impacted by the permanently relocated infrastructure (Hebden Road, power and telecommunications) or areas where landform shaping is required for final landform development and/or drainage purposes will be rehabilitated to LSC Class 4 land (approximately 21 ha). This commitment returns approximately 33% of the potential cropping land impacted by the Project back to a standard that will support intermittent cropping.

The Rehabilitation Strategy (refer to Appendix 24 of the EIS) also includes a commitment to reinstate flatter areas of the terrain to open grassland which may be suitable grazing land. Soils stripped from the more fertile BSAL area impacted by the Project will be prioritised for use in areas identified for open grassland rehabilitation to improve the long-term productivity of these areas, where practicable.

The mine closure planning process will also investigate the potential for other agricultural uses in the rehabilitated landform.

6.3 Review of risks

As required by the Agricultural Impact Statement technical notes a risk assessment relevant to the potential agricultural impacts associated with the Project is presented in **Table 6.1**. The risk ranking is based on the risk assessment presented in Appendix 3 of the Interim Protocol (refer to **Figure 6.1** and **Figure 6.2**).

The Initial Risk rating in **Table 6.1** is based on all conceivable risks prior to detailed investigations and outcomes of the data reviewed. The final risk rating takes into considerations findings of the technical studies and available management and mitigation options for each risk.

PROBABILITY / Consequence	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts	**A1 high**	**B1 high**	**C1 high**	D1 high	E1 medium
2. Significant and /or long term damage. Long term mgt implications. Impacts difficult or impractical to reverse.	**A2 high**	**B2 high**	**C2 high**	D2 medium	E2 medium
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing mgt implications which may be expensive to implement. Minor damage or impacts over the long term.	**A3 high**	**B3 high**	**C3 medium**	D3 medium	**E3 medium**
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations	A4 medium	B4 medium	C4 low	D4 low	**E4 low**
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations	A5 low	B5 low	C5 low	**D5 low**	**E5 low**

where:

= low risk

= medium risk

= high risk

Figure 6.1 Agricultural Impacts Risk Ranking Matrix (reproduced from OEH and OASFS, 2013)

Level	Descriptor	Description
A	Almost Certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Figure 6.2 Agricultural Impact Risk Ranking Probability Descriptors (reproduced from OEH and OASFS, 2013)

Table 6.1 Risk Assessment for Impacts to Agriculture by the Project

Risk	Initial Risk Rating	Findings of AIS Assessment and Technical Studies	Additional Potential Mitigation Measures	Final Risk Rating
Within the Project Area				
Direct impact to land used for agricultural purposes	A2 - High	Open cut mining will impact the Project Area through the creation of an open cut void, overburden emplacement areas, realignment of a section of Hebden Road and other mining related activities. While the land which will be impacted by this disturbance generally has several restrictions for agricultural uses, it is being used for low intensity cattle grazing.	Project alternatives have been thoroughly investigated.	B3 - High
Impact to BSAL	A2 – High	Extensive soil investigations confirmed that a limited extent of BSAL is present in the Project Area. Areas of BSAL are associated with upper terraces of the Bowmans Creek floodplain.	Impacts to BSAL have been limited as much as possible.	D2 - Medium
Impact to land that is moderate, moderately high or high soil fertility	A2 - High	Extensive soil investigations confirmed that moderate soil fertility occurs in areas identified as BSAL. All other areas have moderately low or low soil fertility.	Impacts to areas with moderate fertility have been limited as much as possible.	D2 - Medium
Change from non-stony to stony soils	A2 – High	Soil types in the Project Area generally have a low to moderate stone content, with exclusion to ridge crests. Anthroposols which will be present in the rehabilitated areas will predominantly be stony as the majority of the soil type will be formed by overburden. Impacted soils have not been cultivated prior to mining and will not be used for cropping in the post-mining landscape. Stoniness has a higher importance where there is cultivation.		C3 - Medium
Impact to soil chemical characteristics	A2 – High	Extensive soil investigations showed that the soil type of large parts of the Additional Disturbance Area is Sodosol, which has severe chemical limitations to agriculture. While there will still be a change in the chemical characteristics between this existing soil type and the future soil type (Anthroposol), chemical characteristics of the existing soil are already poor.	Soil will be tested before being used for rehabilitation. Soil amendments and fertiliser will be applied as required based on laboratory results and intended vegetation community.	C4 - Low

Risk	Initial Risk Rating	Findings of AIS Assessment and Technical Studies	Additional Potential Mitigation Measures	Final Risk Rating
Direct impact to existing private agricultural enterprises	D2 - Medium	No private enterprises exist in the Project Area.		E5 - Low
Direct impact to existing agricultural enterprises currently managed by Colinta in the Project Area	C3 – Medium	Agricultural Production in the Project Area makes up approximately 30% of the production on the Mount Owen Complex. The percentage of cattle run in the Project Area compared to the NSW and Australian operations is low.		B5 - Low
Indirect impact to existing agricultural enterprises currently managed by Colinta in the Project Area	C3 – Medium	Small areas between the Additional Disturbance Area and Bowmans Creek will remain undisturbed but due to fragmentation and isolation it will not be viable to be grazed.		B5 - Low
Direct impact to Critical Industry Clusters	D2 – Medium	No Critical Industry Clusters in the Project Area.		E5 - Low
Impact to surface water	C2 – High	The lower reach of Yorks Creek is proposed to be realigned as part of the Project. Modelling has shown that there will be no significant negative impacts to the creek flow, stability or water quality as a result of the realignment.	The Water Management System has been designed to avoid adverse impacts (i.e. discharge of pollutants) to Bowmans Creek.	C4 – Low
Impacts to groundwater	B3 - High	No adverse impacts on other groundwater users are predicted as a result of the Project.	The Water Management Plan will be implemented to monitor and manage groundwater impacts.	C4 - Low
In the Project Locality				
Impact to downstream water users	B3 - High	The changes in landform catchments over time will result in localised changes to flow patterns but no changes to impacts at infrastructure or private landholders. No impact to downstream users in relation to water quality is expected.	The Water Management Plan will be implemented to avoid downstream impacts to agricultural water users.	C4 - Low

Risk	Initial Risk Rating	Findings of AIS Assessment and Technical Studies	Additional Potential Mitigation Measures	Final Risk Rating
Permanent/temporary impact to agriculture	C3 - Medium	There is no impact, permanent or temporary, expected to agricultural properties in the Project Locality as a result of the Project.		C4 - Low
Indirect impacts (amenity) to local farming activities (air/noise/blasting etc.)	B3 – High	Modelling indicates air quality and noise impacts are consistent with the impacts associated with the approved Glendell Mine, with a slight increase in impacts within the Hebden area however predictions remain within relevant criteria. Assessment of the rock strata between Bowmans Creek and the Glendell Pit Extension anticipated that blasting induced cracks would not be readily transmitted through the strata and that an increase in permeability would be limited to less than 30 m from the blast face.	Operations will continue to be undertaken in accordance with relevant management plans and programs.	C4 - Low
Increased soil erosion	D3 - Medium	Various areas within the Project Area subject to erosion.	Operations will continue to be undertaken in accordance with the Erosion and Sediment Control Plan requirements.	C4 - Low
Land Management (Feral animals and invasive species and bushfire)	C4 - Low	Land management at the Mount Owen Complex is highly regulated and compliant with invasive species controls.		D4 – Low
Impact on Critical Industry Cluster (equine or viticulture)	D3 - Medium	There are no Critical Industry Clusters in the Project Locality		D4 - Low
Impact on quality of BSAL land	D3 - Medium	BSAL is mapped to occur in the Project Locality, but no off site impacts are proposed that would affect this BSAL.		C5 - Low

The majority of risks are rated low. A high risk remains for the land directly impacted within the Additional Disturbance Area. A medium risk remains for the impact to soil fertility, changes to soil type associated with rehabilitation and areas of verified BSAL. Impacts to areas of high soil fertility and verified BSAL have been limited as much as possible. While the land within the Additional Disturbance Area will be altered and will be utilised for non-agricultural land use, the pre-mining landscape also has a range of limitations for agricultural use.

No impacts are expected to the surrounding agricultural land uses within the Project Locality. There are some groundwater drawdown impacts, which are largely associated with the existing approved mining at Glendell and other surrounding approved operations, however, these impacts are not predicted to result in significant impacts on agriculture.

6.4 Uncertainty and significance of potential impacts

6.4.1 Significance of potential impacts

Overall, the Project presents a medium to low risk to agricultural resources or to agricultural enterprises in the Additional Disturbance Area and a low risk in the Project Locality:

- risks to BSAL are medium as there is verified BSAL in the Additional Disturbance Area, no impacts on BSAL in the Project Locality is expected
- risks to other agricultural resources in the Additional Disturbance Area are low, detailed technical studies determined that the agricultural resources in the Additional Disturbance Area have strong limitations to agriculture
- risks to agricultural enterprises in the Project Area and Project Locality are low
- risks to agricultural support services are low
- impacts and risks to the landscape character of the area are low.

6.4.2 Uncertainty

There is a high level of certainty about the relatively low quality of agricultural resources in the Project Area, based on the detailed on-the-ground assessments carried out.

There is a high level of certainty about the capacity of land to be returned to a safe, stable and non-polluting post mining landform based on the EIS studies and evident in the actual results of the rehabilitation practices at the Mount Owen Complex.

There is good information regarding the agricultural productivity in the Project Locality and the broader region and the impacts of the Project on agriculture are well understood with good information regarding the agricultural use of the land provided by Colinta. Therefore, there is limited uncertainty regarding the predicted impacts of the Project on the agriculture in the locality and broader region, including indirect impacts.

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APPENDIX 1

LSC Assessment

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LAND AND SOIL CAPABILITY MAPPING OF ADDITIONAL DISTURBANCE AREA

Glendell Continued Operations Project

FINAL

November 2019

LAND AND SOIL CAPABILITY MAPPING OF ADDITIONAL DISTURBANCE AREA

Glendell Continued Operations Project

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glendell Tenements Pty Limited

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V1	David Holmes	November 2019	David Holmes	November 2019

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Tables

1.0 Assessing LSC hazards

The Glendell Continued Operations Project is located in the Central and Eastern Divisions of NSW. As a result, only tables relevant to this division will be presented in the following text. All tables are taken from OEH (2012).

1.1 Water erosion hazard

The slope class for the Central and Eastern Division is presented in

Table 1.1, the slopes and resulting slope class for the detailed sites are shown in **Table 1.2**. Soils that do not have sodic subsoils have a LSC Class of either Class 1 (nine sites) or Class 2 (three sites). This is a reflection of the survey aim, which was to identify Biophysical Strategic Agricultural Land (BSAL). As an excluding BSAL criterion is a slope exceeding 10%, sites were only placed in areas with a slope of less than 10%.

Soils with subsoil sodicity, expressed by the majority of the B horizon having an Exchangeable Sodium Percentage (ESP) of more than 6%, have a LSC Class of 5 (**Table 1.2**).

To gain a better understanding of Slope Class across the Project Area, LiDAR slope analysis was undertaken as well.

Table 1.1 Slope class for each LSC class used to determine water erosion hazard for the Eastern and Central divisions

Slope class (%) for each LSC class							
Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
<1	1 to <3	3 to <10 or 1 to <3 when slopes >500m	10 to <20 No gully erosion or sodic/dispersible soils are present	10 to <20 Gully erosion and/or sodic/dispersible subsoils are present.	20 to <33	33 to <50	>50

Table 1.2 Determining LSC Class for the water erosion hazard for detailed sites

Site ID	Slope (%)	LSC Class	Comment
GN03	<1	1	
GN04	<1	1	
GN05	5	5	Sodic subsoil
GN06	<1	1	
GN07	1	5	Sodic subsoil
GN08	1	5	Sodic subsoil
GN09	<1	1	
GN10	<1	1	

Site ID	Slope (%)	LSC Class	Comment
GN11	<1	5	Sodic subsoil
GN12	2	5	Sodic subsoil
GN13	<1	1	
GN14	<1	5	Sodic subsoil
GN15	2	5	Sodic subsoil
GN16	2	2	
GN17	4	5	Sodic subsoil
GN18	1	5	Sodic subsoil
GN32	1	2	
GN39	5	5	Sodic subsoil
GN66	1	5	Sodic subsoil
GN67	<1	5	Sodic subsoil
GN68	<1	5	Sodic subsoil
GN69	<1	1	
GN71	1	2	
GN73	<1	1	
GN75	<1	1	
GN80	<1	5	Sodic subsoil

1.2 Wind erosion hazard

To determine the wind erosion hazard the following needs to be determined:

- Average rainfall
- Wind erosive power based on Figure 6 of OEH (2012)
- the exposure of the tract of land to wind, taking into account local variations in wind power
- the soil erodibility to wind based on soil texture

Based on Figure 6 of OEH (2012) the Project Area is located in close proximity to High and Moderate wind erosive power. For a conservative assessment of the LSC Class in the Project Area, the moderate wind erosive power category has been chosen for this assessment. The Bureau of Meteorology stations Singleton Stp (#061397, 2002 – current) and Singleton Army (#061275, 1969 – 1990) mean annual rainfall is 685.45 mm (659.1 mm for station #061397, 711.8 mm for station #061275).

As a result **Table 1.3** for shows parameter relevant for an area of moderate wind erosive power and annual rainfall exceeding 500 mm. **Table 1.4** shows that the LSC class for the wind erosion hazard does not exceed LSC Class 3, the majority of the detailed sites had LSC Class 2 (16 sites).

Table 1.3 LSC class for wind erosion hazard for a Moderate wind erosive power and average rainfall exceeding 500 mm per year

Wind erodibility class of surface soil	Exposure to wind	LSC Class
Low	Low	1
	Moderate	2
	High	3
Moderate	Low	2
	Moderate	3
	High	4
High	Low	4
	Moderate	5
	High	6

Table 1.4 Determining LSC Class for the wind erosion hazard for detailed sites

Site ID	Surface soil texture	Class	Site exposure	Class	Wind erosive power	LSC Class
GN03	Coarse Sandy Loam	Moderate	Floodplain sheltered by stream veg	Moderate	Moderate	3
GN04	Sandy Loam	Moderate	Plain close to hill	Moderate		3
GN05	Sandy Loam	Moderate	Mid-slope, facing west	Moderate		3
GN06	Sandy Clay Loam	Low	Flat, sheltered by vegetation	Low		1
GN07	Sandy Loam	Moderate	Flat, sheltered by vegetation	Low		2
GN08	Sandy Clay Loam	Low	Flat on hillsope, facing west	Moderate		2
GN09	Sandy Clay Loam	Low	Flat, floodplain	Moderate		2
GN10	Silty Clay Loam	Low	Flat, sheltered by vegetation	Low		1
GN11	Silty Clay Loam	Low	Flat, plain, in drainage line, facing west	Moderate		2
GN12	Silty Clay Loam	Low	Lower slope, facing south	Moderate		2
GN13	Silty Clay Loam	Low	Flat on lower terrace	Low		1
GN14	Silty Clay Loam	Low	Footslope, flat	Moderate		2
GN15	Sandy Clay Loam	Low	Midslope, facing north-west	Moderate		2

Site ID	Surface soil texture	Class	Site exposure	Class	Wind erosive power	LSC Class
GN16	Sandy Clay Loam	Low	Crest	High		3
GN17	Silty Clay Loam	Low	Midslope, facing west, sheltered by vegetation	Low		1
GN18	Silty Clay Loam	Low	Midslope, facing west	Moderate		2
GN32	Sandy Clay Loam	Low	Crest	High		3
GN39	Silty Clay Loam	Low	Midslope, facing south	Moderate		2
GN66	Clay Loam	Low	Lower slope, facing west	Moderate		2
GN67	Light Clay	Low	Plain, sheltered by vegetation	Low		1
GN68	Silty Clay Loam	Low	Flat, footslope	Moderate		2
GN69	Clay Loam	Low	Flat, plain	Moderate		2
GN71	Silty Clay Loam	Low	Flat, plain	Moderate		2
GN73	Silty Clay Loam	Low	Flat, plain	Moderate		2
GN75	Silty Clay Loam	Low	Flat, plain	Moderate		2
GN80	Silty Clay Loam	Low	Flat, plain	Moderate		2

1.3 Soil Structure Decline Hazard

Soil structure decline is assessed based on surface soil texture, degree of sodicity of the surface soil and degree of self-mulching as shown in **Table 1.5**. The soil structure decline LSC Class is predominantly 3, with highly silty and mildly sodic surface soils having an LSC Class 4.

Table 1.5 LSC class for soil structural decline hazard

Field texture (surface soils)	Modifier	Outcome – surface soil type	LSC Class
Loose sand	Nil	Loose sand	1
Sandy loam	Nil	Fragile light textured surface soil	3
Fine sandy loam	Normal	Fragile light textured soil	3
	High levels of silt and very fine sand (>60%)	Fragile light textured soil – very hardsetting	4

Field texture (surface soils)	Modifier	Outcome – surface soil type	LSC Class
Loam	Normal	Fragile medium textured soil	3
	Friable/ferric	Friable medium textured soils – includes dark, friable loam soils	1
	High levels of silt and very fine sand	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic loam surface soil	4
	Moderately sodic	Moderately sodic loam surface soil	6
Clay loam	Normal	Fragile medium textured soil	3
	Friable/ferric	Friable clay loam surface soil – includes dark, friable clay loam soils	1
	High levels of silt and very fine sand (>60%)	Fragile medium textured soil – very hardsetting	4
	Mildly sodic	Mildly sodic clay loam surface soil	4
	Moderately sodic	Moderately sodic clay loam surface soil	6
Clay	Friable/ferric	Friable clay surface soil	2
	Strongly self-mulching	Strongly self-mulching surface soil	1
	Weakly self-mulching	Weakly self-mulching surface soil	3
	Mildly sodic	Mildly sodic/coarsely structured clay surface soil	4
	Moderately sodic	Moderately sodic/coarsely structured clay surface soil	6
	Strongly sodic	Strongly sodic surface soil	7
Highly organic soils	Mineral soils with high organic matter (>8% organic carbon)	Mineral soils with high organic matter	-
	Organosol/peat soils	Organic/peat soils	7

Table 1.6 Determining LSC Class for the soil structure decline hazard for detailed sites

Site ID	Surface soil texture	Modifier	LSC Class
GN03	Coarse Sandy Loam	Nil	3
GN04	Sandy Loam	Nil	3
GN05	Sandy Loam	Mildly sodic (ESP 5.6)	4
GN06	Sandy Clay Loam	Nil	3
GN07	Sandy Loam	Nil	3
GN08	Sandy Clay Loam	Nil	3
GN09	Sandy Clay Loam	Nil	3
GN10	Silty Clay Loam	Nil	3
GN11	Silty Clay Loam	High levels of silt	4
GN12	Silty Clay Loam	Nil	3

Site ID	Surface soil texture	Modifier	LSC Class
GN13	Silty Clay Loam	High levels of silt	4
GN14	Silty Clay Loam	Nil	3
GN15	Sandy Clay Loam	Nil	3
GN16	Sandy Clay Loam	Nil	3
GN17	Silty Clay Loam	Nil	3
GN18	Silty Clay Loam	Nil	3
GN32	Sandy Clay Loam	Nil	3
GN39	Silty Clay Loam	Nil	3
GN66	Clay Loam	Mildly sodic (ESP 5.3)	4
GN67	Light Clay	Weakly mulching	3
GN68	Silty Clay Loam	Mildly sodic (ESP 7.6)	4
GN69	Clay Loam	Nil	3
GN71	Silty Clay Loam	Nil	3
GN73	Silty Clay Loam	Nil	3
GN75	Silty Clay Loam	Nil	3
GN80	Silty Clay Loam	Nil	3

1.4 Soil Acidification Hazard

Soil acidification hazard is determined by the laboratory pH as well as the buffering capacity of the surface soil and the mean annual rainfall amount. The buffering capacity was assessed based on the surface soil texture and Table 10 of the OEH (2012) guideline, which has been replicated in **Table 1.7** below. Soil acidification LCS Classes for the detailed soils ranged from Class 2 to Class 5. The majority of the sites had a LSC Class 3 (15 sites) (**Table 1.9**).

Table 1.7 Estimating surface soil buffering capacity based on texture

Surface soil texture	Buffering Capacity
Sands and sandy loams – no calcium carbonate	Very low (VL)
Sands and sandy loams – with calcium carbonate	Medium (M)
Fine sandy loams – no calcium carbonate	Low (L)
Fine sandy loams – with calcium carbonate	Medium (M)
Loams and clay loams – no calcium carbonate	Medium (M)
Loams and clay loams – with calcium carbonate	High (H)
Dark loams and clay loams (e.g. topsoils in Chernozems and Prairie Soils)	High (H)
Clays – no calcium carbonate	High (H)
Clays – with calcium carbonate	Very High (VH)
Clays – with high shrink–swell VH	Very High (VH)

Table 1.8 LSC class for soil acidification hazard for areas with mean annual rainfall between 550-700 mm

Texture/buffering capacity	pH (water) of the natural surface soil				
	<4.7	4.7-5.5	5.5-6.7	6.7-8.0	>8.0
Very low	6	5	5	4	n/a
Low	5	5	4	3	n/a
Moderate	5	4	3	3	1
High	n/a	n/a	2	2	1
Very high	n/a	n/a	1	1	1

Table 1.9 Determining LSC Class for the acidification hazard for detailed sites

Site ID	Surface soil texture	Buffering capacity	pH	LSC Class
GN03	Coarse Sandy Loam	VL	5.6	5
GN04	Sandy Loam	VL	5.9	5
GN05	Sandy Loam	VL	6.1	5
GN06	Sandy Clay Loam	M	5.8	3
GN07	Sandy Loam	VL	4.8	5
GN08	Sandy Clay Loam	M	5.4	4
GN09	Sandy Clay Loam	M	5.7	3
GN10	Silty Clay Loam	M	6.4	3
GN11	Silty Clay Loam	M	6.4	3
GN12	Silty Clay Loam	M	5.6	3
GN13	Silty Clay Loam	M	6.1	3
GN14	Silty Clay Loam	M	5.3	4
GN15	Sandy Clay Loam	M	5.5	4
GN16	Sandy Clay Loam	M	5.7	3
GN17	Silty Clay Loam	M	5.9	3
GN18	Silty Clay Loam	M	5.7	3
GN32	Sandy Clay Loam	M	5.5	4
GN39	Silty Clay Loam	M	5.6	3
GN66	Clay Loam	M	5.7	3
GN67	Light Clay	H	5.9	2
GN68	Silty Clay Loam	M	5.9	3
GN69	Clay Loam	M	5.4	4
GN71	Silty Clay Loam	M	6.6	3
GN73	Silty Clay Loam	M	5.4	4
GN75	Silty Clay Loam	M	5.7	3
GN80	Silty Clay Loam	M	5.7	3

1.5 Salinity hazard

The salinity hazard is determined by the recharge and discharge potential of a site as well as the salt stores of the area (**Table 1.10**).

The recharge potential of an area is determined by soil texture, soil permeability, soil thickness and the type of bedrock. Recharge potential is highest where there is high rainfall relative to evaporation, low leaf area and plant water use, low water-holding capacity, and high permeability of the soils, regolith and rocks. Discharge potential depends on the position in the landscape, the depth to water table, groundwater pressure, soil type, substrate permeability and evapotranspiration (OEH, 2012).

Salt stores are determined based on Figure 7 of the OEH (2012) guideline. Based on this figure, the Project Area is located in a region with a low salt store class.

The Hunter Catchment Salinity Assessment report (OEH, 2013) linked a high salinity risk to underlining Permian Coal Measures. The majority of the Project Area is underlain by the Permian Wittingham Coal Measures, Vane Subgroup. Alluvial areas are underlain by Quaternary alluvium. The Wittingham Coal measures are known to significantly contribute to salinity in the Hunter River Catchment. Salt releases from the Vane Subgroup through erosion have been estimated as 40 tonnes/km^2/year. According to the Hunter Catchment Salinity Assessment, the Project Area is located in an area with a high salinity risk, with a low salinity risk along the creeklines (OEH, 2013).

Table 1.10 LSC class for salinity hazard

Recharge Potential	Discharge Potential	Salt Store	LSC Class
Low	**Low**	Low	1
		Moderate	3
		High	4
	Moderate	Low	1
		Moderate	4
		High	4
	High	Low	
		Moderate	4
		High	5
Moderate	**Low**	Low	1
		Moderate	3
		High	4
	Moderate	Low	2
		Moderate	5
		High	6
	High	Low	1(3)*
		Moderate	6
		High	6
High	**Low**	Low	1
		Moderate	4
		High	5
	Moderate	Low	3 (2)*

Recharge Potential	Discharge Potential	Salt Store	LSC Class
		Moderate	4
		High	7
	High	Low	2 (3)*
		Moderate	6
		High	7

*The values in brackets are more accurate and should be used in preference to the original rating

Based on the Hunter Catchment Assessment (OEH, 2013) and the Hunter Coalfield Regional 1:100 000 (Glen and Beckett, 1993), detailed sites overlaying the Wittingham Coal Group assumed to have a high salt store, sites over alluvium have a low salt store.

Table 1.11 Determining LSC Class for the salinity hazard for detailed sites

Site ID	Salt Store (OEH, 2012)	Surface Geology (Glen and Beckett, 1993)	Adjusted Salt Store	Recharge potential	Discharge Potential	LSC Class unadjusted	LSC Class adjusted for surface geology
GN03	Low	Quaternary Alluvium	Low	High	High	3	3
GN04	Low	Wittingham Coal Measure, Vane Subgroup	High	High	Moderate	2	7
GN05	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN06	Low	Quaternary Alluvium	Low	Low	Moderate	1	1
GN07	Low	Quaternary Alluvium	Low	Low	Moderate	1	1
GN08	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN09	Low	Quaternary Alluvium	Low	Low	Moderate	1	1
GN10	Low	Quaternary Alluvium	Low	High	Moderate	2	2
GN11	Low	Wittingham Coal Measure, Vane Subgroup	High	High	Low	1	5
GN12	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN13	Low	Quaternary Alluvium	Low	Moderate	Moderate	2	2
GN14	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN15	Low	Wittingham Coal Measure, Vane Subgroup	High	Moderate	Low	1	4
GN16	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN17	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN18*	Low	Quaternary Alluvium	Low	Low	Low	1	1
GN32	Low	Wittingham Coal Measure, Vane Subgroup	High	High	Low	1	5
GN39	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4
GN66	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	5
GN67	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	5
GN68	Low	Quaternary Alluvium	Low	Low	Low	1	1
GN69*	Low	Quaternary Alluvium	Low	Low	Moderate	1	1
GN71	Low	Quaternary Alluvium	Low	Low	Moderate	1	1
GN73	Low	Quaternary Alluvium	Low	High	Moderate	2	2
GN75	Low	Quaternary Alluvium	Low	High	Moderate	2	2
GN80	Low	Wittingham Coal Measure, Vane Subgroup	High	Low	Low	1	4

* Close to boundary to Wittingham Coal Measure, Vane Subgroup. To be conservative, the site is assumed to be still on Quaternary Alluvium

The LSC Class for the salinity hazard lies between LSC Class 1 and LSC Class 3 if the local geology is not taken into account (LSC Class unadjusted in **Table 1.11**). If the local geology is taken into account, the LSC Classes for the sites on the alluvium do not change as the salt stores for these areas remained *Low*. Sites mapped above the Wittingham Coal Measures have been assigned a high salt store. As a result, salinity hazard LSC Classes adjusted for surface geology lie between LSC Class 1 and 7. The LSC Class 7 is the result of a highly permeable soil, formed by ex-situ material, overlaying the Wittingham Coal Measures. Most sites on this geology have an LSC Class of 4 and 5.

1.6 Water logging hazard

The assessment of a water logging hazard is based on the drainage classes of the soil, as shown in **Table 1.12**. The water logging LSC Classes for the detailed sites range from LSC Class 1 for rapidly draining Rudosols and Tenosols to LSC Class 5 for imperfectly drained clayey subsoils with distinctive mottling (**Table 1.13**).

Table 1.12 LSC class for waterlogging hazard

Typical waterlogging duration (months)	Return period	Typical soil drainage	LSC class
0	Every year	rapidly drained and well drained	1
0 – 0.25	Every year	moderately well drained	2
0.25 – 2	Every year	imperfectly drained	3
2 – 3	Every 2 to 3 years	imperfectly drained	4
2 – 3	Every year	imperfectly drained	5
>3	Every year	poorly drained	6
Almost permanently	Every year	very poorly drained	8

Table 1.13 LSC Class for the water logging hazard for detailed sites

Site ID	LSC Class	Site ID	LSC Class	Site ID	LSC Class
GN03	1	GN12	5	GN66	4
GN04	1	GN13	5	GN67	3
GN05	4	GN14	4	GN68	4
GN06	5	GN15	5	GN69	3
GN07	5	GN16	3	GN71	3
GN08	4	GN17	5	GN73	2
GN09	2	GN18*	4	GN75	2
GN10	1	GN32	1	GN80	5
GN11	1	GN39	4		

1.7 Shallow soils and rockiness hazard

To assess the shallow soils and rockiness hazard, an estimated percentage of rocky outcrops is required as well as the soil depths. Rock outcrops occur on the rolling hills of the Project Area, but they do not exceed 30% coverage. Thus, only the criteria for assessing the shallow soils and rockiness hazard for less than 30% coverage are shown in **Table 1.14**.

Soil depth assessment has been based on the field observations, where available, and the understanding of the soil and landscape, where soil pits did not exceed 100 cm and no bedrock was encountered at the bottom of the soil pit.

Table 1.14 LSC class for shallow soils and rockiness hazard

Rocky outcrop (% coverage)	Soil depth (cm)	LSC Class
Nil	>100	1
<30	>100	2
	75 - <100	3
	50 - <75	4
	25 - <50	6
	0 - <25	7

Table 1.15 LSC Class for the water logging hazard for detailed sites

Site ID	Rocky outcrop	Soil depth (cm)	Comment	LSC Class
GN03	Nil	90	Many (20-50%) 20-60 mm sub-rounded conglomerate large pebbles at 650cm would inhibit root growth. LSC Class based on 65cm depth	4
GN04	Nil	85+	Alluvium assessment indicates no rooting restrictions to 230 cm (AGE, 2019)	1
GN05	Nil	80+	80cm limit of observation, no bedrock. Assumed soil depths of 100cm	3
GN06	Nil	80+	Alluvium assessment indicates no rooting restrictions to 210 cm (AGE, 2019)	1
GN07	Nil	90+	Alluvium assessment indicates no rooting restrictions to 330 cm (AGE, 2019)	1
GN08	<30 %	80+	BC horizon from 60cm, soil depth assumed <100 cm	3
GN09	Nil	90+	Alluvium assessment indicates no rooting restrictions to 330 cm (AGE, 2019)	1
GN10	Nil	90+	Alluvium assessment indicates no rooting restrictions to 260 cm (AGE, 2019)	1
GN11	Nil	85+	80cm limit of observation, no bedrock. Assumed soil depths of 100cm	3
GN12	<30%	80		3
GN13	Nil	85+	Alluvium assessment indicates no rooting restrictions to 350 cm (AGE, 2019)	1

Site ID	Rocky outcrop	Soil depth (cm)	Comment	LSC Class
GN14	Nil	90+	Alluvium assessment indicates rooting restrictions to 100 cm (AGE, 2019)	3
GN15	<30%	85+	BC horizon from 60cm, soil depth assumed <100 cm	3
GN16	<30 %	58		4
GN17	Nil	70		4
GN18	<30%	100	Alluvium assessment indicates bedrock at 130 cm (AGE, 2019)	2
GN32	<30%	45		6
GN39	Nil	80+	80cm limit of observation, no bedrock. Assumed soil depths of 100cm	3
GN66	Nil	110+		1
GN67	Nil	95+	95cm limit of observation, no bedrock. Assumed soil depths of 100cm	3
GN68	Nil	110+		1
GN69	Nil	115+		1
GN71	Nil	100+	100cm limit of observation, no bedrock. Assumed soil depths of >100cm	1
GN73	Nil	100+	100cm limit of observation, no bedrock. Assumed soil depths of >100cm	1
GN75	Nil	110+		1
GN80	Nil	90+	90 cm limit of observation, no bedrock. Assumed soil depths of 100cm	3

1.8 Mass movement hazard

To assess the mass movement hazard, any mass movement is taken into account as well as average annual rainfall (**Table 1.16**). As the aim of the soil survey was to assess BSAL, only one detailed site (Site 17) was in close vicinity of mass movement. This site has an LSC Class 6, while all other sites have an LSC Class 1. However, the project area has been assessed for mass movement based on site visits and aerial imagery. As a result, large areas have been classed as LSC Class 6 or 7, depending on slope.

Table 1.16 LSC Class for mass movement hazard for areas with annual rainfall >500 mm

Mean annual rainfall	Mass movement present	Slope class (%)	LSC Class
>500 mm	No	n/a	1
	Yes	<20	6
		20-<50	7
		>50 or scree and talus slope	8

2.0 Overall LSC Class

The overall LSC Class is determined by the highest LSC Class for each hazard. A summary of the detailed sites is shown in **Table 2.1**. A summary of the ASC Orders is presented below.

- Chromosol – This ASC Order has LSC Classes between 3 and 5. The higher LSC Class (GN06) was driven by waterlogging.
- Dermosol – Dermosols have a LSC Class of 5 and 6. The former is due to subsoil sodicity and the latter to mass movement, which is likely cause d by the subsoil sodicity.
- Kandosol – This ASC Order has an overall LSC Class of 5, mainly due to waterlogging.
- Rudosol – Rudosols have LSC Classes between 3 and 6. The clastic Rudosol (GN32) has a LSC Class 6 due to the shallowness of the soil. While GN10 has a LSC Class of 3, it is located on a lower floodplain of Yorks Creek. The remaining sites (GN4 and GN11) have a LSC Class 5.
- Sodosol – This ASC Order has an LSC Class of 5 in areas where no mass movement is present.
- Tenosol – The Tenosol on the lower floodplain (GN03) has a LSC Class 5, whereas areas on the upper floodplain the LSC Class is 3 and 4.

Based on the LSC Classes of the detailed survey sites as well as aerial imagery, in the Project Area occur 13 ha of LSC Class 3, 53 ha of LSC Class 4, 582 ha of LSC Class 5 and 135 ha of LSC Class 6. Areas currently or very recently disturbed by mining have been classed as LSC Class 8 (6 ha) (**Figure 2.1**).

Table 2.1 Overall LSC Class of Detailed Sites

Site ID	Soil Order	Hazard type								Overall LSC Class
		Water	Wind	Structure	Acidification	Salinity	Water logging	Soil depth	Mass movement	
GN06	Chromosol	1	1	3	3	1	5	1	1	5
GN09		1	2	3	3	1	2	1	1	3
GN16		2	3	3	3	4	3	4	1	4
GN69		1	2	3	4	1	3	1	1	4
GN71		2	2	3	3	1	3	1	1	3
GN17	Dermosol	5	1	3	3	4	5	4	6	6
GN67		5	1	3	2	5	3	3	1	5
GN13	Kandosol	1	1	4	3	2	5	1	1	5
GN15		5	2	3	4	4	5	3	1	5
GN04	Rudosol	1	3	3	5	2	1	1	1	5
GN10		1	1	3	3	2	1	1	1	3
GN11		5	2	4	3	5	1	3	1	5
GN32		2	3	3	4	5	1	6	1	6
GN05	Sodosol	5	3	4	5	4	4	3	1	5
GN07		5	2	3	5	1	5	1	1	5
GN08		5	2	3	4	4	4	3	1	5
GN12		5	2	3	3	4	5	3	1	5
GN14		5	2	3	4	4	4	3	1	5
GN18		5	2	3	3	1	4	2	1	5
GN39		5	2	3	3	4	4	3	1	5
GN66		5	2	4	3	5	4	1	1	5
GN68		5	2	4	3	1	4	1	1	5
GN80		5	2	3	3	4	5	3	1	5
GN03	Tenosol	1	3	3	5	3	1	4	1	5
GN73		1	2	3	4	2	2	1	1	4
GN75		1	2	3	3	2	2	1	1	3

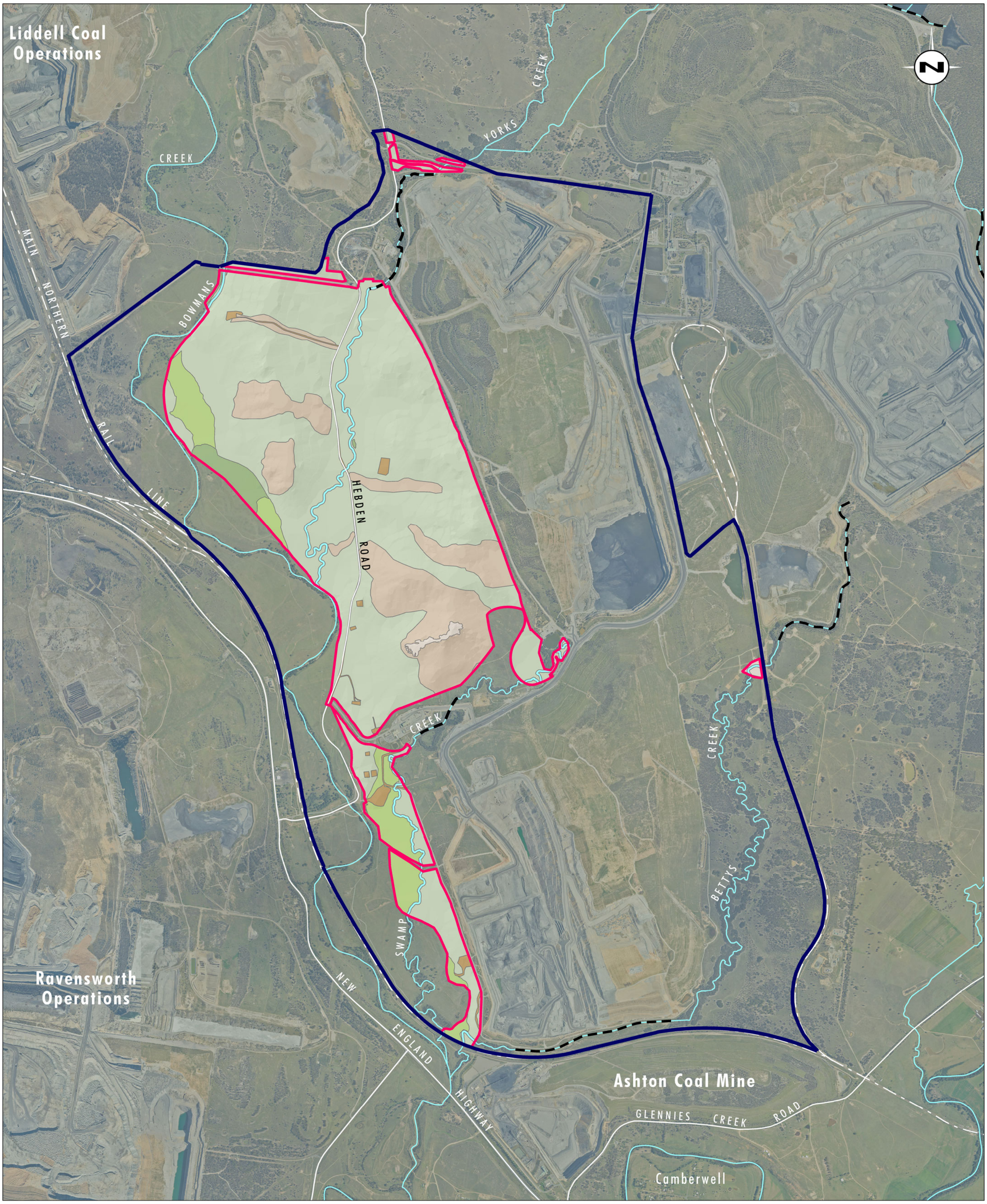

Image Source: Glencore (Dec 2018)
Data Source: Glencore (2019), Umwelt (2019)

0 0.5 1.0 2.0km

Legend

Project Area
Additional Disturbance Area
Existing Creek Diversion
Creek
Disturbed

Verified Land and Soil Capability:
Class 3
Class 4
Class 5
Class 6
Class 8

FIGURE 2.1

Land and Soil Capability in the Additional Disturbance Area

3.0 References

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