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GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

Preliminary Environmental Assessment

FINAL

May 2018

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Preliminary Environmental Assessment

FINAL

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

Project Director:	Bret Jenkins
Project Manager:	David Holmes
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Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
Final	David Holmes	16 May 2018	Bret Jenkins	16 May 2018

Summary of PEA

The Glendell Continued Operations Project is a project to extend the life of coal mining operations at Glendell to approximately 2044 and provide for ongoing employment for its existing workforce and contractors. The Project would also involve the ongoing use of the Mount Owen Complex CHPP and associated coal handling and transport infrastructure to approximately 2045. **Section 3.0** of the document contains a description of the Project, including identification of elements of the Project which are still being refined. **Section 4.0** outlines justification for the Project and contains details of the issues considered in the development of the Project design. The new development consent being sought for the Project will include the current approved mining operation (and associated rehabilitation requirements) relating to the Glendell Pit at the Glendell Mine and therefore the Glendell Consent will be surrendered should approval be granted for the Project. In accordance with section 4.63(3) of the EP&A Act, the consent authority is not required to re-assess the likely impact of continued development under the existing Glendell Consent.

Glencore is seeking the Department of Planning and Environment Secretary's Environmental Assessment Requirements (SEARs) for the Environmental Impact Statement (EIS) being prepared for the Project.

A comprehensive stakeholder engagement strategy has been developed for the Project and engagement with key stakeholders is already significantly advanced. This consultation is outlined in **Section 5.0** and **Appendix A**. The results of the stakeholder engagement undertaken to date, prefeasibility environmental assessment studies, past environmental and social impact assessments for projects in the area and ongoing environmental monitoring have all been considered in the identification of key issues for the Project (refer to **Section 7.0**). The proposed approach to the assessment of 'key' issues is set out in **Section 8.0** and 'other' issues are addressed in **Section 9.0**.

The EIS will accompany a development application and will include relevant technical studies to confirm the environmental and socio-economic impacts of the Project.

The EIS will also accompany applications to modify approved operations under the Mount Owen Continued Operations Consent (and potentially the Liddell Coal Operations and Ravensworth Operations Consents) to seek approval for aspects of the Project interacting with operations approved under those consents.

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1.0 Introduction

1.1 Mining Context

The Glendell Mine forms part of the Mount Owen Complex located 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**).

In addition to the Glendell Mine, the Mount Owen Complex comprises mining operations at the Mount Owen Mine (North Pit) and Ravensworth East Mine (Bayswater North Pit). The Mount Owen Complex also includes a coal handling and preparation plant (CHPP) and coal handling and transport infrastructure (refer to **Figure 1.2**).

Mt Owen Pty Limited (Mount Owen) operates the Ravensworth East (Bayswater North Pit) and Glendell mining operations at the Mount Owen Complex with mining operations at the Mount Owen Mine North Pit operated by Thiess Pty Ltd pursuant to a contractual arrangement with Mount Owen. The Mount Owen Complex is adjacent to the Integra Underground, Liddell Coal and Ravensworth Operations, which are also operations owned and operated by subsidiaries of Glencore Coal Assets Australia Pty Limited (Glencore) and its joint venture partner (JV). Glencore and the joint venture partner also hold a number of exploration licences surrounding the Mount Owen Complex.

The Glendell Mine currently operates under development consent DA 80/952 (Glendell Consent). The Glendell Consent regulates the mining of coal from the Glendell Pit and the rehabilitation of the mining area. The processing of coal mined from the Glendell Pit is regulated by development consent SSD-5850 (Mount Owen Continued Operations Consent) which also regulates mining at the Mount Owen and Ravensworth East Mines, and associated activities. Liddell Coal operates under DA 305-11-01 (Liddell Consent). This consent regulates open-cut mining from the South and Entrance Pits and associated facilities. **Section 2.1** contains further details regarding the existing operations.

1.2 The Proposed Project

Glencore proposes to seek approval to extend open cut mining operations north from the existing Glendell Mine as shown on **Figure 1.3**.

Mining authorities in the area north of the approved Glendell Mine are held by a variety of different companies and in most areas are stratified. Glencore's interests in Liddell and the Mount Owen Complex has brought a number of these authorities into common ownership. In recent years, contractual arrangements with Glencore's JV partner, who also hold interests in some of these authorities, has enabled the investigation and development of mining options in this area which has identified further coal reserves to the north of the approved Glendell Mine. Glencore proposes to seek approval to extend open cut mining operations north from the existing Glendell Mine to extract these reserves (refer to **Figure 1.3**) (the Project).

This proposed extension of the current open cut mining operations at the Glendell Mine would extract an additional 140 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 the Hebden Seam. The Project would extend the life of mining operations at Glendell to approximately 2044 and provide ongoing employment. ROM coal from Glendell will continue to be processed by the Mount Owen CHPP and associated infrastructure and utilise the Mount Owen Rail Loop for coal transport.

The Project will also retain the ability to transport up to 2 million tonnes per annum (Mtpa) of coal to the Liddell CHPP for processing and rail loading (which is already approved pursuant to the Mount Owen Continued Operations Consent). The Project will extend the operating life of this infrastructure to 2045[1].

The Project will necessitate the realignment of a section of Hebden Road, diversion of Yorks Creek and the relocation of Ravensworth Homestead. The Project will also require the demolition/ relocation of the existing Glendell Mine Infrastructure Area (MIA) and construction of a new MIA or utilisation and augmentation of either the existing MIA at Liddell Coal or the Mount Owen Mine MIA (or a combination of these options). Depending on the MIA option chosen, a Heavy Vehicle Access Road may also be required for accessing the MIA[2].

Further details of the Project are contained in **Sections 1.1** and **3.0**. The design of the Project and associated infrastructure has had regard to a range of environmental and social constraints. These are discussed in further detail in **Section 4.1**.

1.3 Approval and assessment requirements

1.3.1 Approval requirements for Glendell Pit Extension and related works

The Project is State Significant Development (SSD) as defined under the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) and will require development consent under the *Environmental Planning and Assessment Act 1979* (EP&A Act). As SSD, an Environmental Impact Statement (EIS) will be prepared to accompany the development application for the Project. This Preliminary Environmental Assessment (PEA) has been prepared to support a request for the Secretary's Environmental Assessment Requirements (SEARs) for the EIS (refer to **Section 1.6**). The new development consent being sought for the Project will include the current approved mining operation (and associated rehabilitation requirements) relating to the Glendell Pit at the Glendell Mine and therefore the Glendell Consent will be surrendered should approval be granted for the Project. In accordance with section 4.63(3) of the EP&A Act, the consent authority is not required to re-assess the likely impact of continued development under the existing Glendell Consent.

In addition to the existing operations, this development consent would cover the Glendell Pit Extension and works directly associated with the pit extension including:

- rehabilitation of areas disturbed by mining activities, including overburden emplacement areas
- the realignment of Hebden Road
- the relocation of Ravensworth Homestead
- the Yorks Creek Diversion
- relocation of an existing water transfer pipeline from the Mount Owen Complex to Ravensworth Operations
- construction/use of MIA facilities and associated related infrastructure and
- construction/use of a Heavy Vehicle Access Road).

[1] A longer operating life for the Mount Owen CHPP and related infrastructure is required to account for the processing of coal material mined from the Glendell Pit Extension in the later stages of the 2044 calendar year.

[2] The proposed MIA strategy will be identified and assessed in the EIS to be prepared to accompany the Development Application.

The preferred location of some of these components of the Project is yet to be finalised however it will overlap, at least partly, with the development consent areas for the existing consent associated with the Mount Owen Mine, and may overlap with the development consent areas of the Liddell Coal Operations and Ravensworth Operations (refer to **Figure 1.2**).

In addition to overlapping with consent areas, the Project will interact with operations regulated by a number of different development consents including:

- the Project will extend the life of the Mount Owen CHPP and associated infrastructure, including the Mount Owen Rail Loop, beyond its current approval and will utilise the Bayswater North Pit and North Pit voids (refer to **Figure 1.2**) for water storage and potentially tailings disposal once approved mining has ceased in those mining areas

- the continued integration and supplementing of the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS), including relocation of the water transfer pipeline between the Mount Owen Complex and Ravensworth Operations and

- potential to utilise the Liddell MIA for the Project and the use of Liddell Coal open cut voids for future tailings disposal.

To the extent that the Project alters approved operations at Liddell or Mount Owen, these consents may require modification to cover the interactions between operations. The EIS prepared for the Project will address the impacts associated with the interactions with these other operations.

Due to the EIS needing to cover the assessment of both the new development application and the potential modification of the Mount Owen Continued Operations Consent, Liddell Consent and Ravensworth Operations Consents, the Project Area for the purposes of the PEA therefore includes the existing approved Glendell Mine, the Mount Owen Continued Operations Consent project area and relevant parts of the Liddell Coal Consent and Ravensworth Operations project areas; this Project Area is shown on **Figure 1.3**. The Project Area for the purposes of the development application for the Project will be further defined during the EIS studies phase and interactions with the existing consents that overlap with the Project will be clearly articulated in the EIS to be prepared for the Project.

The Project will impact on areas currently approved for mining related disturbance. The Project will also involve the additional disturbance of land. The areas of land that may be impacted by the Project that are not currently approved for mining related disturbance are referred to in this PEA as the Potential Additional Disturbance Area (refer to **Figure 1.4**). The disturbance area associated with the Project will be further refined throughout the EIS process and will be defined in the EIS.

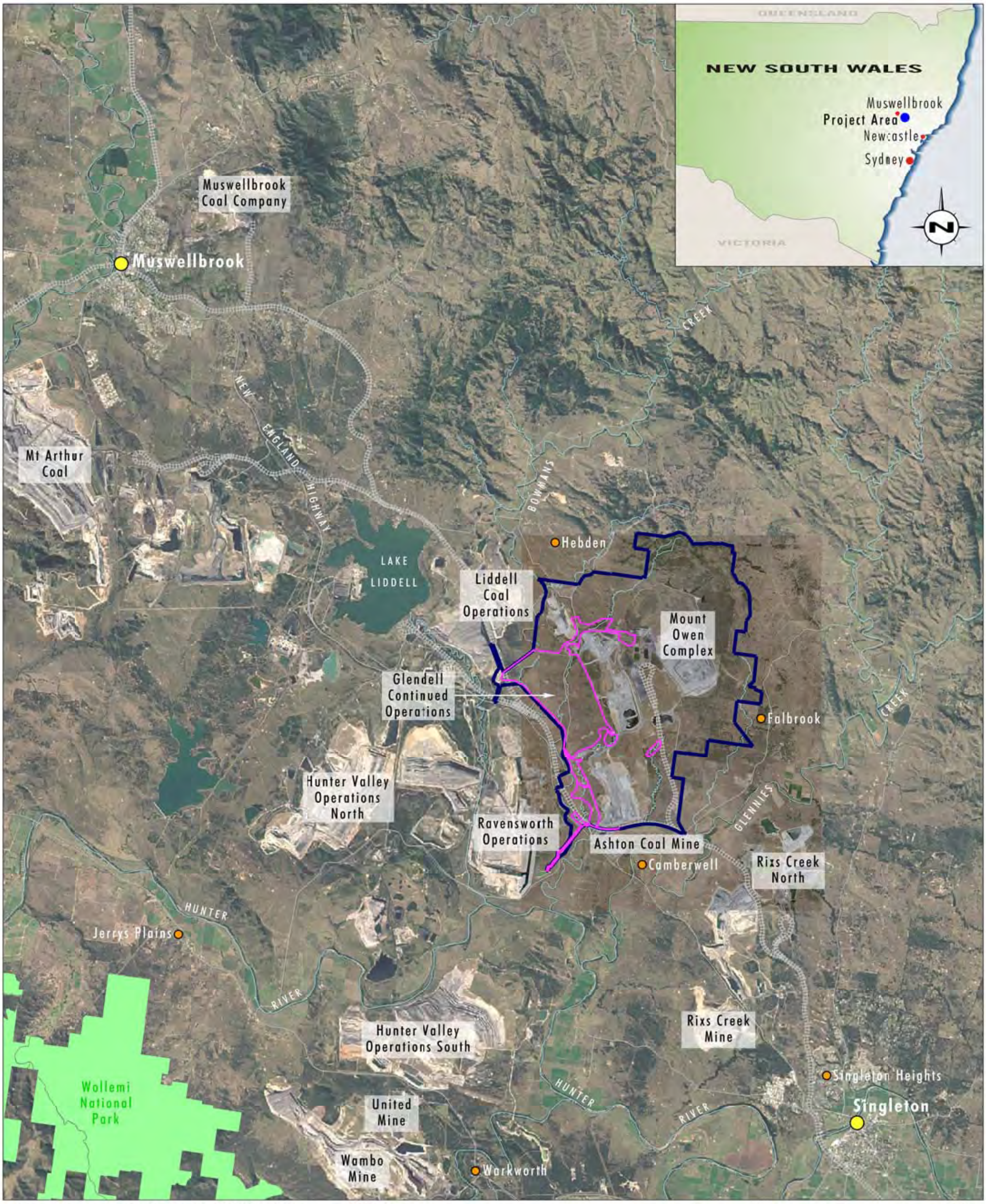


Image Source: Google Earth (2016), Glencore (2017)
Data Source: Glencore (2018), OEH (2013)

0 2.5 5.0 10km
1:200 000

Legend

- Project Area
- Potential Additional Disturbance Area
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Localities

FIGURE 1.1

Locality Plan

File Name (A4): R01/4166_062.dgn
20180515 14.06

umwelt

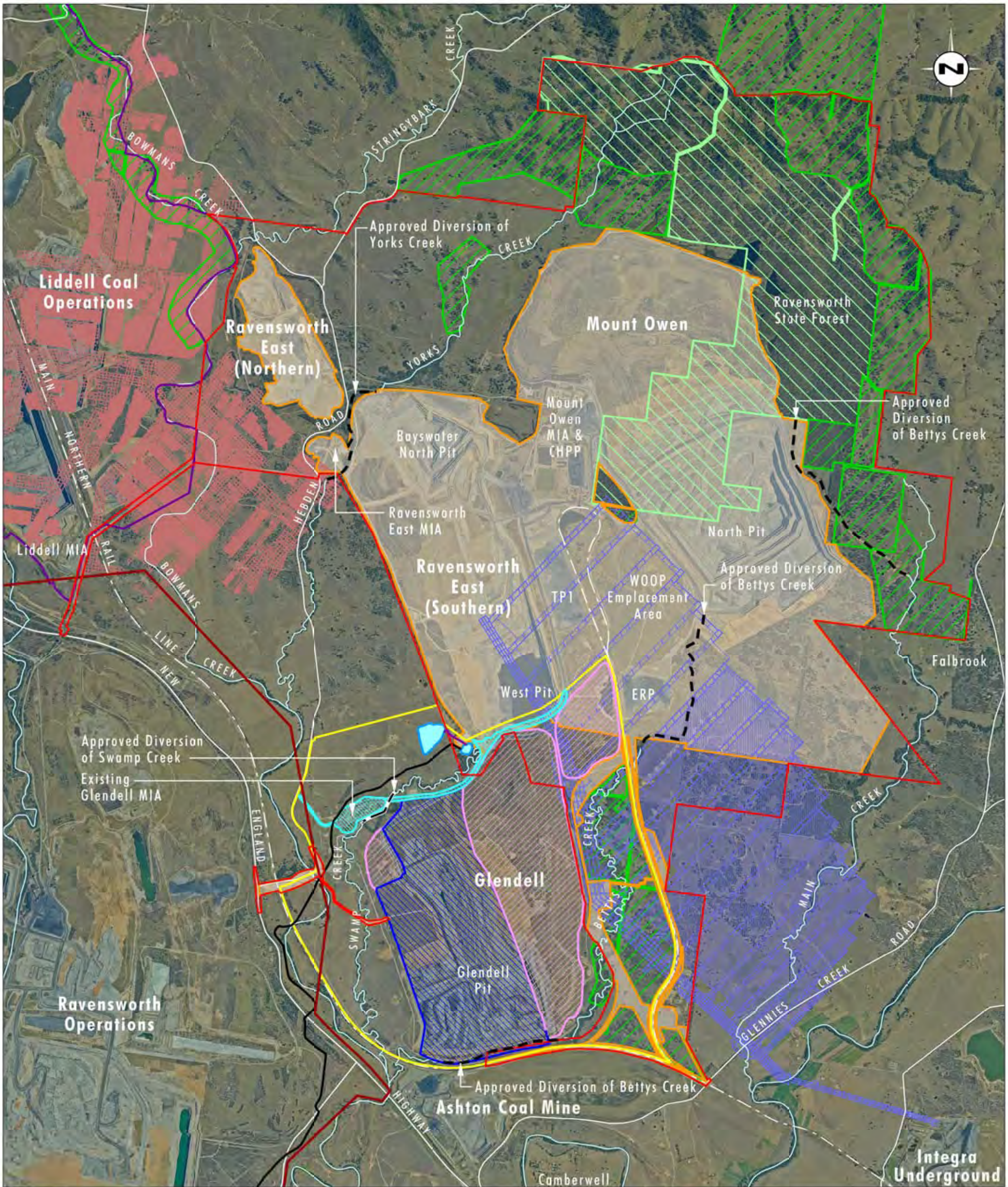


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

Legend

- Glendell Consent Boundary
- Liddell Consent Boundary
- Mount Owen Consent Boundary
- Mount Owen Continued Operations Disturbance Area
- Ravensworth Consent Boundary
- Approved Glendell Overburden Emplacement Area
- Approved Glendell Mining Area
- Approved Glendell Water Storage
- Approved Infrastructure Area
- Approved Link Pipeline
- Existing Creek Diversion
- Existing Narama Pipeline
- Approved Integra Underground Mining Area - Middle Liddell Seam Workings
- Integra Underground Workings Middle Liddell Seam as at May 2018
- Liddell Underground Mining Area
- Existing Offset
- State Forest

FIGURE 1.2

Existing Glendell Mine and Other Approved Operations

File Name (A4): R01/4166_029.dgn
20180516 14.21

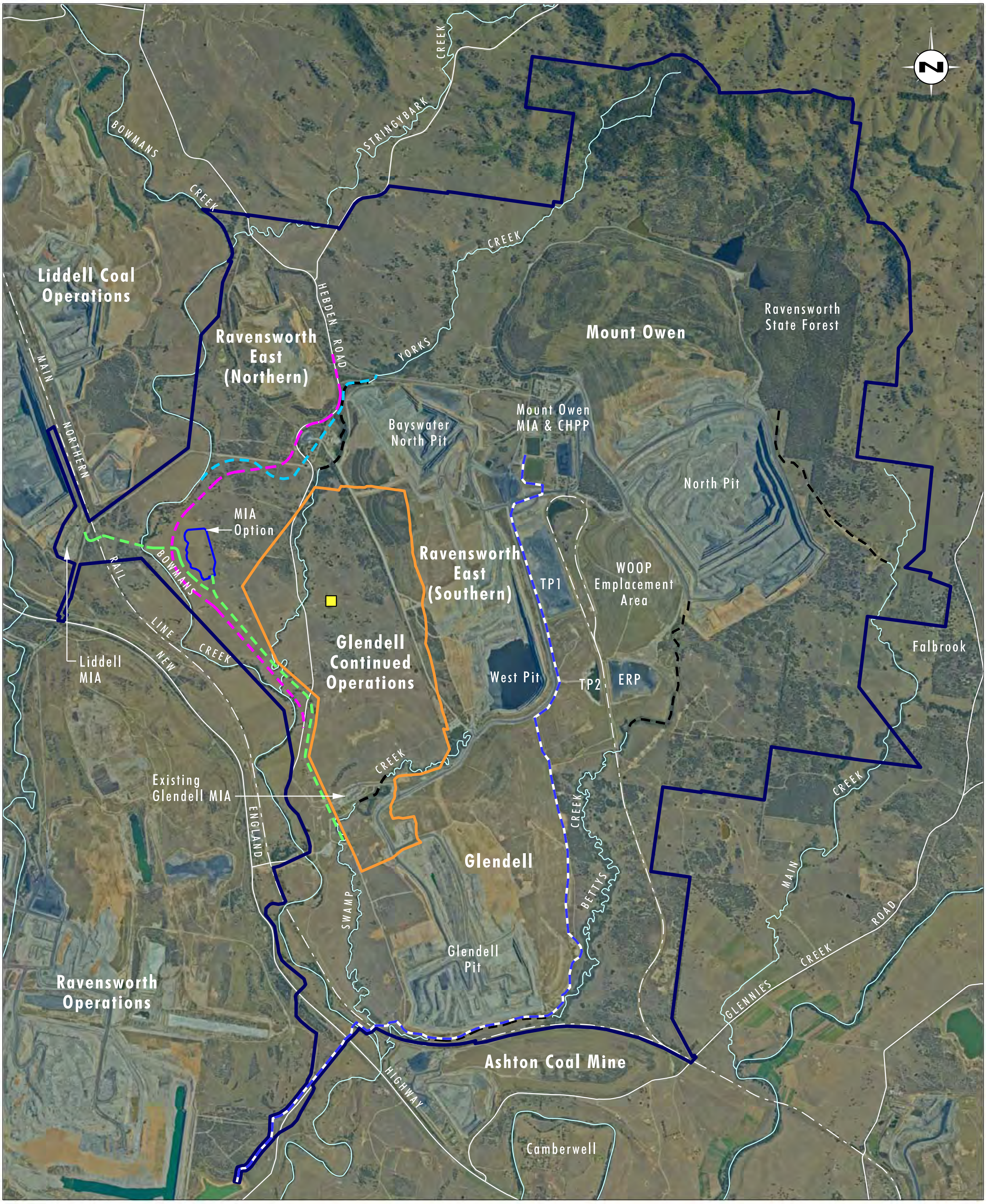


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)
Note: Ravensworth Homestead to be relocated

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Ravensworth Homestead
- Existing Creek Diversion

Project Features:

- New MIA Option
- Indicative Relocated Narama Pipeline Alignment
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 1.3

Proposed Project

File Name (A4): R01/4166_037.dgn
20180515 13.58

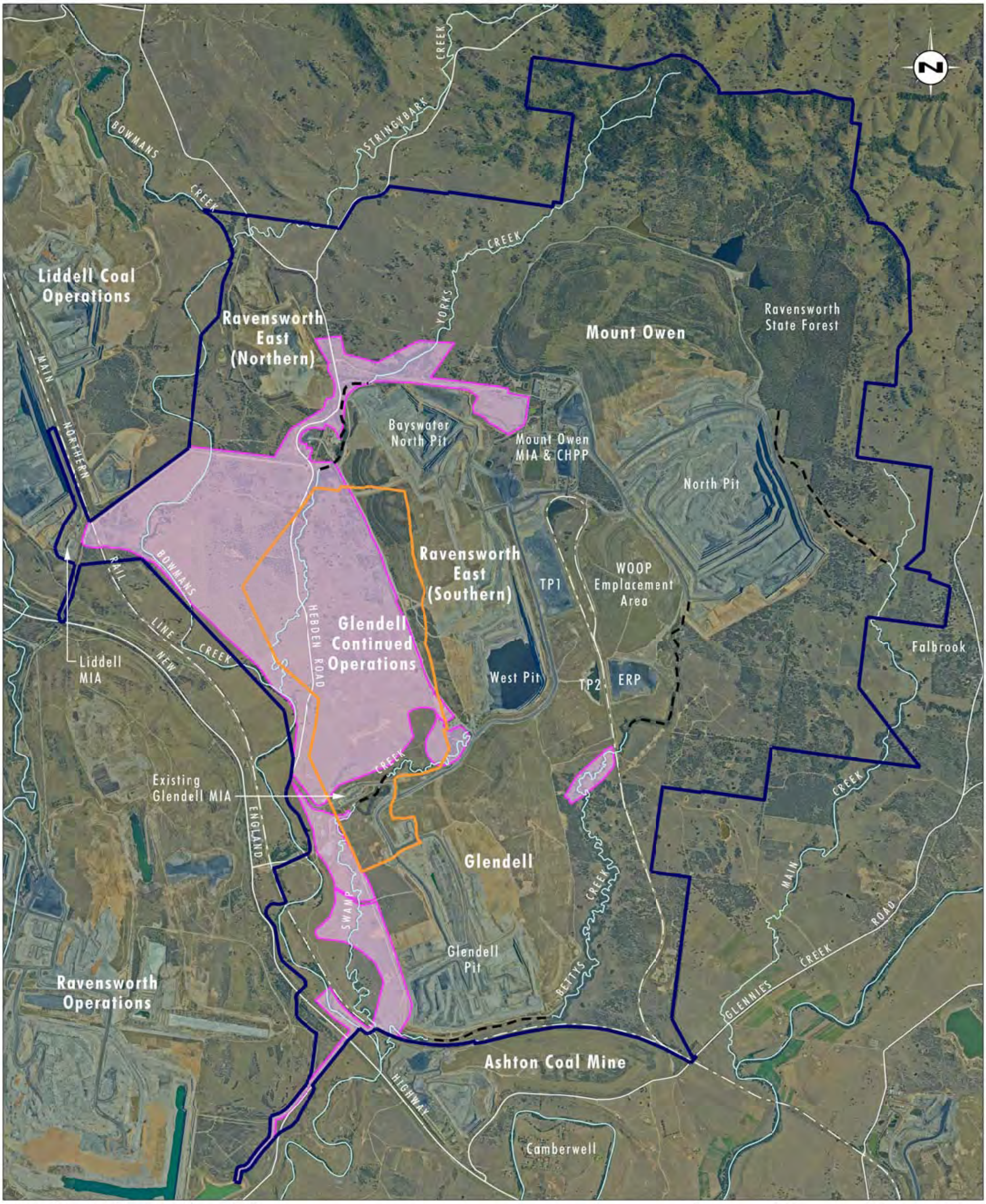


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

0 1.0 2.0 3.0km
1:60 000

Legend
- Project Area
- Proposed Glendell Pit Extension
- Potential Additional Disturbance Area
- Existing Creek Diversion

FIGURE 1.4

Potential Additional Disturbance Area

1.4 The Proponent

Glendell Mine (Glendell Pit), Ravensworth East Mine (Bayswater North Pit) and the Mount Owen CHPP and associated infrastructure are owned and operated by Mount Owen, a subsidiary of Glencore. Mount Owen Mine (North Pit) is operated by Thiess Pty Ltd under contractual arrangements with Mount Owen.

The applicant for the development application for the Project will be Glendell Tenements Pty Ltd. Glendell Tenements Pty Ltd is a 100% owned subsidiary of Glencore. Any related modifications of existing approved operations under other consents required (refer to **Section 1.1**) will be undertaken by the Glencore entities (including its JV partners) having responsibility for the operations regulated by those consents. For the purposes of this PEA, the proponents are collectively referred to as Glencore.

1.5 Purpose of the Document

As SSD, the development application for the Project must be accompanied by an EEIS (Section 4.12(8) of the EP&A Act). This PEA has been prepared by Umwelt (Australia) Pty Limited (Umwelt) on behalf of Glencore, to accompany Glendell Tenement's request for the SEARs for the EIS. The EIS will also support applications to modify approved operations under the Mount Owen Continued Operations Consent (and potentially the Liddell Coal Operations and Ravensworth Operations Consents) to seek approval for aspects of the Project interacting with operations approved under those consents.

The purpose of the PEA is to brief relevant government agencies, the community and other stakeholders about the proposed Project.

This PEA:

- provides an overview of the Project and its interactions with other approved operations;
- identifies the key environmental and social issues associated with the Project;
- includes a summary of alternatives considered in the project design process, having regard to mining, environmental and social constraints and considerations;
- identifies details to be further refined during the assessment process;
- details the stakeholder engagement undertaken to date and the approach to consultation to be undertaken during the preparation of the EIS;
- discusses the planned approach for the environmental and social assessments to be undertaken as part of the EIS for the Project; and
- includes details regarding the approval requirements which will apply to the Project.

2.0 Existing Operations

2.1 Summary of Approved Mining Operations at Mount Owen Complex

Mining operations at the Mount Owen Complex commenced at the Ravensworth East Mine (previously known as Swamp Creek Mine) and date back to the early 1960s.

Ravensworth East Mine has been subject to various modifications including:

- integration with the Mount Owen and Glendell Mines in 2008 to allow efficient processing and haulage of coal to the Mount Owen CHPP and
- the emplacement of tailings within the Ravensworth East voids from the Mount Owen CHPP.

Mining in the Ravensworth East Mine is currently limited to the Bayswater North Pit and tailings emplacement in the West Pit void; these activities are regulated by the Mount Owen Continued Operations Consent.

Mining operations within the Mount Owen Mine (North Pit) commenced in 1993 under the management of Hunter Valley Coal Corporation Pty Limited (HVCC). Glencore (formerly Xstrata) has managed Mount Owen Mine, Ravensworth East and Glendell Mines as the Mount Owen Complex since 2004.

The Glendell Consent was granted on 2 May 1983. A modification of the Glendell Consent granted in February 2008 approved the integration of the Glendell Mine with the broader Mount Owen Complex. This modification removed the duplication of coal processing, handling and transport infrastructure and enabled integrated water and tailings management at the operations forming the Mount Owen Complex.

The Mount Owen Continued Operations Consent (SSD-5850), granted in 2016, brought the Mount Owen and Ravensworth East Mines under a single development consent with the former consents for these operations to be surrendered. The Mount Owen Mine is currently in the process of finalising a modification application which would extend the mine life of mining in the North Pit by 6 years. This application is expected to be lodged in Quarter 2 2018.

As discussed in **Section 1.0**, the Glendell Mine forms part of the broader Mount Owen Complex with integrated coal handling and processing facilities, product transport, tailings disposal and water management systems. ROM coal extracted from the Glendell Pit is transported to the Mount Owen CHPP for processing. The Mount Owen CHPP is currently approved for up to 17 Mtpa ROM coal throughput. Product coal is transported from the Mount Owen Complex using the Mount Owen Rail Loop or to the Liddell or Bayswater Power stations by conveyor. Up to 2 Mtpa ROM coal and/or crushed gravel can also be transported by conveyor from the Mount Owen Complex to the Liddell Coal Mine and/or Ravensworth Coal Terminal.

Glendell Mine and Mount Owen Mine both operate 7 days per week, 24 hours per day.

The integration of water management and tailings disposal systems between the other Glencore operated mines of Integra Underground, Liddell Coal and Ravensworth Operations is also approved under the various development consents and project approvals for each operation. This integrated water and tailings management system is known as the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS) and enables water and tailings to be transferred between sites to optimise water use and management at these operations and provide for more efficient management of fine tailings from CHPPs.

Thiess Pty Ltd currently operates the Mount Owen Mine (excluding the CHPP and associated infrastructure) under a contractual agreement with Mount Owen. Mount Owen operates the Mount Owen CHPP and associated infrastructure, and the Ravensworth East Mine (Bayswater North Pit) and the Glendell Mine (Glendell Pit).

Key operational aspects at the current Mount Owen Complex are provided in **Table 2.1**. Key features of existing approved development and development consent boundaries are shown on **Figure 1.2.**

Table 2.1 Key Operational Aspects of Mount Owen Complex

Operational Aspect	Mount Owen Continued Operations Consent (SSD-5850)	Glendell Consent (DA 80/952)
Mining Area	North Pit Bayswater North Pit	Glendell Pit
Production Limits	North Pit – up to 10 Mtpa Bayswater North Pit – up to 4 Mtpa	Glendell Pit – up to 4.5 Mtpa
Mining Method	North Pit – Open Cut (Truck and excavator) Bayswater North Pit – Open Cut (Truck and excavator)	Glendell Pit – Open Cut (Truck and excavator)
Approved Mine Life	North Pit – to 31 December 2031 Mount Owen Continued Operations Modification 2 Project is seeking an extension to the mining operations in North Pit which would extend the mine life and operation of the Mount Owen CHPP to approximately 2037 Bayswater North Pit – to approximately 2022	Glendell Pit – to 30 June 2024
Previously mined areas	Eastern Rail Pit (ERP), Tailings Pit 1 (TP1), Tailings Pit 2 (TP2), RW Pit, North Void Stage 1 (NVS1), North Void Stage 2 (NVS2), West Pit	N/A – Barrett Pit currently being mined
Tailings Emplacement	West Pit Former tailings disposal areas include: TP1, RW Pit, NVS1 and NVS2 Approved transfer of tailings to other operations as part of the GRAWTS	N/A - Tailings generated by processing of coal at the Mount Owen CHPP and regulated under the Mount Owen Continued Operations Consent.
Overburden Emplacement	In-pit emplacement (Bayswater North Pit and North Pit) Out-of-pit emplacement at Western Out-of-pit (WOOP) Dump, and parts of Ravensworth East Emplacement Area Tailings capping of former tailings facilities and West Pit	In-pit emplacement and out-of-pit emplacement adjacent to Glendell Pit
Approved final voids	Bayswater North Pit North Pit	Glendell Pit

Operational Aspect	Mount Owen Continued Operations Consent (SSD-5850)	Glendell Consent (DA 80/952)
Coal Processing	Mount Owen CHPP (up to 17 Mtpa) and Liddell CHPP (up to 2 Mtpa ROM)	Mount Owen CHPP
Coal Transportation	Mount Owen Rail Loop and M series conveyor to Liddell Coal and/or Ravensworth Coal Terminal	Mount Owen Rail Loop
Mine Infrastructure Area (MIA)	Mount Owen MIA and Ravensworth East MIA	Glendell MIA
Workforce	Approximately 920 full time equivalent (FTE) positions	Approximately 300 FTE positions
Creek Diversions	Upper reaches of Bettys Creek into Main Creek Diversion of section of Bettys Creek to the south of WOOP Dump Yorks Creek diverted as part of former Swamp Creek Mine around current Ravensworth East MIA (refer to **Figure 1.2**)	Bettys Creek diverted around southern extent of Glendell Pit (refer to **Figure 1.2**) Swamp Creek diverted adjacent to Glendell MIA

2.2 Water Management System

The Glendell Mine Water Management System (WMS) is an integrated component of the Mount Owen Complex WMS. In addition, the Mount Owen Complex is an integral part of the GRAWTS and is connected to the water management systems of Liddell Coal Operations, Ravensworth Operations and Integra Underground Operations. The GRAWTS allows greater flexibility in mine water management by the Mount Owen Complex by allowing water to be transferred from sites with excess water to sites with storage capacity and/or higher usage demands or discharge opportunities.

Water management at the Mount Owen Complex considers three (3) categories of water, each with different potential to cause environmental harm. The target design criteria for each of the three (3) categories of water are summarised in **Table 2.2**.

Table 2.2 Design Criteria for components of Mount Owen Complex WMS

Water Category	Water Description	Target Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas and selected hard surface areas where coal and fuel/oil contamination risks are low.	Release, where practicable, to downstream environment.
Sediment	Runoff from disturbed areas (does not include water captured in mining pit areas, runoff from coal processing areas and workshops).	Managed in line with the Blue Book (*Managing Urban Stormwater: Soils and Construction Volumes 1* and *2E*). Designed to manage runoff from the 5 day, 95th percentile rainfall event. Water captured in sediment dams is pumped to storage dams where it is used for operational purposes.
Mine	Runoff from active mining areas and areas exposed to coal or water used in coal processing or from coal stockpile areas.	Contained for events up to and including the 1% annual exceedance probability (AEP) 24 hour storm event.

2.3 Historical and Approved Impacts on Creeks

2.3.1 Yorks Creek

Yorks Creek is a tributary of Bowmans Creek. 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. The upper catchment of Yorks Creek above the Glendell Pit Extension has been significantly modified due to approved mining at Ravensworth East and Mount Owen. As these areas are rehabilitated, runoff will be progressively returned into the Yorks Creek catchment. This progressive increase in the size of the upper catchment will occur during the life of the Project.

2.3.2 Swamp Creek

The upper reaches of Swamp Creek are located within the existing approved disturbance area for Mount Owen Mine and Ravensworth East Mine. This former catchment of Swamp Creek is located entirely within the approved Mount Owen and Glendell disturbance areas and is managed as part of the Mount Owen Complex WMS. This upper catchment is broadly approved to be redirected towards Swamp Creek as part of the conceptual final landform once rehabilitated. A section of Swamp Creek adjacent to the existing Glendell MIA has previously been diverted (refer to **Figure 1.2**). The upper reaches of Swamp Creek have also been diverted around the North Pit emplacement area and now form part of the Yorks Creek catchment.

2.3.3 Bettys Creek

Bettys Creek is located to the east of the current Glendell operations and has previously been diverted around the southern end of the Glendell Pit mining area approved under the Glendell Consent. The remnant upper reaches of Bettys Creek catchment to the north of the Mount Owen Complex have previously been diverted towards Main Creek as part of the approved Mount Owen operations (refer to **Figure 1.2**). Parts of the former Bettys Creek catchment are also located within the approved disturbance area for the Mount Owen Complex and are managed as part of the Mount Owen Complex WMS. The conceptual final landform for the Mount Owen Continued Operations (Mount Owen Continued Operations) Project retains the diversion of the upper catchment of Bettys Creek towards Main Creek. Part of the former Bettys Creek catchment is also located within the approved final void catchment for North Pit.

2.4 Existing Approvals

2.4.1 Planning Approvals

Table 2.3 summarises the development consents for the operations at the Mount Owen Complex and existing modifications of these consents.

Table 2.3 Mount Owen Complex Development Consents

Development Consent Reference	Title	Description	Approval Granted	Expiry
Glendell Consent				
DA 80/952	Glendell Mine	Initial approval of Glendell Mine operations Dragline and truck and shovel mining methods Production Rate of 3.6 Mtpa	2/5/1983	2/5/2013
DA 80/952 Modification No.1	Glendell Open Cut	Approval to use the Swamp Creek Mine South Void for overburden emplacement and extension of mining area	1997	30/6/ 2013
DA 80/952 Modification No.2	Glendell Mine Operations	Modification of mining footprint and integration with Mount Owen Complex coal handling, processing and transport facilities. Increase in production rate to 4.5 Mtpa Extended approved mining operations to 30 June 2024.	February 2008	30/6/2024
DA 80/952 Modification No.3	Powerline Relocation	Realignment of a 2.7 km section of an existing 132 kV Ausgrid powerline and associated activities	1/12/2016	30/6/2024
Mount Owen Continued Operations Consent				
SSD - 5850	Mount Owen Continued Operations Project	Consolidated planning approvals for Ravensworth East Mine and Mount Owen Mine under a single consent (and surrender of former consents for these operations) Approved extension of operations at Bayswater North Pit and North Pit Life of mine at Mount Owen Complex extended Continued integration with GRAWTS (initially approved under previous consents)	3/12/2016	31/12/2031
SSD – 5850 Modification No. 1	Integra to Mount Owen Complex Water Pipeline modification	Modification to facilitate the construction of a water pipeline to convey mine water from Integra Underground Mine to the Mount Owen Complex.	15/09/2017	31/12/2031

Mount Owen is currently preparing an application to modify the Mount Owen Continued Operations Consent to extend the North Pit mining area. The proposed modification will enable approximately 35 Mt of additional ROM coal to be mined from the North Pit. Recovery of the additional coal reserve will result in approximately 46 ha of additional disturbance and require an increased depth across the extent of the North Pit to provide for mining down to the Hebden Seam. This change to the North Pit mine plan will allow the extension of the approved Mount Owen mine life through to 2037 (an additional 6 years).

Liddell Coal operates under DA 305-11-01. This consent regulates open-cut mining of 8 Mt of ROM coal per year from the South and Entrance Pits. DA 305-11-01 was granted by the Minister of Planning on 20 November 2002 under Part 4 of the EP&A Act and has been modified on 6 occasions with major amendments relating to production increases (Modification 2) and extension of mining until 2028 (Modification 5).

Ravensworth Operations, Ravensworth Underground, Liddell Coal and Integra Underground consents all include provision for the integration of water and tailings management systems as part of the GRAWTS. The existing water transfer pipeline between the Mount Owen Complex (Ravensworth East Mine) and Ravensworth Operations was approved under a development consent granted by Singleton Council on 22 December 2000 (DA506/2000).

2.4.2 Environment Protection Licences

Tables 2.4 identifies the Environment Protection Licences (EPLs) held under the *Protection of the Environment Operations Act 1997* (POEO Act) for the mining operations at Mount Owen Complex. Mount Owen is currently in the process of rationalising these EPLs to an EPL covering Glendell Mine and a separate EPL covering the remainder of the Mount Owen Complex operations. The Integra Underground EPL also includes surface areas that are within the Project Area.

Table 2.4 Environment Protection Licenses

	Mount Owen Mine	Glendell Mine	Ravensworth East Mine	Integra Underground
Licence	EPL 4460	EPL 12840	EPL 10860	EPL 3390

None of the EPLs for the Mount Owen Complex have licensed discharge points. Excess water at the Mount Owen Complex is managed under the GRAWTS with any necessary discharges occurring at the Ravensworth Operations site pursuant to licenses held for that operation.

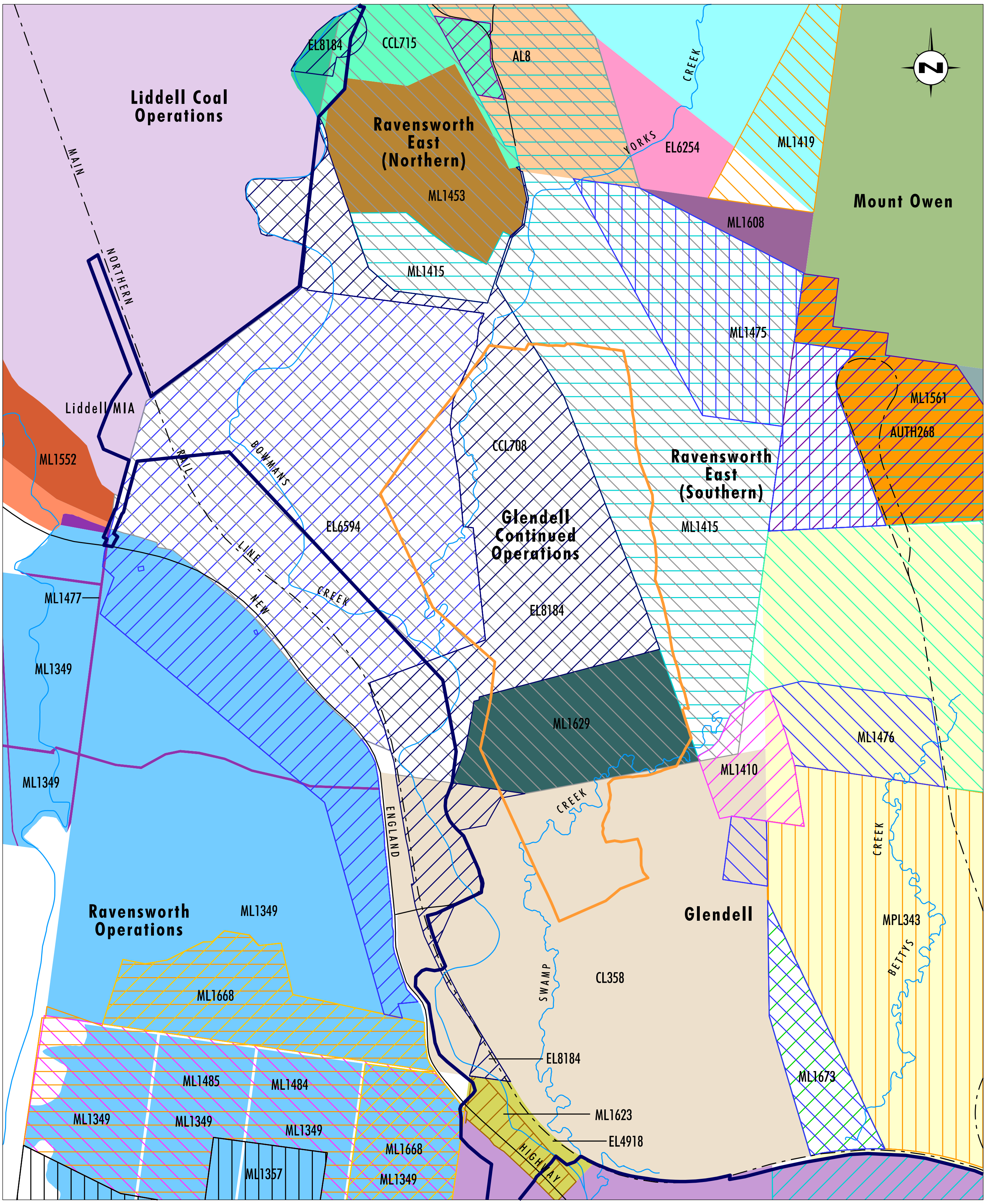
2.4.3 Mining Authorities

Table 2.5 details the mining authorities held in relation to the Mount Owen Complex and Glendell Continued Operations Project Area. These authorities in the immediate area of the Glendell Pit Extension are shown on **Figure 2.1**.

Table 2.5 Mining Authorities within Project Area

Reference	Authority Type	Expiry	Holder	Depth (m)
Mining leases				
CCL 708	Mining Lease	30/12/2023	Liddell Tenements Pty Ltd	Varying
CCL 715	Mining Lease	12/09/2019	Mt Owen Pty Ltd	Varying
CL 358	Mining Lease	27/03/2032	Glendell Tenements Pty Ltd	Varying
CL 382	Mining Lease	11/11/2033	HV Coking Coal Pty Ltd	Varying
CL 383	Mining Lease	12/11/2033	Mt Owen Pty Ltd	Surface to unlimited
ML 1313	Mining Lease	13/10/2023	Liddell Tenements Pty Ltd	Varying
ML 1349	Mining Lease	31/12/2023	Glencore Newpac Pty Ltd	Varying
ML 1355	Mining Lease	26/07/2036	Mt Owen Pty Ltd	Surface to unlimited
ML 1380	Mining Lease	18/09/2037	Centennial Newstan Pty Ltd	Varying
ML 1410	Mining Lease	04/07/2020	Glendell Tenements Pty Ltd	Surface to 106.68m
ML 1415	Mining Lease	04/07/2020	Mt Owen Pty Ltd	Surface to 106.68m in Project area
ML 1419	Mining Lease	12/11/2033	Mt Owen Pty Ltd	Surface to 15.24m
ML 1453	Mining Lease	04/07/2020	Liddell Tenements Pty Ltd	Surface to 106.68m
ML 1475	Mining Lease	23/11/2021	Mt Owen Pty Ltd	Surface to 15.24m
ML 1476	Mining Lease	23/11/2021	Glendell Tenements Pty Ltd	Varying
ML 1477	Mining Lease	29/11/2021	Resource Pacific Pty Ltd	Varying
ML 1525	Mining Lease	17/11/2023	HV Coking Coal Pty Ltd	Depth of 5m below surface to 20m
ML 1533	Mining Lease	25/02/2024	White Mining (NSW) Pty Ltd	Varying
ML 1561	Mining Lease	16/02/2026	Mt Owen Pty Ltd	Surface to 15.24m
ML 1597	Mining Lease	05/11/2028	Liddell Tenements Pty Ltd	Surface to depth
ML 1608	Mining Lease	19/12/2028	Mt Owen Pty Ltd	Surface to depth
ML 1623	Mining Lease	30/10/2029	White Mining (NSW) Pty Ltd	Depth of 5m below surface to 900m
ML 1625	Mining Lease	07/11/2029	Resource Pacific Pty Ltd	Integra lease vent shaft
ML 1629	Mining Lease	09/03/2030	Mt Owen Pty Ltd	Surface to 15.24m
ML 1673	Mining Lease	11/11/2033	Mt Owen Pty Ltd	Varying
ML 1676	Mining Lease	04/04/2026	HV Coking Coal Pty Ltd	Surface to 5m
ML 1694	Mining Lease	22/10/2034	Mt Owen Pty Ltd	Varying
MPL 343	Mining Lease (Mining Purposes)	04/01/2026	Glendell Tenements Pty Ltd	Surface to 5m
Assessment Leases				
AL08 (MLA512)	Assessment Lease	Mining Lease Pending	Mt Owen Pty Ltd	Surface to 15.24m

Reference	Authority Type	Expiry	Holder	Depth (m)
Exploration Licences				
A268	Exploration Licence	25/08/2022	Mt Owen Pty Ltd	Varying
A423	Exploration Licence	23/12/2018	Mt Owen Pty Ltd	Varying
A429	Exploration Licence	27/07/2019	Mt Owen Pty Ltd	Surface to depth
EL 4918	Exploration Licence	Renewal Pending	White Mining (NSW) Pty Ltd	Varying
EL 5824	Exploration Licence	Renewal Pending	Mt Owen Pty Ltd	Surface to 20m
EL 6254	Exploration Licence	03/06/2019	Mt Owen Pty Ltd	Surface to depth
EL 6594	Exploration Licence	06/07/2020	Glendell Tenements Pty Ltd	Surface to 15.24m in Project area
EL 8184	Exploration Licence	14/10/2018	Glendell Tenements Pty Ltd	Surface to 15.24m and 20m in Project area
EL8458	Exploration Licence	25/08/2022	HV Coking Coal Pty Ltd	Varying



Data Source: Glencore (2018), Minview (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- AL8
- AUTH268
- AUTH423
- AUTH429
- CCL708
- CCL715
- CL358
- CL382
- CL383
- EL4918
- EL6254
- EL6594
- EL8184
- ML1313
- ML1349
- ML1355
- ML1357
- ML1398
- ML1410
- ML1415
- ML1419
- ML1453
- ML1475
- ML1476
- ML1477
- ML1484
- ML1485
- ML1529
- ML1533
- ML1552
- ML1561
- ML1597
- ML1608
- ML1623
- ML1629
- ML1668
- ML1673
- ML1694
- MPL343

FIGURE 2.1

Mining Authorities

File Name (A4): R01/4166_065.dgn
20180426 8.54

2.4.4 Environment Protection and Biodiversity Act 1999 Approval

The Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) Approval 2013/6978, covers the approved Mount Owen and Ravensworth East operations, including all surface infrastructure and train loading facilities. Liddell Coal Operations operates under EPBC Act Approval 2013/6908.

Referrals were submitted for the Integra Underground Mine Longwall Modification (EPBC 2017/8105) and Mount Owen Continued Operations Modification 2 Project (EPBC 2017/8083). Both projects were declared not to be controlled actions.

The Glendell Consent was originally granted prior to the commencement of the EPBC Act and was therefore not subject to approval under that Act. The 2007 modification of the Glendell Consent sought a reduction in the overall area of disturbance approved under the consent in force at that time and the modification was therefore not referred under the EPBC Act.

2.5 Environmental Management

All current operations are undertaken in accordance with approved Environmental Management Plans (EMP) and Strategies as detailed below:

- Mining Operations Plan
- Air Quality 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, Bettys and Swamp Creeks Diversions Plan, integration with GRAWTS)
- Biodiversity and Offset Management Plan
- Aboriginal Cultural Heritage Management Plan
- Historic Heritage Management Plan; and
- Pollution Incident Response Management Plan.

A Rehabilitation Management Strategy has recently been submitted for approval which applies to the Mount Owen Continued Operations Consent project area only.

These management plans have been recently reviewed and revised to incorporate the requirements associated with both the Mount Owen Continued Operations Consent and Glendell Consent. The management plans include detailed environmental monitoring programs.

Mount Owen 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 environmental monitoring of all key aspects of the current operations.

Figure 2.2 shows the location of the monitoring network associated with the Mount Owen Complex. Monitoring is also undertaken by Liddell Coal and selected Liddell monitoring locations relevant to the Project are also shown on **Figure 2.2**.

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

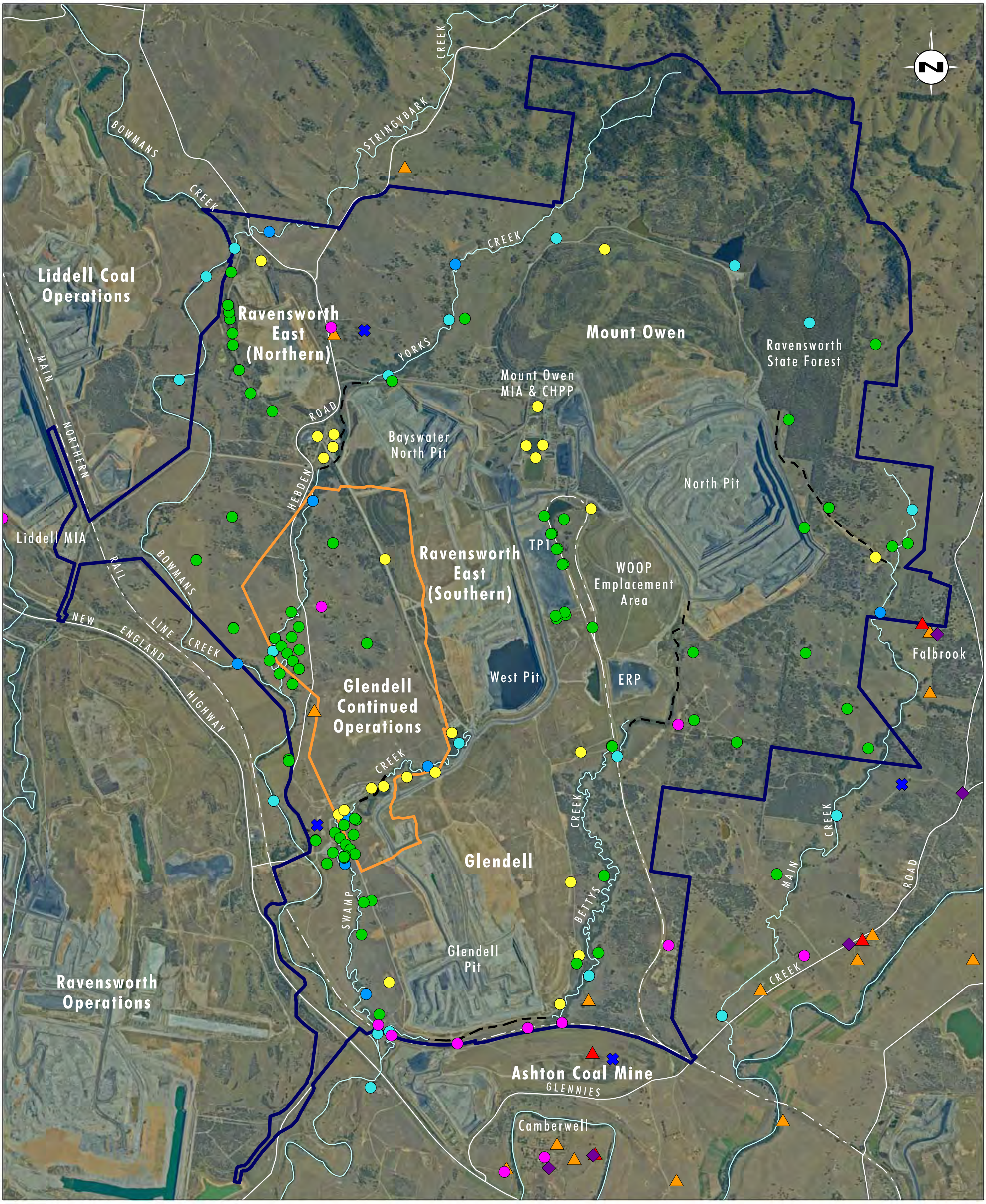


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

Legend

- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- MET Station
- Air Quality Monitoring Location
- Blast Monitoring Location
- Attended Noise Monitoring Location
- Continuous Noise Monitoring Location
- Groundwater Monitoring Location
- Surface Water - Channel Stability and Stream Health
- Surface Water Onsite Storage
- Surface Water - Watercourse

FIGURE 2.2

Existing Mount Owen Complex Monitoring Network

File Name (A4): R01/4166_033.dgn
20180511 9.31

3.0 Project Overview

3.1 Project Summary

The Project proposes the extension of mining at Glendell Mine to the north of the current Glendell Pit. Mining operations would extend the existing open cut operations to the north with mining down to the Hebden Seam (Glendell Pit Extension). Estimated ROM coal reserves in the proposed mining area are approximately 140 Mt. Mining operations would be undertaken using truck and excavator mining methods.

Mining operations would initially proceed at the current approved production rate (up to 4.5 Mtpa) with production increasing during the life of the operations as production at Bayswater North Pit and North Pit decline and eventually cease. Maximum annual production from the Glendell Pit Extension would be capped at 10 Mtpa ROM coal. **Section 3.2** provides further details regarding the geology of the proposed mining area and **Sections 3.3** to **3.4** contains further details of proposed mining operations.

ROM coal would be transported by truck from the Glendell Pit Extension to the Mount Owen CHPP for washing, consistent with current practice. The Project will not result in any increase to the currently approved 17 Mtpa ROM coal throughput at the Mount Owen CHPP, however the Project will extend the life of the Mount Owen CHPP and associated coal handling and transport infrastructure by an additional 8 years beyond that currently contemplated by the Mount Owen Continued Operations Modification 2 Project and 14 years from the date currently approved under the Mount Owen Continued Operations Consent. **Section 3.6** contains further details regarding mining infrastructure. **Figure 3.1** shows the key project features.

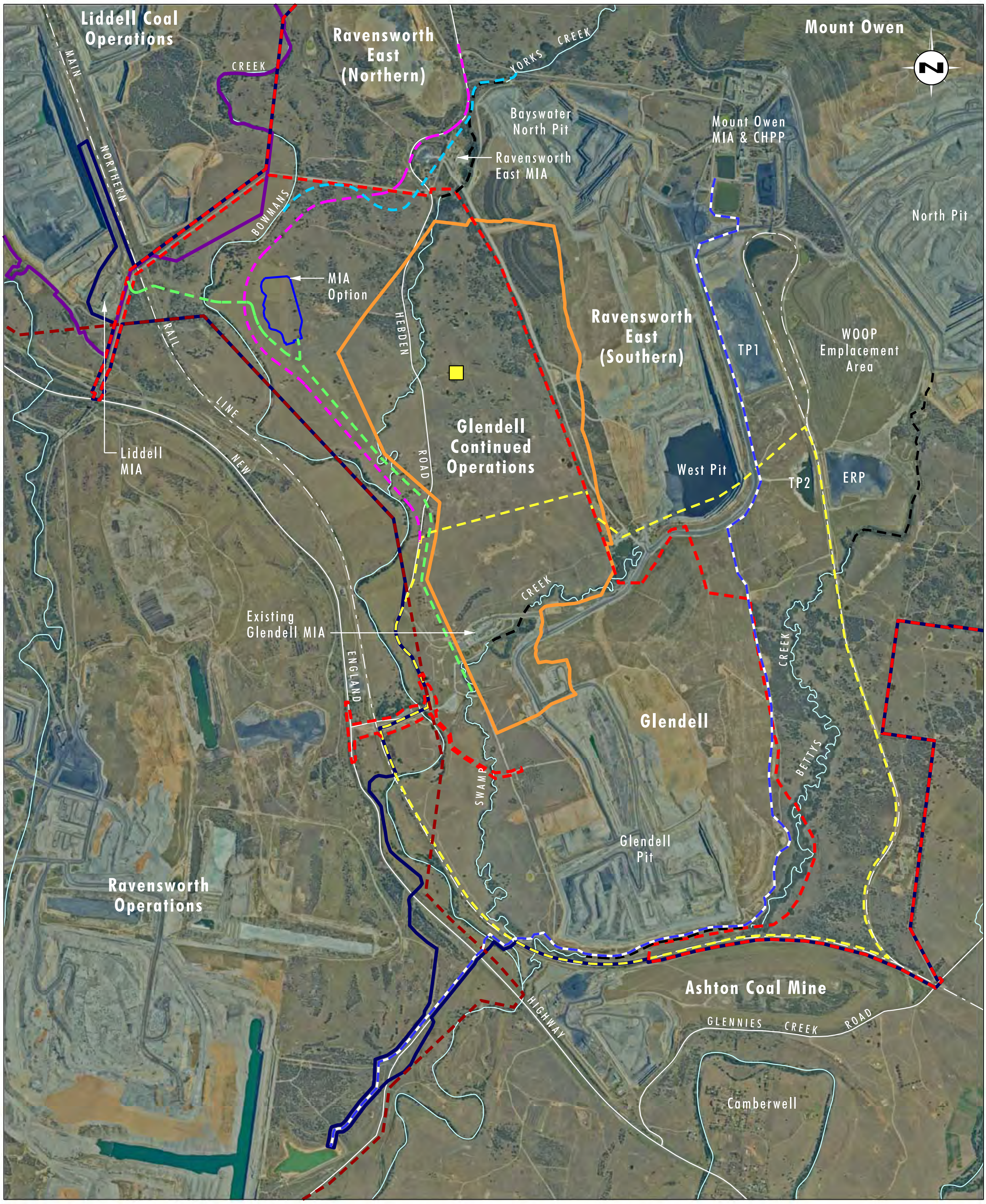


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)
Note: Ravensworth Homestead to be relocated.

Legend

- Project Area
- Proposed Glendell Pit Extension
- Liddell Consent Boundary
- Mount Owen Consent Boundary
- Glendell Consent Boundary
- Ravensworth Consent Boundary
- Ravensworth Homestead
- Existing Creek Diversion

Project Features:

- New MIA Option
- Indicative Relocated Narama Pipeline Alignment
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 3.1

Key Project Features

Overburden removed as part of the mining operations will be emplaced in-pit to the south of the mined area as mining progresses to the north. Overburden emplacement would also occur on existing Glendell emplacement areas and areas disturbed as part of the Ravensworth East operations. The final emplaced landform will be developed using natural landform techniques and will be progressively rehabilitated over the life of the Project.

Water and tailings management associated with the Project will be integrated with the Mount Owen Complex WMS and GRAWTS. The existing water transfer pipeline between the Mount Owen Complex to Ravensworth Operations will be impacted by the Glendell Pit Extension, necessitating a realignment of the easement. An indicative realignment option for this pipeline is shown on **Figure 3.1**.

As a result of mining progressing to the north, the Project will require the realignment of a section of Hebden Road and the diversion of Yorks Creek. Indicative alignments for Hebden Road and Yorks Creek are shown in **Figure 3.1**. The pit extension will also mine through the current Glendell MIA. The Project will therefore require the construction of a new MIA, utilisation of the Liddell MIA or utilisation of the Mount Owen MIA or a combination of these options. **Sections 3.4** to **3.12** provide further details regarding ancillary aspects of the Project. The Project will also mine through the site of the Ravensworth Homestead and the Project also proposes its relocation (refer to **Section 3.11** for further details regarding the relocation).

Table 3.1 provides a summary of key Project components.

Table 3.1 Project Summary

Project Component	Summary of the Project
Mining Method	Truck and Excavator/Shovel
Resource	All seams down to and including the Hebden Seam (Glendell Mine currently approved to mine down to a depth of approximately 200 m)
Disturbance Area	An additional disturbance area (refer to **Section 7.0)** will be associated with Glendell Pit Extension and associated infrastructure, Hebden Road realignment, Yorks Creek diversion and MIA facilities (Potential Additional Disturbance Area- UP TO approximately 1050 ha) Mining down to and including the Hebden Seam
Annual Production	Glendell Mine (Glendell Pit Extension) - up to 4.5 Mtpa increasing to 10 Mtpa ROM coal as production rates in Bayswater North Pit and North Pit decline Approved mining production rates at Bayswater North Pit and North Pit would remain the same
Mine Life	Glendell Mine – to 2044 (Glendell Pit currently approved to 2024)
Total Resource Recovered	Additional approximately 140 Mt ROM coal from Glendell Pit Extension
Coal Processing and Transport	Mount Owen CHPP - up to 17 Mtpa (no change). Extension of operating life of Mount Owen CHPP and associated coal handling infrastructure to 2045[3] Current export coal transportation via rail will remain the same Current CHPP throughput of 17 Mtpa ROM coal will remain the same Continued transportation of up to 2 Mtpa ROM coal and crushed gravel on an as required basis to Liddell Coal Operations and the Ravensworth Coal Terminal (RCT). Adjustments required to conveyor alignment and infrastructure and/or transport arrangements to accommodate the Yorks Creek Diversion works

[3] Coal extracted to the end of 2044 will require an extended approval timeframe for coal processing facilities.

Project Component	Summary of the Project
Management of Overburden (Glendell Pit Extension)	Emplacement of overburden in-pit and on existing emplacement areas at Glendell Mine and areas disturbed as part of the Ravensworth East Mine. Areas of out-of-pit emplacement to assist in final landform
Mount Owen CHPP Rejects (coarse and fine)	Fine tailings emplacement within West Pit and other tailings facilities approved at neighbouring mining operations as part of the GRAWTS. Coarse rejects co-disposed with overburden at Mount Owen Complex (including overburden associated with the proposed Glendell Pit Extension)
General Mine Infrastructure	Demolition of Glendell MIA^ New MIA required (either temporary MIA with long term use of the existing Liddell MIA, Mount Owen MIA, new MIA constructed to northwest of proposed Glendell Pit Extension or a combination of these options). Heavy vehicle access road to be established for new MIA and/or accessing the Liddell MIA Continued use of the Mount Owen CHPP and associated coal transport infrastructure Additional water management infrastructure such as sediment dams, clean and dirty water diversion drains, pipelines and use of voids for water storage Changes to GRAWTS pipeline infrastructure affected by Glendell Pit
Final Landform	Final landform at Glendell and Ravensworth East to 200 mAHD (approximately 40 m higher than existing approved operations at Glendell) No increase in number of voids relative to approved operations
Other Infrastructure Changes	Realignment of an approximately 5 km section of Hebden Road Relocation of local telecommunications and electricity infrastructure
Other Major Associated works	Diversion of Yorks Creek Construction of a replacement water pipeline from Mount Owen Complex to Ravensworth Operations (Narama Dam) – existing pipeline will be impacted by proposed Glendell Pit Extension Upper reaches of former Swamp Creek catchment (currently within Mount Owen Complex disturbance area) to be diverted to Bettys Creek as part of final landform development Relocation of Ravensworth Homestead
Operational Workforce	Overall workforce at the Mount Owen Complex will remain similar to current workforce numbers of approximately 1220 FTE positions during concurrent operations. This will reduce following cessation of mining operations at Mount Owen Mine (circa 2036-7) Glendell workforce numbers will progressively increase over the duration of the Project from approximately 300 FTE to approximately 600 FTE positions in the latter stages of the Project. The increasing workforce at Glendell coincides with a reduced workforce at the Mount Owen and Ravensworth East Mines as production declines and then stops
Hours of Operation	No change – 24 hours per day, 7 days per week

Key objectives of the Project include:

- maximising the recovery of accessible reserves within relevant mining tenements while optimising the use of existing infrastructure and equipment
- avoiding the sterilisation of accessible reserves
- extending the economic life of the Glendell Mine, Mount Owen Complex infrastructure and providing ongoing employment for the existing workforce
- further development of the existing environmental mitigation and management strategies, expanding the existing commitments to mitigate and manage the predicted impacts associated with the Project and cumulative impacts
- establishing a final landform that is safe and stable, and which provides sustainable post mining land use options

3.2 Geology and Coal Resource

The proposed Glendell Pit Extension, like the current Glendell Pit, is located along the Camberwell Anticline. The Camberwell Anticline is the major structural feature in the area and runs in a general north-south alignment through the proposed Glendell Pit Extension. The Camberwell Anticline exhibits steep dips (>20 degrees) on its eastern flank, and dips up to 12 degrees on its western flank. The main open cut resources occur along the axis of the anticline with deeper resources present on the western and eastern margins.

The two other major geological features present in the area are the Block Fault Zone (which occurs towards the northern extent of the proposed Glendell Pit Extension) and the Hunter Valley Dyke, (which occurs to the north-west of the proposed Glendell Pit Extension). Both features run in a general north-east/south-west alignment.

The locations of the key geological features in the area are shown on **Figure 3.2.**

The target coal reserves for the Glendell Pit Extension are the Burnamwood, Bulga and Foybrook Formations, which are the lowermost coal bearing formations of the Wittingham Coal Measures. Seven seams with open cut potential exist from the Bayswater seam to the Hebden seam and range in depth to approximately 240 m (refer to **Figures 3.2** and **3.3**). The Bayswater and Upper Lemington Seams are limited to the eastern extent of the proposed pit.

Figure 3.4 shows a stratigraphic cross section of the proposed Glendell Pit Extension.

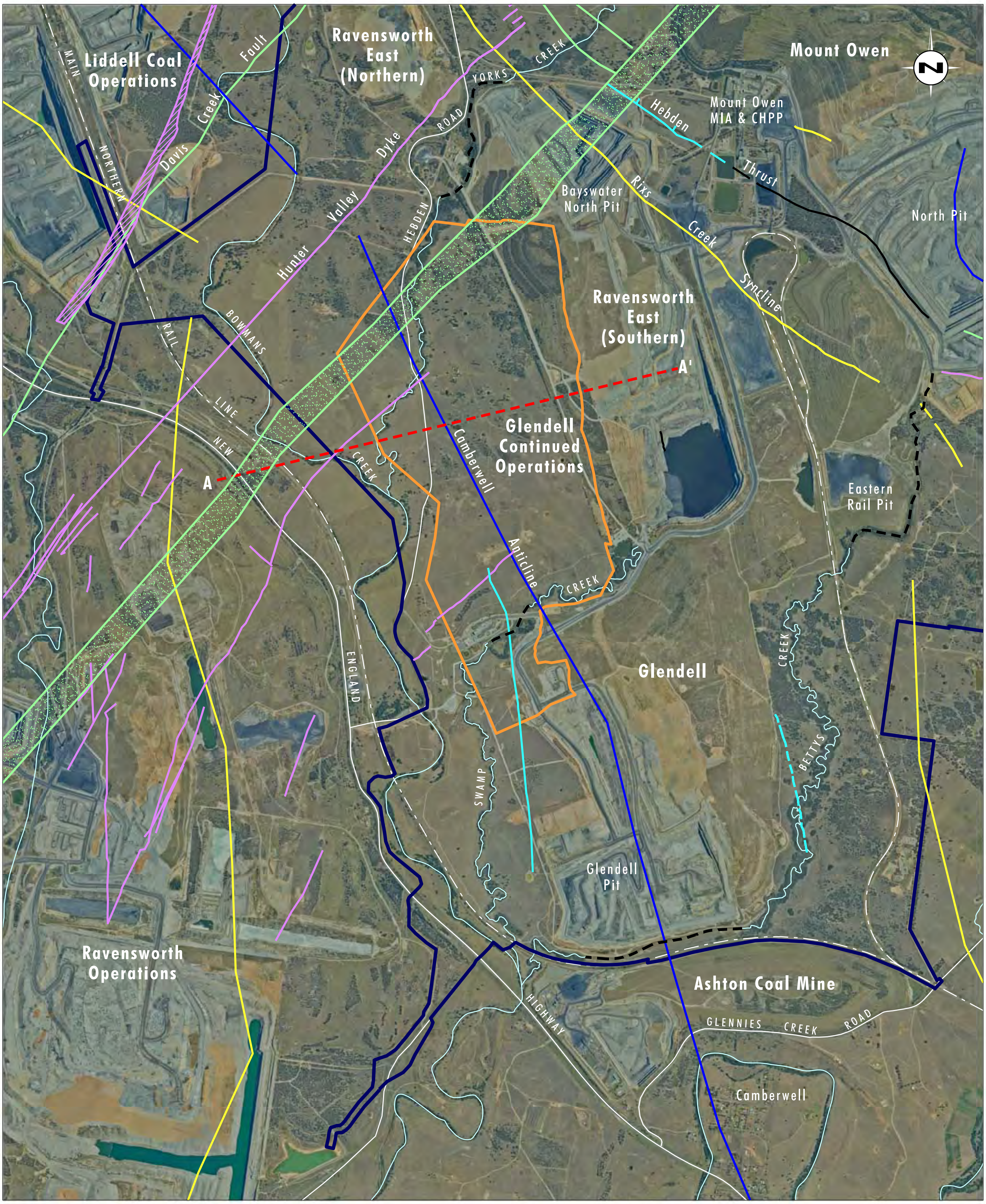


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

Legend

- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Geological Cross Section (Refer to Figure 3.4)
- Block Fault Zone
- Dyke, Significant Thickness
- Dyke
- Reverse Fault
- Normal Fault
- Syncline
- Anticline
- Monocline

FIGURE 3.2

Geological Structures

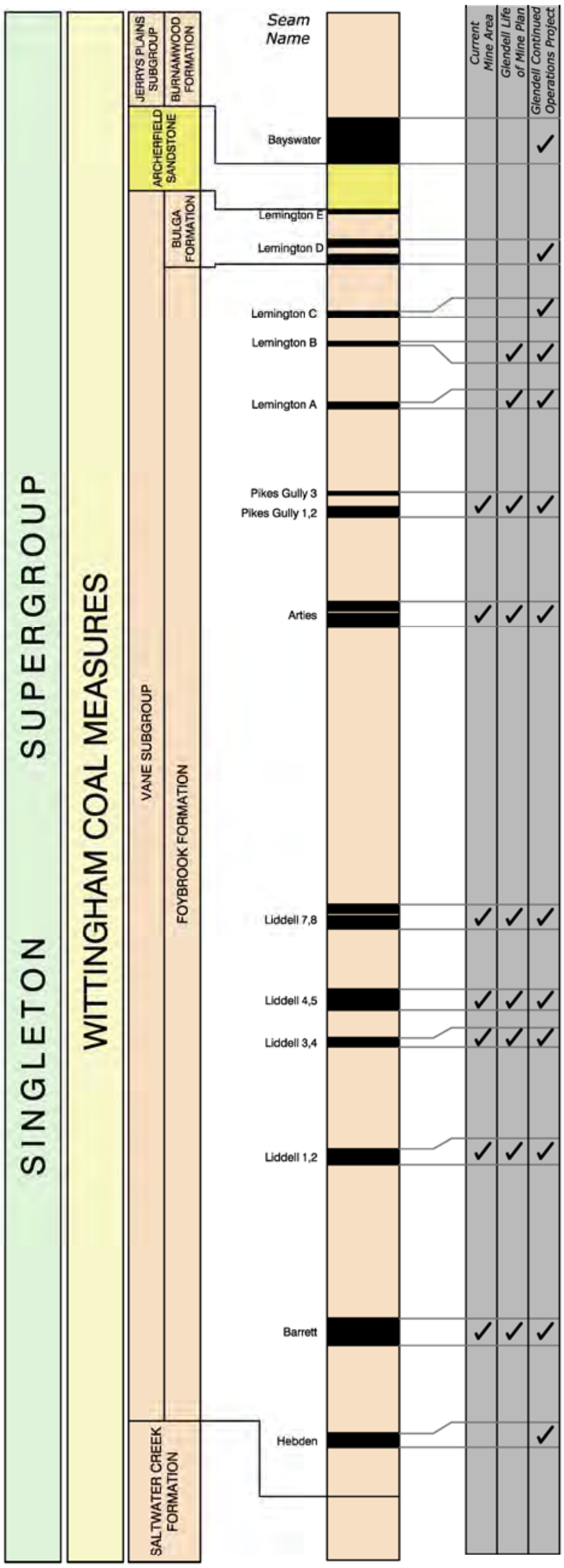
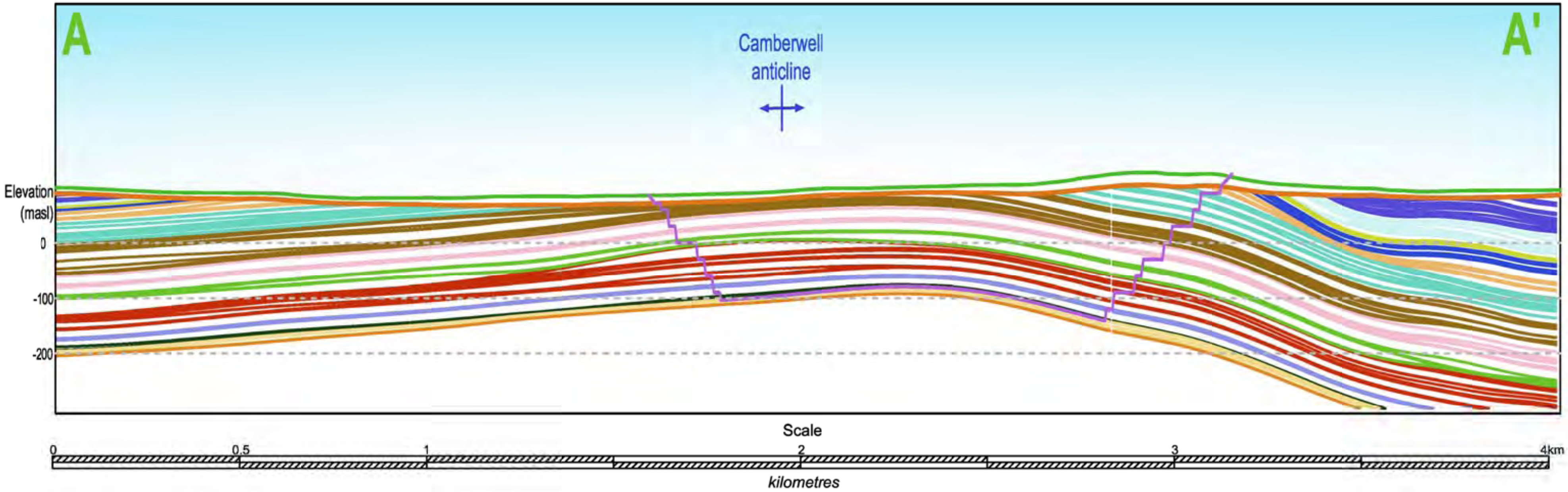


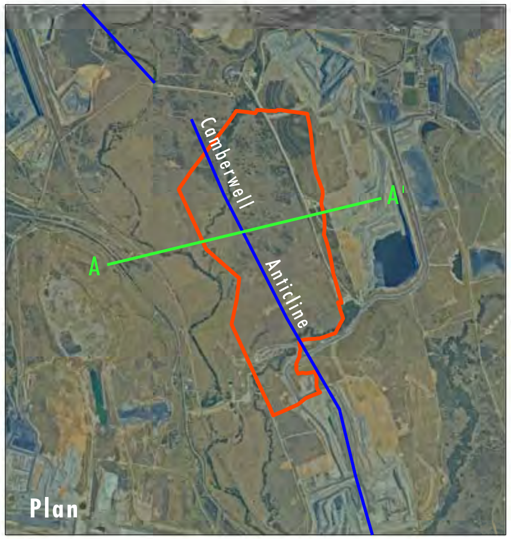
FIGURE 3.3

Target Stratigraphy at Mount Owen Complex

Image Source: Glencore (April 2018)

File Name (A4): R01/4166_057.dgn
20180427 13.16





Legend

- Proposed Glendell Pit Extension
- Surface
- Base of Weathering
- Anticline
- Section Line

Seams Legend

- Ravensworth
- Ravensworth
- Lemington E
- Lemington D
- Lemington C
- Lemington B
- Lemington A
- Pikes Gully
- Arties
- Liddell
- Barrett
- Upper Hunter
- Hebden
- Lower Hebden

FIGURE 3.4

Geological Cross Sections of Proposed Glendell Pit Extension Showing Camberwell Anticline

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

Exploration within the area north of the Glendell Pit site has identified further minable coal reserves which have formed the basis of the mine plan. The proposed Glendell Pit Extension will extract additional coal reserves; this is approximately 140 Mt of ROM coal.

The target seams are stratigraphically identical to those mined in the neighbouring Mount Owen Mine. Experience at Mount Owen has shown that these seams generally exhibit a low propensity for spontaneous combustion.

3.3 Conceptual Mine Plan

Mining at Glendell is currently occurring in the existing Glendell Pit. Glendell Pit initially commenced in the north-east of the current Glendell mining area (to the south of Swamp Creek) and progressed in a southerly direction, mining the eastern extent of the approved resources. The pit orientation then turned to the west and is now progressing in a northerly direction, mining the resources in the western half of the approved mining area. Overburden emplacement is occurring in-pit to the east and south of mining operations as the pit progresses northwards.

The Project will result in mining in the Glendell Pit extending to the north-west, generally along its current alignment. Mining will continue in a northerly direction with in-pit emplacement of overburden behind the active mining area (including the current Glendell Pit mining area) and other emplacement areas. A final void will remain in the northern section of the proposed pit area upon cessation of mining. **Figures 3.5**, **3.6** and **3.7** show the general conceptual progression of mining in the Glendell Pit Extension, however the mining schedule and progression may change throughout the life of the project as a result of mine design changes and refinements.

As mining progresses to the north, the Glendell Pit Extension will mine down to (and including) the Hebden Seam. Glendell Pit Extension production rates will progressively increase as production rates decline with the cessation of mining at the Bayswater North Pit and North Pit. **Figure 3.8** shows an approximated production schedule for the Mount Owen Complex over the life of the Project, however this is subject to change with mine design refinements in the future.

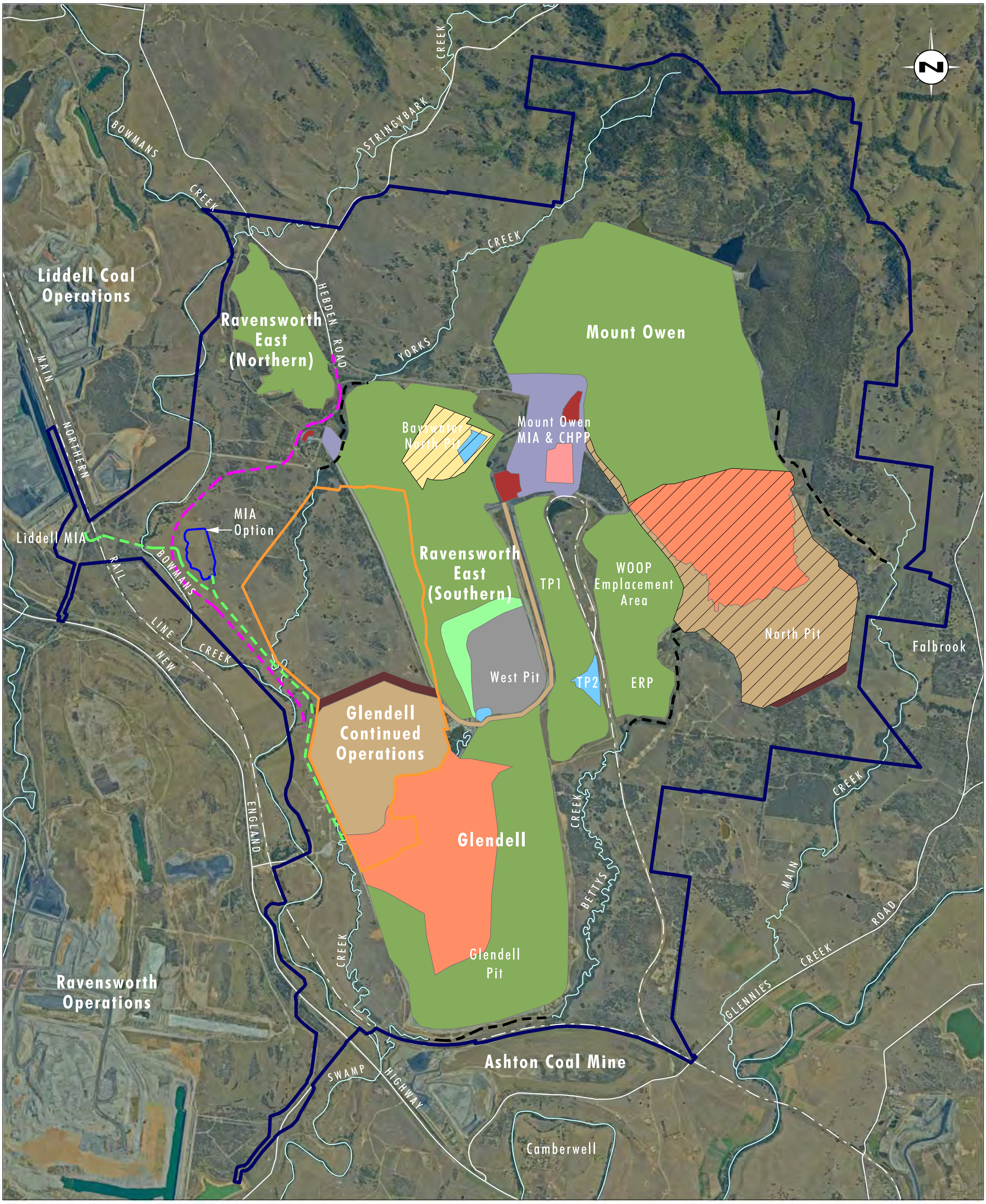


Image Source: Glencore (Feb 2018)
Data Source: Glencore (2018)

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Active Mining Area/Haul Road
- Active Overburden Emplacement Area
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Temporary Vegetation
- Rehabilitation
- Shaped Not Seeded
- Tailings Emplacement
- Topsoil Removal Strip
- Water Storage Area
- Mount Owen Mining Operations and shaping as proposed by MOCO Modification 2
- Existing Creek Diversion
- New MIA Option
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 3.5

Conceptual Progression of Mining Early Project Stage

File Name (A4): R01/4166_034.dgn
20180515 14.14

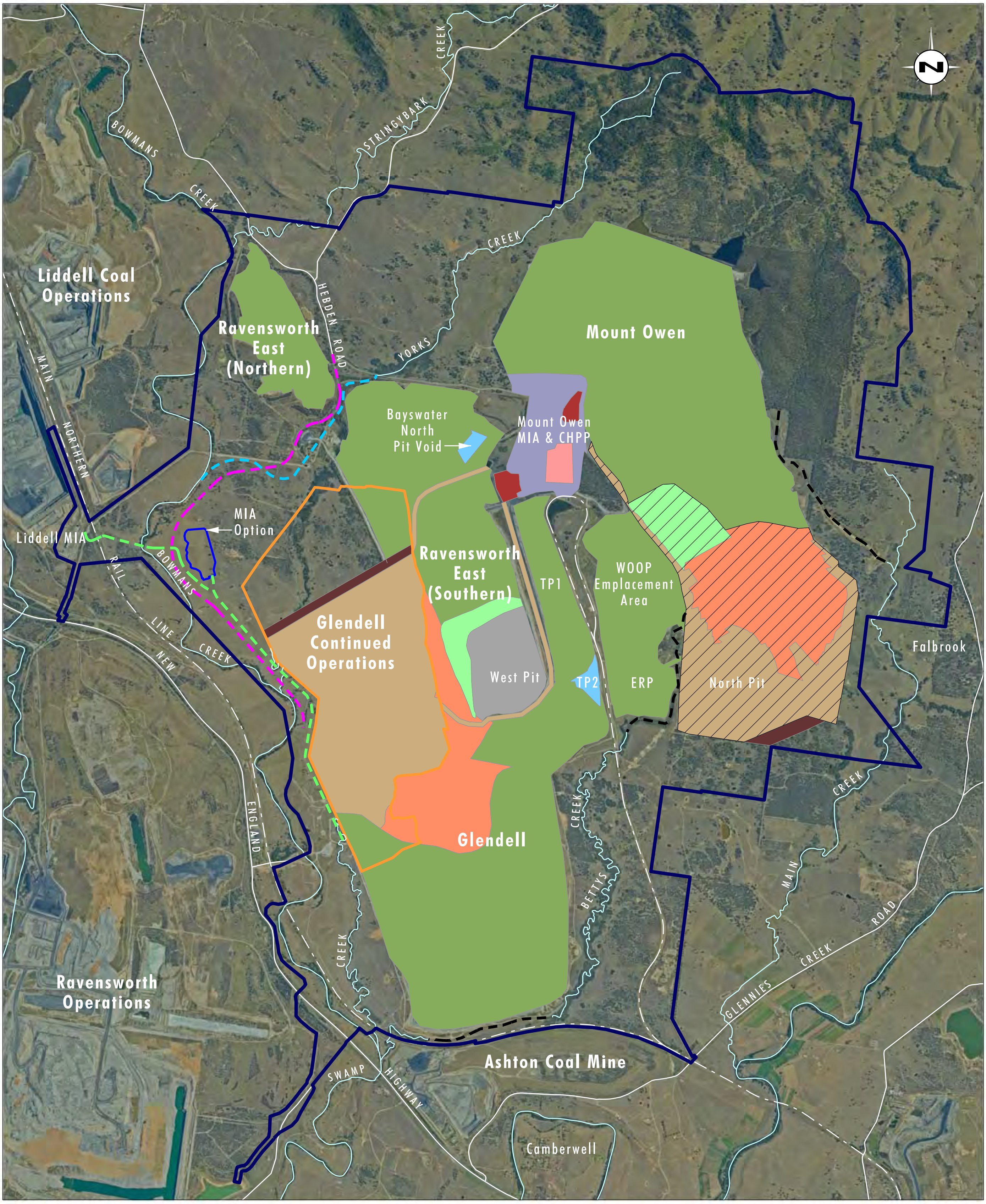


Image Source: Glencore (Feb 2018)
Data Source: Glencore (2018)

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Active Mining Area/Haul Road
- Active Overburden Emplacement Area
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Temporary Vegetation
- Rehabilitation
- Shaped Not Seeded
- Tailings Emplacement
- Topsoil Removal Strip
- Water Storage Area
- Mount Owen Mining Operations and shaping as proposed by MOCO Modification 2
- Existing Creek Diversion
- New MIA Option
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 3.6

Conceptual Progression of Mining Mid Project Stage

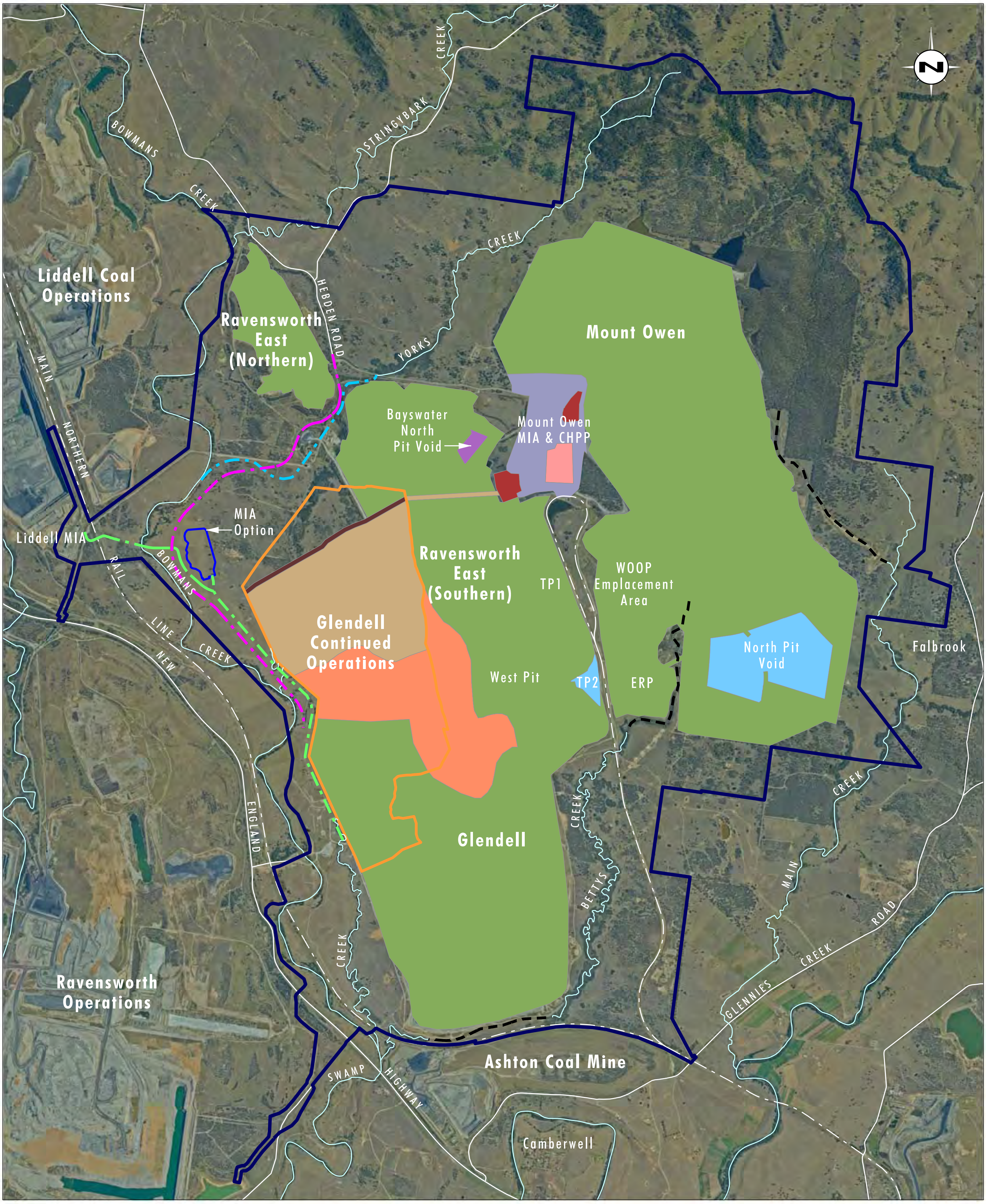


Image Source: Glencore (Feb 2018)
Data Source: Glencore (2018)
Note: Mount Owen mining operations as proposed by MOCO Modification 2

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Active Mining Area/Haul Road
- Active Overburden Emplacement Area
- Coal Stockpile - Product
- Coal Stockpile - ROM
- Infrastructure
- Rehabilitation
- Topsoil Removal Strip
- Water Storage Area
- Tailings Emplacement
- Existing Creek Diversion
- New MIA Option
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 3.7

Conceptual Progression of Mining Late Project Stage

File Name (A4): R01/4166_036.dgn
20180515 14.29

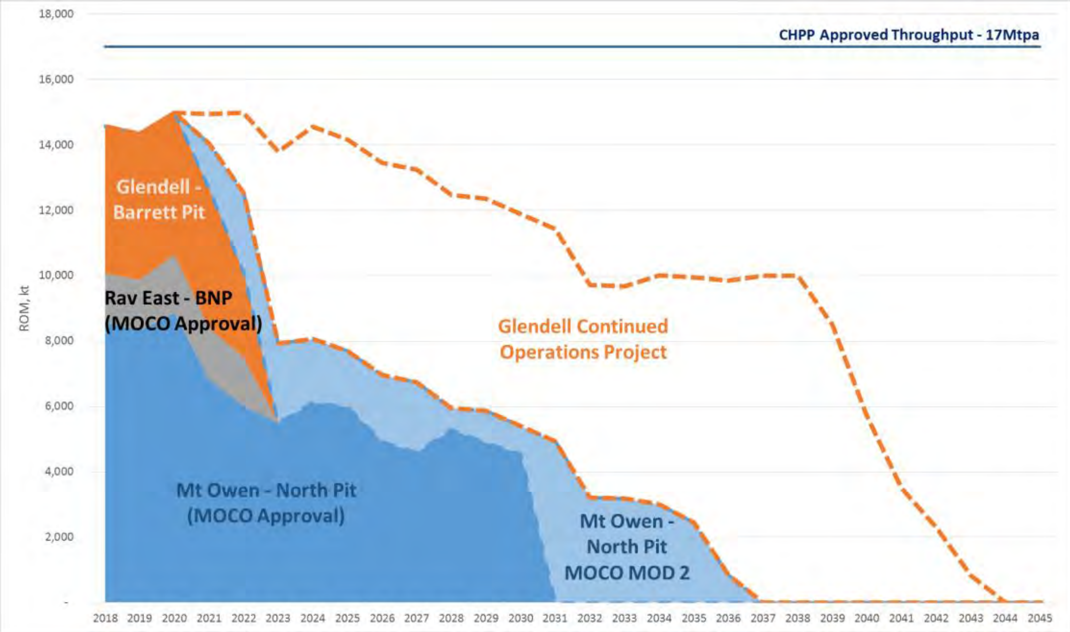


Figure 3.8 Mount Owen Complex Indicative Production Schedule

3.3.1 Overburden Management

The majority of overburden and interburden (referred to collectively as overburden) from mining operations associated with the Project will be emplaced in-pit behind the mining operations. Overburden will also be emplaced on the existing Glendell Mine in-pit and out-of-pit emplacement areas and in the areas disturbed as part of the Ravensworth East operations. Some out-of-pit emplacement will be required for final landform purposes. Overburden may also be used for the capping of tailings at West Pit and Bayswater North Pit (if used as a tailings facility). Overburden will be hauled from the pit to the emplacement location by haul truck.

Out-of-pit overburden emplacement at Glendell Mine is currently permitted to 160 mAHD under the Glendell Consent; this limit also extends to the in-pit-emplacement area under the terms of the approved MOP for the Mount Owen Complex (SLR, 2017). Under the Mount Owen Continued Operations Consent the Ravensworth East emplacement area receives overburden from BNP and has an approved maximum height of 160 m AHD. The WOOP Dump which receives overburden from the North Pit, has an approved maximum height of 190m AHD, while the North Pit in-pit emplacement area has approval to a maximum height of 230m AHD. To allow for the incorporation of natural landform design elements, emplacement across the overburden emplacement areas in Ravensworth East and Glendell utilised for the Project will be generally to 200 mAHD with local variations in topography to facilitate drainage and improve aesthetics. This emplacement strategy avoids the need for additional disturbance which would be associated with separate new out-of-pit emplacement areas. The increased height will not be uniform across the emplacement areas and the variability in height afforded by the increased dumping assists in the development of a natural looking final landform. The Project will not change approved dumping heights for the WOOP Dump or the North Pit in-pit emplacement.

Consistent with existing operations, proactive and reactive mine management will be undertaken to manage noise and dust impacts from the operations.

Overburden from the Project which meets appropriate engineering specifications may also be crushed and used as gravel in the construction of infrastructure on the site, including but not limited to the Hebden Road realignment, the MIA heavy vehicle access road, the MIA hardstand area and haul roads throughout the life of the Project.

3.3.2 Rejects and Tailings Management

Tailings emplacement within the Mount Owen Complex is undertaken within disused mining areas in accordance with the Tailings Management Strategy.

Continued use of the West Pit void is proposed as part of the Project along with the management of tailings across a number of Glencore operations within the Greater Ravensworth Area forming part of the GRAWTS, including the Liddell South Cut void. Opportunities to utilise the Bayswater North Pit void and other voids in the Greater Ravensworth Area for tailings disposal are also being considered. Based on current approvals for operations within the GRAWTS, there is sufficient void capacity available to store tailings associated with all approved operations plus this Project and the Mount Owen Continued Operations Modification 2 Project. A rejects and tailings strategy will be developed for the EIS.

In accordance with the current approvals, tailings emplacement areas at the Mount Owen Complex will be capped with overburden to achieve a stable final landform and allow the area to be rehabilitated in accordance with the proposed mine plans and the mine closure and rehabilitation strategy.

3.3.3 Blasting

Blasting will be undertaken on a regular basis for both overburden removal and coal extraction. Blast practices for the Project will include:

- up to 2 mining related blasts per day and
- an average of 8 blasts per week (averaged over a 12 month period).

As with current operations, blasting will be restricted to between the hours of 9.00 am and 5.00 pm Monday to Saturday and no blasting will be conducted on Sundays or Public Holidays, except where approved by the Planning Secretary.

Temporary closures of Hebden Road will be required when blasting is within 500 m distance to the nearest point of Hebden Road. No blasts associated with the Project are proposed within 500 m of the New England Highway or Main Northern Rail Line. Depending on the timing of approval of the Project, some blasting associated with existing approved operations may still be required within 500 m of the Main Northern Rail Line; existing management practices regarding any such blasts will be maintained as part of the Project.

As noted in **Section 3.13**, some construction activities (e.g. cuttings associated with the Hebden Road realignment and Yorks Creek diversion works) may also require some blasting. Construction related blasts will be in addition to the mining related blasts. Some of these blasts may be within 500 m of Hebden Road however blasting associated with these works is unlikely to be located within 500 m of either the Main Northern Rail Line or the New England Highway.

The timing of road closures on Hebden Road will have regard to key transport times for employees, local residents and local businesses.

3.3.4 Rehabilitation and Final Landform

Progressive rehabilitation has been undertaken throughout the life of Glendell, Ravensworth East and Mount Owen Mines. Rehabilitation works have included extensive flora and fauna monitoring and research projects in order to develop rehabilitation techniques and ensure the development and success of the rehabilitation programs in place. Disturbed areas will be rehabilitated as soon as practicable throughout the life of mining at the Mount Owen Complex.

The current Glendell Consent final landform incorporates a single void in the north-eastern corner of the Glendell Pit. The conceptual final landform developed for the Mount Owen Continued Operations Project includes two final voids remaining following rehabilitation (Bayswater North Pit and North Pit).

The Project will result in a single void in the north of the Glendell Pit Extension and will therefore not result in any additional voids at the Glendell Mine when compared to current approved operations. The Project may utilise the North Pit void for water storage following the cessation of mining at North Pit. The detailed mine planning process to be undertaken for the Project will consider opportunities for the Project to use the Bayswater North Pit void for water and tailings storage and overburden emplacement.

Natural landform design, incorporating micro-relief principles, will be developed for areas emplaced by overburden as a result of this Project.

The micro-relief design process results in a more natural looking landform, which reduces the visual impact of the final landform. Variable height in the topography also assists in the mitigation of potential visual impacts.

The design of the final landform is developed progressively as part of the detailed mine planning process and is included in the staged rehabilitation plans contained in the MOP/Rehabilitation Management Plan. The progressive development of micro-relief in the landform as part of the detailed mine planning process is necessary to ensure that overburden material is efficiently handled and the drainage in the rehabilitated final landform works effectively as part of the mine water management system.

The rehabilitation strategy developed for the Project will have regard to the design principles approved for the Mount Owen Continued Operations Project including the incorporation of wildlife corridors, conservation areas and the management of water resources in the long term.

3.4 Hours of Operation

Mining, CHPP and coal transport operations will continue to be undertaken 24 hours per day, 7 days per week for the life of the Project.

3.5 Operational Workforce

During the life of the Project, workforce demands associated with each operation within the Mount Owen Complex will change however overall workforce numbers at the Mount Owen Complex (Glendell Mine, Mount Owen Mine, Ravensworth East Mine and the Mount Owen CHPP) will be maintained at approximately 1220 full time equivalent (FTE) positions during concurrent operations. Total workforce numbers at the Mount Owen Complex after cessation of mining at North Pit and Bayswater North Pit will decline to approximately 600 FTE positions. Workforce numbers will progressively decline as production rates decline until the cessation of mining in the Glendell Pit Extension (refer to **Figure 3.8**).

Glendell workforce numbers will progressively increase over the duration of the Project from approximately 300 FTE to approximately 600 FTE positions in the latter stages of the Project. The increasing workforce at Glendell coincides with a reduced workforce at Mount Owen as operations at Bayswater North Pit and North Pit decline.

3.6 Mining Infrastructure

3.6.1 Coal Handling and Transport Infrastructure

The Project will utilise the existing Mount Owen CHPP and coal handling infrastructure (conveyors, stockpiles and train loading facilities) for the processing and transport of coal. ROM coal will be hauled from the Glendell Pit Extension to the Mount Owen CHPP via truck. The haul route will remain largely the same as is currently used for mining in the Glendell Pit in the early stages of the Project. During later stages, as the Glendell Pit Extension extends further to the north, ROM coal will be hauled across the (now former) Ravensworth East mining area to reduce the haulage distance.

The currently approved operating capacity of the Mount Owen CHPP and train loading facility will remain the same and has approval to process up to 17 Mtpa of ROM coal. The Project will extend the current approved life of the Mount Owen CHPP to approximately 2045.

The Project will retain the option of transferring up to 2 Mtpa ROM coal and crushed gravel on an 'as required' basis via the existing overland conveyor to Liddell Coal Operations and the Ravensworth Coal Terminal (RCT); alternative transport arrangements will also be considered as part of the design studies being undertaken during the preparation of the EIS. The diversion of Yorks Creek will necessitate realignment and alterations to sections of the existing conveyor. This flexibility is required to maintain production at Glendell and Mount Owen in the event of disruption to the Mount Owen CHPP or the Mount Owen Rail Loop.

The Mount Owen Complex infrastructure facilities will continue to operate 7 days per week.

3.6.2 New Mining Related Infrastructure

New infrastructure requirements for the Project include:

- demolition of the existing Glendell MIA and Ravensworth East MIA (noting that the demolition of the Ravensworth East MIA is the subject of the current Mount Owen Continued Operations Consent)
- construction of a new MIA and/or utilisation of the Mount Owen MIA or Liddell Coal MIA (or a combination of these options)
- construction of a new heavy vehicle access road to the new MIA (Liddell and new MIA options only). If the Liddell MIA option is pursued, this access road will also require the construction of bridges across the relocated Hebden Road, Bowmans Creek and the Main Northern Rail Line to the east of the Liddell Coal MIA
- water management infrastructure including water fill point/s
- temporary construction facilities and laydown areas
- realignment and alterations to the Ravensworth East to Liddell Conveyor or construction and use of alternative transport arrangements.

The progression of mining to the north of the Glendell Pit will necessitate the demolition of the current Glendell MIA and the construction of a new MIA and/or use of existing infrastructure. The demolition will need to occur in the early stages of the Project (circa 2021-2022) meaning any alternative MIA (or use of temporary facilities) would need to be available prior to demolition (i.e. in 2020-2021). Options still being considered include the construction of a new MIA or the use of the Mount Owen and/or Liddell MIAs (or a combination of these options). The Liddell MIA is currently being used for the Liddell Coal open cut mining operations, currently approved until 2028.

The Liddell MIA does not have sufficient capacity for maintaining equipment for both Liddell Coal operations and the Project and temporary facilities would be required (either at Liddell or at an alternative site at Glendell) during the overlap period. These temporary facilities would also continue to be used for the life of the Project for prestart/muster of the operational workforce and for minor equipment maintenance activities. The potential to upgrade the Mount Owen MIA to service the Project remains an option under consideration.

The continued use/upgrade of the Ravensworth East MIA for the Project is not considered to be feasible due to the size of the area available at Ravensworth East and the continued need for the MIA for maintenance activities associated with mining in the Bayswater North Pit. Additionally, the progression of the Glendell Pit Extension to the north necessitates the diversion of Yorks Creek and the works associated with this diversion (see **Section 3.10.1** below) make the continued use of the Ravensworth East MIA for the Project unfeasible.

As the Mount Owen MIA will continue to be used to support mining operations at North Pit, it also does not have capacity to handle both Glendell and Mount Owen mobile equipment without a significant upgrade.

The indicative location of a new MIA for Glendell (if required) and associated heavy vehicle haul road are shown on **Figure 3.1**. The additional access road infrastructure (including bridges over the relocated Hebden Road, Bowmans Creek and Main Northern Rail Line) required if the Liddell MIA is utilised rather than constructing a new MIA or using the Mount Owen MIA is also shown in **Figure 3.1**.

The EIS will identify the preferred MIA strategy and associated infrastructure to be utilised for the Project.

A range of temporary infrastructure will also be required for the construction period including a construction site office(s), car parking areas and hardstand/laydown areas.

Further design studies will be undertaken to refine the concept details and requirements for ancillary infrastructure that might be required to service the Project.

3.6.3 Water Management System

The Glendell water management system is an integrated component of the Mount Owen Complex WMS and the GRAWTS as described in **Section 2.2**.

The Project will require changes to the WMS and approved GRAWTS arrangements, including a realignment of the water pipeline between the Mount Owen Complex and Ravensworth Operations. Drainage infrastructure will need to be constructed and installed to capture water from additional areas disturbed by the Project. This infrastructure will include clean water diversions, pipelines, pumps and sediment dams and dirty water diversion drains. The realignment of the GRAWTS water pipeline between the Mount Owen Complex and Ravensworth Operations is required as the Glendell Pit Extension will mine through the current alignment of this pipeline connection between the operations. The realignment route will utilise existing disturbance areas but may require additional disturbance associated with construction in the area west of the current Glendell Mine. The realignment will include a crossing of Bowmans Creek, the Main Northern Rail Line and the New England Highway. An indicative alignment for the pipeline is shown in **Figure 3.1** and the Potential Additional Disturbance Area (refer to **Figure 1.4**) includes an allowance for alternative Bowmans Creek crossing options. The EIS will identify the preferred route for the pipeline and the means (e.g. through the use of under-boring, bridging or existing culverts) and location for the crossings of Bowmans Creek and other linear infrastructure.

Following the cessation of mining in Bayswater North Pit it will be used as a mine water dam consistent with current approval requirements. North Pit will also be used for water storage for the Project following the cessation of mining in that pit. The utilisation of North Pit as a water storage would enable the Bayswater North Pit to be used for either tailings disposal or overburden emplacement for the Project.

This proposed change to the use of the North Pit void optimises the value of the void during the life of the Project. This change will not materially alter the conceptual final land-use of the North Pit Void as the Mount Owen Continued Operations Consent currently contemplates a pit lake in the North Pit Void.

3.7 Site Access

Glendell Mine currently has a single primary site access at the southern end of Hebden Road; approximately 2 km from the Hebden Road intersection with the New England Highway (refer to **Figure 1.2**).

If the new indicative MIA location is the preferred option for the Project, the primary access for the site will be via a new mine access road linking the proposed MIA and the proposed realigned Hebden Road. As with existing operations, a number of minor access points off Hebden Road and associated hardstand areas will be developed for maintenance and other purposes. If the Liddell MIA is utilised as the MIA for the Project, the primary access point is likely to be via the Old New England Highway. No changes to the existing New England Highway intersection with the Old New England Highway are likely to be necessary. If the Mount Owen MIA is taken forward as the preferred MIA option, primary access to the site will be via the current Mount Owen Access Road off Hebden Road.

3.8 Hebden Road Realignment

The Glendell Pit Extension will necessitate the realignment of a section of Hebden Road. The realignment will also include a crossing of the proposed Yorks Creeks Diversion (refer to **Section 3.10**).

It is proposed that an approximately 5 km section at the southern end of Hebden Road will be realigned to the west around the Glendell Pit Extension in the location shown on **Figure 1.3**. This realignment would extend the trip distance for some road users travelling on Hebden Road by approximately 1.2 km.

The realignment design has also taken into consideration potential future mine planning options for Glendell which may include a possible further extension to the north-west into a portion of the old Liddell Underground Mine that is located to the east of Bowmans Creek. The proposed realignment location would avoid the need for a subsequent realignment of Hebden Road should this option be pursued in the future.

Consultation has commenced with the Singleton Council regarding the design of the road. Consultation with Hebden Road stakeholders such as residents and Hebden Quarries has been undertaken and will continue.

In order to minimise disruptions to traffic, where possible, the realigned section of Hebden Road will be fully constructed prior to decommissioning of the existing section. This is anticipated to be completed in 2021.

Due to the proximity of sections of Hebden Road (both existing alignment and proposed realignment) to the Glendell Pit Extension, temporary closures of sections of Hebden Road will be required for blasting located within 500 metres of the road. These road closures are discussed further in **Section 8.2.**

3.9 Other Infrastructure

Powerlines and telecommunications infrastructure located within the proposed Potential Additional Disturbance Area (refer to **Figure 1.4**) will need to be relocated. These relocations will generally follow the Hebden Road realignment.

3.10 Creek Interactions

3.10.1 Yorks Creek

The progression of the Glendell Pit Extension to the north will necessitate the diversion of the lower portion of Yorks Creek, an ephemeral tributary of Bowmans Creek running in a roughly north-south alignment though the Project Area. Earthworks upstream of the Glendell Pit Extension will also be required to manage the risk of flood waters entering the pit. This area has been previously disturbed by mining and infrastructure associated with the Ravensworth East Mine.

The proposed diversion will commence north of the existing Ravensworth East MIA and progress in a south-westerly direction where it will enter Bowmans Creek. An indicative alignment for the diversion is shown in **Figure 3.1**. Further discussion of the Creek Diversion design process is included in **Section 4.1.3** and **8.13**. The proposed diversion includes the diversion of the section of Yorks Creek that has previously been diverted (refer to **Section 2.3.1**).

This diversion is proposed to be permanent and its design will have regard to a wide range of environmental factors. The diversion is required to be in place by approximately 2027. It is contemplated that construction activities would commence earlier to improve the environmental performance of the proposed diversion.

3.10.2 Swamp Creek

The Project will mine through the remnants of Swamp Creek located immediately north of Glendell Pit. The lower reaches of Swamp Creek to the west of Glendell Pit will not be directly affected by the Project other than through reduced catchment area. Water from the rehabilitated slopes of the south-western part of the final landform of the Project will be directed towards the lower reaches of Swamp Creek to enable the return of some catchment flows.

The terrain developed by the in-pit emplacement of overburden as part of the mining of the Project will result in a reduction to the Swamp Creek catchment. Areas of Swamp Creek catchment within the existing mining disturbance area will generally be diverted towards Bettys Creek as part of final landform drainage. This is discussed further in **Section 3.10.3**.

3.10.3 Bettys Creek

As discussed in **Section 3.10.2**, the Project will result in the redirection of part of the former Swamp Creek catchment towards Bettys Creek as part of the conceptual final landform design. This increase in the Bettys Creek catchment would occur progressively as areas of the former Swamp Creek catchment are rehabilitated such that run-off is of suitable water quality. The overall size of the Bettys Creek catchment in the final landform will not be greater than the pre-mining catchment area.

3.11 Ravensworth Homestead Relocation

Ravensworth Homestead is a collection of buildings constructed in the 1800s and modified over time by subsequent owners. The oldest structure in the Homestead complex dates to circa 1828. The Homestead is listed as an item of local heritage significance under the Singleton Local Environmental Plan 2013 (Singleton LEP). Ravensworth Homestead is owned and maintained by Mount Owen.

The Project includes the relocation of Ravensworth Homestead. Homestead relocation options are being developed and investigated, and will be considered as a key component of the SIA (refer to **Section 8.7**) and the Heritage Assessment (refer to **Section 8.5**) prepared as part of the EIS.

The relocation of the homestead is proposed to occur early in the Project life to minimise indirect impacts associated with blasting.

3.12 Construction

3.12.1 Construction Activities and Schedule

The Project has been designed to maximise the use of existing and currently approved infrastructure, however as outlined in the previous sections, the project will involve a number of significant construction activities including new mine infrastructure, the realignment of Hebden Road and the diversion of Yorks Creek.

The indicative timing of construction activities is set out in **Table 3.2**.

Table 3.2 Indicative Construction Schedule

Feature	Indicative Construction Period
Construction of new Glendell MIA **and/or Construction of temporary MIA if Liddell or Mount Owen MIA used**	2020-2021 (approximately 14 months) 2020-2021 (approximately 6 months)
Construction of Heavy Vehicle Access Road	2020-2021 (approximately 12 -24 months) depending on need for bridge over Bowmans Creek
Construction of Hebden Road realignment	2020-2021 (approximately 12 months)
Demolition of Glendell MIA	2021-2022 (approximately 6 months)
Demolition of Ravensworth East MIA	2024-2025 - coinciding with Yorks Creek Diversion Works (approximately 6 months)
Relocation of Ravensworth Homestead	2021-2024 (approximately 12-24 months)
Yorks Creek Diversion	2024-2025 but works associated with western sections may commence as early as 2020-2021. Full commissioning by approximately 2025

Construction activities in some areas will include blasting for cuttings (Hebden Road and Yorks Creek Diversion). Crushing of overburden and blasted material from cuttings may also be required for road and MIA construction fill.

3.12.2 Construction Hours

Construction activities will generally be undertaken within standard construction hours (7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday). Construction activities outside these hours will be subject to the ability to meet Project noise criteria.

Blasting associated with construction activities will only be undertaken 9.00 am to 5.00 pm, Monday to Friday and 9.00 am to 1.00 pm Saturday.

3.12.3 Construction Workforce

The construction workforce on site at any one time will vary depending on the timing of the various construction components of the Project. The construction workforce is estimated to peak at approximately 300 full-time employees in 2021. This includes the construction of the heavy vehicle access road, new MIA, and the Hebden Road realignment.

It is expected that some short term increases in traffic associated with key infrastructure construction periods will occur.

4.0 Alternatives and Justification

4.1 Project Alternatives

4.1.1 Mine Plan Considerations

As identified in **Section 3.1**, the key objectives of the Project include:

- maximising the recovery of accessible reserves within relevant mining tenements while optimising the use of existing infrastructure and equipment
- avoiding the sterilisation of accessible reserves
- maintaining the economic life of the Glendell Mine and Mount Owen Complex infrastructure and providing ongoing employment for the existing workforce
- further development of the existing environmental mitigation and management strategies, expanding the existing commitments to mitigate and manage the predicted impacts associated with the Project and cumulative impacts and
- establishing a final landform that is safe and stable, and which provides sustainable post mining land use options.

Technical constraints on mining in the area include:

- location of past open cut and underground workings to the east and north of the target area (refer to **Figure 1.2**)
- faulting and other geological structures in the area (refer to **Figure 3.2**)
- the shape of the Camberwell Anticline (refer to **Figure**, **3.4**)
- variations in the thickness of the different coal seams and differing thicknesses of overburden and interburden material in the area (refer to **Figures 3.3** and **3.4**) and
- variability on the quality of the coal in the different seams.

In addition to the mining constraints identified above, the mine plan alternatives considered have had regard to environmental and social constraints, including:

- impacts on surface water and groundwater systems, such as Bowmans Creek, Yorks Creek, Swamp Creek and associated alluvial aquifers
- heritage impacts, particularly impacts in relation to Ravensworth Homestead
- noise
- air quality impacts
- visual impacts
- traffic impacts and additional travel distance associated with a realignment of Hebden Road

- socio-economic impacts
- impacts on agricultural land
- impacts on biodiversity values

The above factors are taken into consideration in designing the sequencing of mining 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.

4.1.2 Mine Plan Alternatives

4.1.2.1 Mine Layout

The key mine plan layout alternatives to the Preferred Project that have been considered include:

- No Project. Finish mining at Glendell when existing approved resources are fully extracted and rehabilitate the site.
- Avoid Swamp Creek. Mine the Glendell Pit to the southern extent of the Swamp Creek Alluvium and recommence mining north of Swamp Creek.
- Mine around Ravensworth Homestead. The Glendell Pit Extension would be designed to avoid Ravensworth Homestead either by finishing south of Ravensworth Homestead or mining around the homestead to the east.
- Avoid Yorks Creek. Mine the Glendell Pit Extension up to the southern extent of the Yorks Creek Alluvium.
- Extend the pit further to the north-west and mine through the former Liddell Underground workings.
- Extend the pit to the north-west and mine through Bowmans Creek and link up with the Liddell Coal open cut working.
- Underground extraction of target seams.

Table 4.1 summarises the key reasons for not pursuing the various options.

Table 4.1 Options analysis for different mine plans considered

Option	Benefits of Option	Reason for Not Pursuing
No Project	No further environmental impacts beyond those currently approved No additional capital expenditure	Significant accessible reserves remain unmined (140 - 170 Mt ROM coal). Mount Owen Complex Infrastructure not efficiently utilised. Reduced local employment opportunities.
Avoid Swamp Creek	Avoids impacts on remaining part of upper Swamp Creek catchment Potential to avoid need to relocate Glendell MIA	Option requires restarting a new pit which has lower economic efficiencies associated with mining. Sterilises easily accessible coal reserves under Swamp Creek. Shorter mine life and reduced local employment opportunities. If Glendell MIA retained, blast practices required to minimise impacts on MIA would add significant constraints to mining.

Option	Benefits of Option	Reason for Not Pursuing
Avoid Ravensworth Homestead	The benefits and opportunities associated with this option are discussed in **Section 4.1.5**	In the long term the post-mining landscape will be further changed in such a way that the homestead would no longer retain any contextual relevance to its original, wider, heritage landscape setting and would remain isolated and inaccessible to the community while mining and rehabilitation activities are being undertaken. Effective sterilisation of readily accessible coal reserves to the north and west of Ravensworth Homestead. Shorter mine life and reduced local employment opportunities Reduced mine life would reduce economic benefits associated with project. Blast practices required to minimise impacts on homestead would add significant constraints to mining and/or present risk of structural damage to buildings. Constraints of utilising the homestead during the life of the mine may result in dilapidation of Homestead. Significant ongoing remedial works would be necessary to maintain the current condition of Ravensworth Homestead. See also discussion in **Section 4.1.5.**
Avoid Yorks Creek	Avoids direct impacts on Yorks Creek Avoids need to construct diversion	Effective sterilisation of easily accessible coal reserves to the north and west of Yorks Creek. Shorter mine life and reduced local employment opportunities. Reduced mine life would reduce economic benefits associated with Project.
Mine through Liddell Underground Workings	Additional coal resources extracted and extended life of mine	Would require careful management to prevent inrush risks from flooded workings. Technically challenging mining conditions. Further technical studies required to resolve uncertainties surrounding ability to seal and dewater sections of underground workings necessary to enable open cut mining.
Mine through Bowmans Creek to merge workings with Liddell Coal Open Cut	Additional coal resources extracted and extended life of mine No significant sterilisation of resources	Would have potentially significant impacts on Bowmans Creek and associated alluvial aquifers. Would require significant works associated with the diversion of Bowmans Creek. Likely to require a temporary diversion and then permanent diversion. Construction of final diversion /reinstatement over mined areas is technically challenging. Technically challenging to mine through former Liddell Underground workings. Would require careful management to prevent inrush risks from flooded workings. Would require different alignments (and suboptimal outcomes in terms of both cost and environment) to Hebden Road and Yorks Creek diversion. These different options are likely to have significantly larger surface water, biodiversity and Aboriginal

Option	Benefits of Option	Reason for Not Pursuing
		cultural heritage impacts relative to other options. Would mine through additional areas of identified Biophysical Strategic Agricultural Land (refer to **Section 7.1.2**). Would impact on known features of potential significant Aboriginal cultural heritage value.
Underground Option	Reduced surface impacts	Underground mining does not optimise resource extraction in the area. Underground mining would restrict recovery to two or three seams and would not enable recovery of thin seams. High capital costs associated with underground mine establishment. Does not optimise use of existing equipment. Management of potential subsidence impacts on surface features (including alluvial aquifers and Ravensworth Homestead) would result in the significant sterilisation of resources.

Of the above options considered, the progression of mining further to the north and through the western sections of the former Liddell Underground Workings (i.e. those east of Bowmans Creek) remains a potentially viable long term option. In order to avoid a further diversion of Yorks Creek and Hebden Road realignment should this option prove to be viable in the future, the alignments of each have been developed with this potential option in mind.

The remaining options have not been pursued primarily due to reduced economic benefits or, in the case of the Bowmans Creek Option, for environmental reasons. The preferred option (the Project) is considered to provide the best balance between environmental and social impacts and the economic benefits associated with the Project.

The Project includes the following design features to avoid, minimise and mitigate environmental and social impacts associated with the Project.

- setbacks of at least 200 m from the high bank of Bowmans Creek
- diversion of Yorks Creek and establishment of riparian vegetation along the diversion
- relocation of Ravensworth Homestead to a new location where it can potentially be reused, either as a private residence or for other purposes in order to preserve this good early example of a colonial farm complex
- construction of Hebden Road realignment prior to closure of Hebden Road to minimise road construction impacts on road users and
- progressively increasing production rates in the Glendell Pit Extension to maintain production, minimise cumulative impacts and maximise employment opportunities at the Mount Owen Complex during the life of the Project.

The need for alluvial cut-offs (or similar mitigation measures) in Yorks Creek and Swamp Creek to the Bowmans Creek alluvial aquifer to avoid direct connectivity with the pit will also be investigated as part of the Groundwater Impact Assessment for the Project.

The Project will include the removal of areas of native vegetation including woodland and derived native grassland communities. The extent of proposed vegetation disturbance is yet to be finalised, however the

Project's Potential Additional Disturbance Area (refer to **Section 1.1** and **Figure 1.4**) is UP TO approximately 1050 ha. Of this, the vast majority of the land is degraded derived native grassland communities. There is little difference between the options considered in terms of potential impacts on native vegetation communities although the options which avoid mining through Yorks Creek and Swamp Creek have reduced vegetation disturbance impacts relative to the other options. Residual vegetation impacts will be required to be offset in accordance with the requirements of the *Biodiversity Conservation Act 2017* (BC Act).

4.1.3 Infrastructure Alternatives

4.1.3.1 MIA

The Glendell MIA will be mined through early in the life of the Project. Glendell MIA options considered are discussed in **Table 4.2**

Table 4.2 Options analysis for different MIA options considered

Option	Benefits/Opportunities of Option	Constraints of Option
Retain existing Glendell MIA	Avoid need for construction of new MIA and heavy vehicle access road.	Existing MIA is located immediately north of current progression of Glendell Pit. Retention in current location would prevent progression of mining from Glendell Pit into the Glendell Pit Extension area and result in sterilisation of coal resources and reduce the mining efficiencies associated with continuing the current Glendell Pit to the north. Retention in current location would impose operational constraints associated with blasting (vibration impacts and exclusion zones for blasting within 500 m of the MIA).
Utilise Liddell MIA - requires construction of a temporary MIA that would also be used as a pre-start/muster area long term and for minor equipment maintenance activities	Avoids the need for a new MIA to be constructed. Optimises the use of existing infrastructure.	Liddell MIA does not become available for several years after a new Glendell MIA is required. This would necessitate a temporary MIA being constructed until the Liddell MIA becomes available. The temporary MIA would continue to be used for the life of the Project as a pre-start/muster area for the operational workforce and for carrying out minor equipment maintenance activities. Temporary MIA constructed on land identified as being Biophysical Strategic Agricultural Land. Operational considerations with managing 2 facilities. Likely to require some upgrade of Liddell infrastructure Requires the construction of a bridge over the relocated Hebden Road, Bowmans Creek and Main Northern Rail Line for heavy vehicles to move from the Liddell MIA to the Glendell Pit Extension. These construction works and ongoing presence of a bridge over Bowmans Creek may have impacts on Bowmans Creek, particularly during high flow events which would need to be managed.

Option	Benefits/Opportunities of Option	Constraints of Option
New MIA to north-west of Glendell Pit Extension	Can be constructed within time period which enables transition from current MIA to the new MIA. Can be custom built for proposed Project with incorporation of modern design principles and environmental controls. Located adjacent to section of proposed realignment of Hebden Road which facilitates access for employees and new plant arriving by road.	Requires construction of new facility. Constructed on land identified as being Biophysical Strategic Agricultural Land. Additional costs associated with management of potential subsidence impacts due to location over old Liddell underground workings. Location may require installation of flood levees to avoid inundation in extreme flood events (>100 year ARI).
Utilise Ravensworth East MIA	No increase in disturbance footprint. Optimises use of existing infrastructure.	Existing Ravensworth East MIA required for maintenance of equipment used for mining at Bayswater North Pit until approximately 2022. Facilities would require significant upgrade to cater for increased scale of Project relative to current requirements. The Ravensworth East MIA is located adjacent to Yorks Creek in an area upstream from the proposed Glendell Pit Extension. To manage potential inrush issues, this area needs to be filled and Yorks Creek realigned. This will require the demolition and rebuild of the MIA if this location is to be used. Temporary MIA facilities would be required while this is occurring.
Utilise Mount Owen MIA	No increase in disturbance footprint. Optimises use of existing infrastructure.	Mt Owen MIA required for maintenance of equipment used for mining at Mount Owen Mine until approximately 2037. Facilities would require upgrade to cater for increased scale of Project relative to current requirements.

The options of using the Mount Owen MIA, Liddell MIA (with temporary facilities during overlap period and as a pre-start/muster area for the operational workforce for the life of the Project) and a new MIA (or a combination of these options) remain under consideration. A preferred MIA strategy will be identified for the Project and the EIS will assess the impacts associated with the preferred strategy.

4.1.4 Yorks Creek Diversion Options

Four layout options for diverting Yorks Creek have been considered. Two options (Options 1 and 2) considered potential diversions to the north around the former Swamp Creek mine workings and into Bowmans Creek near its confluence with Stringybark Creek (refer to **Figure 4.1**). A further diversion option (Option 3) considered an alignment that runs south from the existing Mount Owen Mine Access Road, cuts through the Ravensworth East MIA site, and runs adjacent to the Glendell Extension Pit crest before tying back into Yorks Creek upstream of its confluence with Bowmans Creek. The proposed diversion alignment initially follows the alignment of Option 3 to the south, but instead of running adjacent to the proposed pit crest, the preferred alignment runs to the west where it cuts through an existing ridgeline before discharging into Bowmans Creek. These options are shown conceptually in **Figure 4.1.**

Options 1 and 2 were ultimately not progressed due to the scale of excavations required and difficulties associated with establishing natural systems within the large engineered cuttings. The southern diversion option (Option 3) provided potentially better grades for geomorphology and biodiversity than the preferred option, however the diversion alignment passes through an area of potential future mineable resources. The proposed alignment was considered to be preferable relative to the southern diversion option as there is a high likelihood that the Option 3 alignment would again require diversion if this resource was to be mined in the future. Option 3 also involves significant additional costs relative to the preferred option.

The preferred option was considered to provide the best balance between environmental and geomorphological objectives, costs and resource sterilisation.

The design of the preferred Yorks Creek diversion option is being progressed concurrently with the EIS studies and will have regard to the long term geomorphology and aquatic ecology objectives for the diversion.

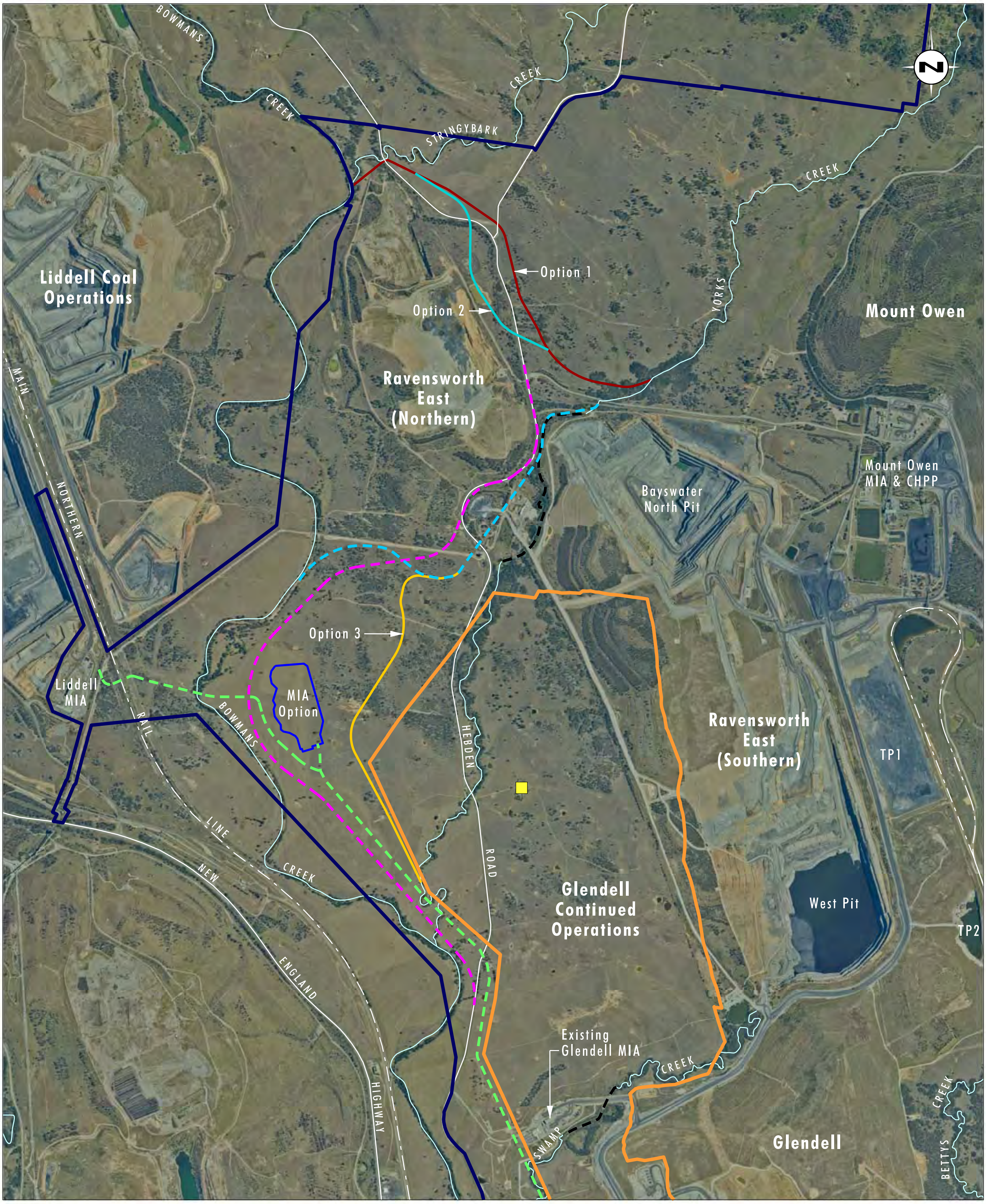


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)
Note: Ravensworth Homestead to be relocated

Legend

- Project Area
- Proposed Glendell Pit Extension
- Ravensworth Homestead
- New MIA Option
- Existing Creek Diversion
- Proposed Heavy Vehicle Access Road
- Proposed Hebden Road Realignment
- Proposed Yorks Creek Diversion

Alternative Yorks Creek Diversion Options:

- Option 1
- Option 2
- Option 3

FIGURE 4.1

Yorks Creek Diversion Alternatives

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4.1.5 Ravensworth Homestead Alternatives

The Project proposes to relocate the Ravensworth Homestead as described in **Section 3.11**. Other options for Ravensworth Homestead which have been considered include:

- Mine around Ravensworth Homestead. The Glendell Pit Extension avoids Ravensworth Homestead either by finishing south of Ravensworth Homestead or mining around the homestead with a distance buffer to minimise impacts to the Homestead.
- Demolish Ravensworth Homestead. The Project would remain as currently proposed, however the Ravensworth Homestead would be demolished to allow for mining to continue in the Glendell Pit Extension.

Table 4.3 summarises the key reasons for not pursuing the various options.

Table 4.3 Key reasons for not pursuing various options

Option	Benefits/ Opportunities of Option	Constraints of Option
Mine around Ravensworth Homestead	Avoids direct impacts on heritage item Avoids need to relocate homestead	In the long term the post-mining landscape will be further changed in such a way that the homestead would no longer retain any contextual relevance to its original, wider, heritage landscape setting and would remain isolated and inaccessible to the community while mining and rehabilitation activities are being undertaken. Effective sterilisation of readily accessible coal reserves to the north and west of Ravensworth Homestead. Shorter mine life and reduced local employment opportunities Reduced mine life would reduce economic benefits associated with project. Blast practices required to minimise impacts on homestead would add significant constraints to mining and/or present risk of structural damage to buildings. Constraints of utilising the homestead during the life of the mine may result in dilapidation of Homestead. Significant ongoing remedial works would be necessary to maintain the current condition of Ravensworth Homestead.
Demolish Ravensworth Homestead	Avoids need to relocate homestead	Complete loss of cultural and heritage values of the Homestead, including associated community values. Loss of locally listed heritage buildings (Singleton LEP) important in the story of the development of the Hunter Valley.
Dismantling and re-establishment post mining	Ongoing presence of the homestead is maintained on the property	The Homestead would be re-established on overburden spoil and the landform where the homestead would be rebuilt would be significantly altered as a result of mining associated with the Project. Ongoing settlement of overburden is likely to present technical challenges to the re-establishment of the homestead and may impose constraints on the future use(s) of the Homestead. The post-mining landscape will be changed in such a way that the homestead would no longer retain any contextual relevance to its original wider, heritage landscape setting and would likely remain isolated and inaccessible to the community. Ongoing remedial works to ensure conservation of Ravensworth Homestead. Dilapidation of Homestead if not maintained post re-establishment.

The options considered above have not been pursued as they do not provide a favourable outcome for the conservation of the Ravensworth Homestead for the benefit of the local and wider community and would come at significant economic cost due to implications for resource recovery, mine life and mine design. Leaving the Homestead *in-situ* and mining up to or around it would expose the homestead to impacts associated with blasting (such as vibration, fly rock) and dust. Additionally, if left *in-situ*, the complex would remain inaccessible to the community during the mining and rehabilitation phases and would be located in a post-mining landscape that would not resemble the pre-mining setting. The relocation of the homestead is considered the only viable option for the conservation of the structures.

4.2 Project Justification

The complicated tenure ownership arrangements in the area north of Glendell have historically prevented the optimal development of resources in this area. As discussed in **Section 1.0**, common ownership of mining titles and negotiated arrangements with JV partners who also hold interests in mining authorities in the areas of the Glendell Pit Extension has enabled the investigation of resources in the target area. These investigations have resulted in the development of the Project.

The Project will provide the following key benefits:

- maximising the coal resource recovery from the identified resource adjoining the existing Glendell Mine operation
- ongoing employment opportunities for the Glendell workforce for the life of the Project, with resultant significant flow on effects for the local and regional economy
- recovery of approximately 140 Mt of ROM coal
- an ongoing contribution to local, regional and state economies from an existing and well established mining operation
- payment of significant royalties to the State Government of NSW, and
- significant export earnings for Australia.

The Project is a logical continuation of the existing mining operations at Glendell Mine. The Project will extend the life of the operation and provide an opportunity for significant efficiencies to be achieved through the utilisation of existing infrastructure and experienced personnel, allowing for the economic recovery of coal resources. Importantly, the Project will increase employment opportunities associated with the mining operations at the Mount Owen Complex (between 300 and 600 FTE positions) relative to the alternative of mining ceasing at Glendell circa 2024 and North Pit (circa 2036-37). If mining of the target resource is delayed to a later date, the efficiencies in the Project associated with the continuation of mining from the Glendell Pit and the use of other infrastructure may not be available; this is likely to significantly impact on the viability of mining this resource in the future.

The Project also provides significant advantages in providing an integrated final landform design across both the existing approved and proposed mining areas as there will be no additional void as a result of the Project relative to current approved operations.

Significant design features have been incorporated into the preferred Project design to minimise potential environmental impacts associated with the Project.

Further detailed justification for the Project will be provided in the EIS, considering the potential environmental, social and economic impacts and benefits.

5.0 Stakeholder Engagement

5.1 Authority Engagement

The engagement process for the Project has commenced with initial briefing meetings held with relevant government agencies. These meetings introduced the Project, discussed the approvals process and sought feedback on relevant issues to be considered in the EIS. The following NSW Government agencies have been briefed on the Project:

- Department of Planning and Environment (DPE) – 2 meetings, November 2017 and March 2018
- Commonwealth Department of the Environment and Energy (DoEE) – December 2017
- Department of Planning and Environment, Resources Regulator (formerly Division of Resources and Geosciences (DRG)) – Conceptual Project Development Plan (CPDP) meeting - November 2017
- Singleton Council – 3 meetings (including one with Councillors), December 2017 (2) and April 2018 and
- Office of Environment and Heritage (OEH) – Heritage Division – March 2018

The next phase of the consultation process is the lodgement of this PEA with DPE. Following the lodgement of the PEA, DPE will provide the SEARs for the Project.

During the EIS preparation, the above agencies will continue to be consulted on Project details and impact assessment findings. Additional agencies to also be consulted for the Project throughout the preparation of the EIS include[4]:

- NSW Department of Primary Industries – Water (DPI-Water) – April 2018
- Office of Environment and Heritage – April 2018
- Environment Protection Authority (EPA) – April 2018
- Roads and Maritime Services (RMS)
- Department of Primary Industries, including Agriculture NSW and Fisheries NSW
- Subsidence Advisory NSW and
- Department of Industry – Lands and Water (Crown Lands)

5.2 Community and Other Stakeholder Engagement Process

The DPE has developed the *Social impact assessment guidelines for State significant mining, petroleum production and extractive industry development* (DPE, September 2017) (SIA Guidelines). The SIA Guidelines include stakeholder engagement expectations for the different phases of a project, including the Preliminary Environmental Assessment/scoping phase of the EIS process. A comprehensive Stakeholder Engagement Strategy has been developed for the Project having regard to the SIA Guidelines. The strategy identifies the potentially impacted people or groups and other stakeholders relevant to the Project, the methods of engagement to be used to most effectively engage with these stakeholders, the timing of consultation and the feedback mechanisms required.

[4] The EPA and OEH were approached for a briefing on the project prior to lodgement of the PEA.

In consulting with stakeholders, Glencore aims to:

- be proactive in its engagement with the community
- be transparent and honest in dealings with the community
- utilise a range of consultation methods so that all stakeholder interests are considered and addressed in a timely manner, and
- satisfy the requirements of the SIA Guidelines.

The stakeholders relevant to the Project will continue to evolve as the Project and assessment process progress, with some key initial stakeholders to be involved including:

- local landholders – including rural landholders and residents within Hebden, Camberwell, Middle Falbrook and Glennies Creek
- Hebden Road residents and road users such as Hebden Quarries
- community groups including the Mount Owen Complex Community Consultative Committee (CCC);
- environmental groups
- Registered Aboriginal Parties (RAPs) (refer to **Section 8.6**), Plains Clan of the Wonnarua People as the registered Native Title Claimant and other Aboriginal stakeholder groups
- service providers and infrastructure owners – TransGrid, Ausgrid, Australian Rail Track Corporation (ARTC), Telstra and RMS.

A variety of engagement mechanisms have been and will be utilised to consult with stakeholders to keep them informed and facilitate their input to the SIA, EIS and wider Project. These mechanisms are summarised in **Table 5.1**.

The consultation process for the Project will be undertaken in stages that align with the key milestones of the environmental and social impact assessment process. The key stages of the consultation process for the Project are outlined in **Table 5.2**.

Table 5.1 Key engagement mechanisms

Engagement/ Communication Mechanism	Description
Letters and Invitations	Developed when direct contact is required and can be tracked
Community Information Sheets	To provide updates on Project progress at key milestones with 3 to be prepared throughout the assessment process – 1) Project overview; 2) Project issues requiring assessment; 3) Summary of key SIA and EIA outcomes (impacts and management strategies)
Landholder-specific Information Sheets	To provide updates on Project progress and assessment outcomes to landholder impacted by a specific issue, as needed
Briefings – Internal and External	Informal and formal briefings e.g. 'tool box talks', project presentations
Tool box talks*	Short briefings provided to workforce, typically pre or post shift change
Workforce Communication Days*	Provide updates on the Project progress to the workforce and provide a forum of open discussion
Personal Interviews	Proactive contact and personal visits with near neighbours and key stakeholders to outline project activities. Personal interviews to be undertaken to identify Project issues and to inform project mitigation and enhancement
Ravensworth Homestead Advisory Committee (RHAC)*	Established as part of the Ravensworth Homestead Stakeholder Engagement Strategy and Plan. The Ravensworth Homestead Advisory Committee is facilitated by an independent chair and comprises representatives from the local community, and Singleton's business and heritage sectors[#]. The intent of the committee is to identify and investigate options for the relocation of the Ravensworth Homestead complex with consideration to preserving its heritage value, whilst also providing an end use that is economically sustainable and allows some form of on-going access
Mount Owen Complex and Integra Underground Mine CCC*	Established as part of the Mount Owen Complex and Integra Underground Mine operations. Provide information to the wider community
Collaborative Assessment Forums	Collaborative Assessment Forums with key stakeholders for key impact issues
Community Information Session	Informal interactive way to communicate the outcomes of the SIA and EIS studies to the local community. To be advertised through letter invitation to facilitate near neighbour and wider community involvement e.g. local hall/facility/location of interest.
VPA consultation	Discussions with Singleton Council regarding the preparation of a Voluntary Planning Agreement (VPA) for the Project
Formal Aboriginal cultural heritage assessment processes	Consultation with RAPS as per relevant assessment guidelines (refer to **Section 8.6**)
Website Updates	To be updated at key milestones with Project content and key outcomes

*Glencore established mechanism.

[#] Individuals from key sectors of interest were approached for involvement. Along with the Committee representatives as listed in Table 2.4; Singleton Council, the Singleton Heritage Committee, and Arts Upper Hunter were also approached seeking representation. However, each declined to nominate a representative.

Table 5.2 Engagement Mechanisms by SIA Phase

Phase	Assessment and Engagement Mechanism
Phase 1: Stakeholder Engagement Plan and Profiling	Engagement strategy development Preliminary Stakeholder analysis
Phase 2: Issue Scoping and PEA development	Personal meetings with potentially impacted landholders/ residents in proximity to the Project Open Day Key stakeholder meetings Community Information Sheet No.1 Tool box talks
Phase 3: Impact Assessment	Key stakeholder meetings Formal Aboriginal cultural heritage assessment processes Community Information Sheet No. 2
Phase 4: Mitigation Strategy Development (SIA/EIS)	Key stakeholder meetings Formal Aboriginal cultural heritage assessment processes Project briefings Open Day No. 2 VPA consultation with Singleton Council Collaborative Assessment Forums (if used)
Phase 5: Reporting	Key stakeholder meetings Formal Aboriginal cultural heritage assessment processes Community Information Sheet No. 3 – EIS/SIA Summary Landholder-specific Information Sheets as required Community Information Session Workforce Communication Day
Phase 6: Monitoring and Management (Post SIA)	Social Impact Monitoring and Evaluation Plan

The matrix below (refer to **Table 5.3**) outlines the mechanisms which may be utilised to engage and communicate across the various stakeholder groups.

Table 5.3 Mechanisms by Key Stakeholder Group Matrix

Stakeholder Group	Letters and Invitations	Project Info Sheets	Landholder-specific Info Sheets	Project Briefings	Tool Box Talks	Workforce Communication Days	Personal Interviews	Community Info Session	Open Days	Collaborative Assessment Forums	VPA Consultation
Highly Interested/ Impacted Neighbours/ Tenants											
Internal Stakeholders											
State Government Agencies											
Commonwealth Agencies											
Singleton Council											
Local Community											
Education and Community Groups											
Environmental / Interest Groups											
Historical Interest Groups											
Business and Industry Groups											

Note: Registered Aboriginal Parties will also be consulted outside of this process via the Aboriginal Cultural Heritage Assessment (refer to **Section 8.6**).

5.3 Community and Stakeholder Engagement Undertaken

Appendix A is the SIA – Scoping Report; this report identifies the consultation undertaken to date and includes a summary of the key issues identified by Stakeholders and the results of Phases 1 and 2 of the SIA Process.

Table 5.4 summarises the stakeholders contacted and those who have participated in the scoping phase.

Table 5.4 Engagement statistics – Scoping phase

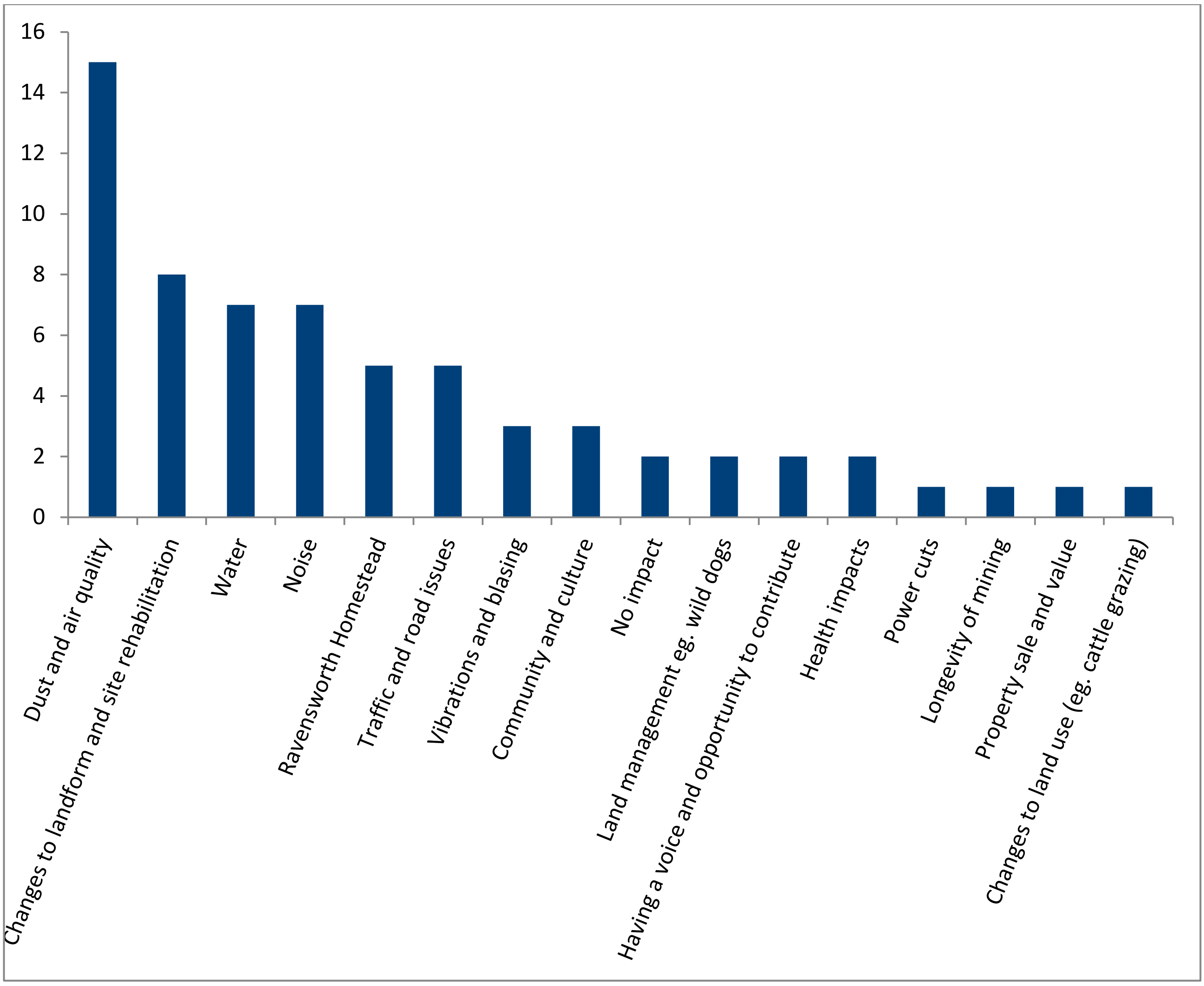
Stakeholder Group	No. contacted	No consultations (interviews/focus groups. Undertaken)	No. participants in interview or focus group^	No. declined	No. requesting information be sent	No. unable to be contacted and materials mailed
Proximal Landholders	50	20	32	6	3	21
Service Providers (in the local area)	2	1	1	1	-	-
Businesses (in the local area)	2	2	4	-	-	-
Singleton Business Chamber Committee members	7	1	7	-	-	-
Aboriginal Groups	4	4	4	-	-	-
RHAC Members	6	6	6	-	-	-
Heritage stakeholders	13	2 focus groups	13	-	-	-
TOTAL	**84**	**36**	**67**	**7**	**3**	**21**

^Interview responses may reflect the views of two or more people interviewed in a group setting

As noted in **Section 5.3**, personal interviews and surveys were undertaken with landholders, businesses in the local area, aboriginal groups and service providers.

A detailed interview guide was developed to direct stakeholder interviews and to address key aspects noted in the SIA guideline. Stakeholders' perceptions regarding the potential impacts associated with the Project were captured through these interviews. Landholders, aboriginal group, local businesses and service providers in the local area were asked to identify (unprompted), their main issues or concerns in relation to the Project, with a range of issues noted. These issues have been collated and coded by impact theme and are presented in **Figure 5.5**.

The most frequently cited concerns raised by stakeholders in the scoping phase related to dust and air quality, particularly the cumulative effects of this impact across a number of mine sites in the area. Changes to land form and the importance of appropriate site rehabilitation were the next most common project concerns identified. These were followed by concerns about potential impacts on rehabilitation water (including concern about the potential diversion of part of Yorks Creek, potential pollution of water ways and the impacts on drinking water), noise, the potential relocation of Ravensworth Homestead, road access and traffic issues.



Note: Multiple responses allowed. Data is based on the responses of 29 surveys, 49 participants.

Figure 5.1 Perceived Potential Project Impacts (unprompted)

When prompted, participants again identified further impacts of dust/air quality, land management, and site rehabilitation and final landform in relation to the Project. Other issues of relevance included health and wellbeing, particularly stress/anxiety related to living with environmental impacts such as dust, the positive impact of employment, particularly given previous downturn in the mining sector. Lack of trust in the assessment process was also noted.

A level of concern was also indicated in relation to European cultural heritage impacts, particularly the proposed relocation of the Ravensworth Homestead, the part diversion of Yorks Creek, and surface and groundwater impacts more broadly.

In relation to the proposed relocation of part of Hebden Road, this was identified as a greater issue of concern to business operators and service providers. These stakeholders noted the importance of the new, diverted road being in place before closing off the old road and the need to ensure good access at all times in order to ensure business continuity and access for emergency services. Residents who regularly use Hebden Road noted the importance of the road diversion being managed in a way to minimise disruptions, as a result of road diversion and due to blasting, with the additional note that power cuts associated with mining and construction should also be minimised. Very few residents were concerned about the proposed additional 1.3 km length. The benefit of improved road infrastructure, consistent with the current Glencore-funded bypass over the rail line was also noted.

In addition, interviews and focus groups were undertaken with stakeholders with an interest in heritage and members of the Ravensworth Homestead Advisory Committee.

A detailed analysis of the results of the stakeholder engagement undertaken to date is contained in **Appendix A**. The views of stakeholders has also been considered in the identification of key issues for the Project (refer to **Section 7.2**).

6.0 Planning Considerations

6.1 NSW Approval Process

There are a number of legislative instruments in NSW which regulate the environmental impact of development. The primary instrument is the EP&A Act which regulates the environmental assessment and approval process for development in the State.

The Project will require development consent under Part 4 of the EP&A Act. Being development for the purpose of coal mining, the Project is declared to be a State significant development (SSD) under the provisions of the State Environmental Planning Policy (State and Regional Development) 2011 and is subject to the provisions of Division 4.7 of the EP&A Act. The development application will be lodged with the Planning Secretary of DPE. This Report supports the request for SEAR's for the EIS, which must accompany the development application for the Project.

All areas of the Project Area where the mining for coal is proposed is either subject to a mining lease or exploration licence under the *Mining Act 1992* (Mining Act), which relates to coal (Group 9). The written consent of the holders of all authorities within the area directly affected by the Glendell Pit Extension will be required to accompany any development application for the Project to satisfy the preconditions under section 380AA of the Mining Act.

6.1.1 Permissibility

The key features of the Project (refer to **Section 3.1**) are all located on land zoned RU1 – Primary Production under the Singleton Local Environmental Plan 2013 (Singleton LEP). With the exception of some existing offset areas associated with the Mount Owen Continued Operations Consent (which are zoned E3), the entirety of the Project Area is zoned RU1 – Primary Production (refer to **Figure 6.1**).

Open Cut Mining is permissible with development consent in the RU1 Zone. Additionally, clause 7 of the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (the Mining SEPP) provides that mining may be carried out, with development consent, on land where development for the purposes of agriculture or industry may be carried out. Agriculture is permissible in both zones.

The Project does not involve any works in the land zoned E3 that are not already approved under the Mount Owen Continued Operations Consent. Extensive agriculture is permitted with consent in the E3 Zone.

6.1.2 Gateway Process

Part 4AA of the Mining SEPP together with Clause 50A of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) provides for the implementation of the NSW Government's Strategic Regional Land Use Plans (SRLUPs). The 'gateway process' applies to Projects located on Biophysical Strategic Agricultural Land (BSAL) and Critical Industry Cluster Land (CIC land) (as defined by the regional mapping presented in the Mining SEPP) outside of existing mining lease areas. A project that triggers the gateway process must obtain a Gateway Certificate.

The parts of the Potential Additional Disturbance Area where mining leases may be required (Verification Area)[5] includes land identified by the relevant maps in the Upper Hunter SRLUP as BSAL. No land is identified as being a CIC within the Project Area and the nearest CIC is located approximately 15 km from the Project Area. Fieldwork undertaken in accordance with the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) (Interim Protocol) has identified that the area of BSAL within the Verification Area is more restricted than is mapped in the Upper Hunter SRLUP. The location of the BSAL mapped under the SRLUP and the BSAL verified by fieldwork is shown in **Figure 6.2** and discussed in further detail in **Section 7.1.2**. Approximately 40.4 ha of identified BSAL is located within the Verification Area.

Due to the potential for the Project to involve components that will require a new mining lease which could cover areas of identified BSAL, a Gateway Application will be lodged in relation to the Verification Area (refer to **Figure 6.2**).

6.1.3 Other State Approvals

Other approvals that will be or are likely to be required for the Project include:

- a mining lease(s) under the Mining Act for aspects of the Project requiring a mining lease
- a variation of existing EPL(s) under the *Protection of the Environment Operations Act 1997* (POEO Act) (note that EPLs are already held in relation to each of the existing mining operations at Glendell and Mount Owen)
- consent under section 138 of the *Roads Act 1993* (Roads Act) for works associated with the realignment of Hebden Road and applications under Part 4 of the Roads Act for closure of roads
- *Crown Lands Act 1989* approval for works and mining in Crown Land
- an approval under section 22 of the Coal *Mine Subsidence Compensation Act 2017* and
- licensing of water allocations under the WM Act (note that licences are already held by Mount Owen for the existing mining operation and Glencore hold a large number of licences authorising surface and groundwater take in Water Sharing Plans relevant to the Project).

[5] Mining leases are only required for mining and designated ancillary mining activities (refer to Sections 5 and 6 of the *Mining Ac 1992*). Mining leases will not be required over the whole of the Verification Area.

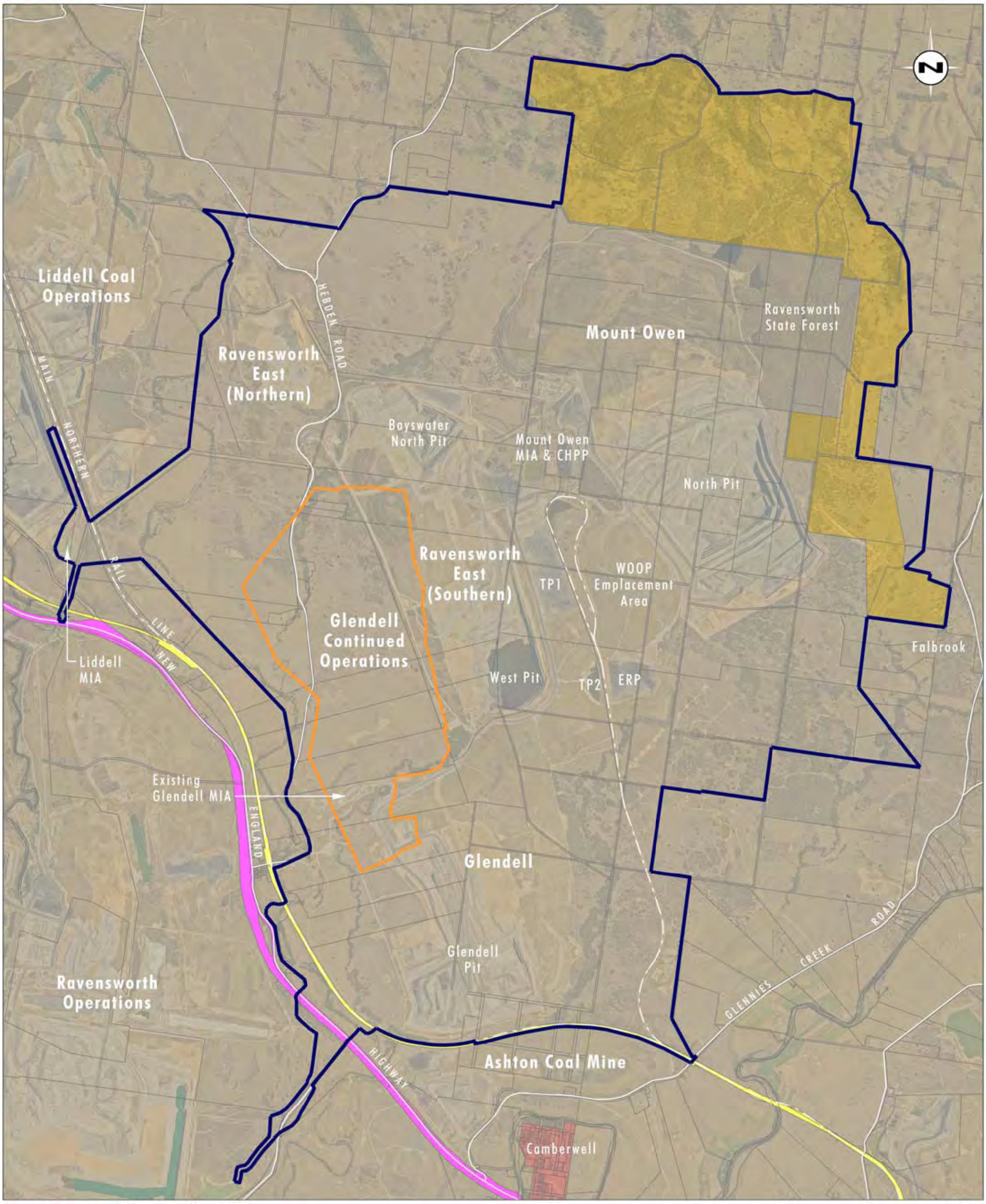


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018), Department of Finance, Services & Innovation (2017), Singleton LEP (2013)

0 1.0 2.0 3.0km
1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- E2 Environmental Conservation
- SP2 Infrastructure Railway
- SP2 Infrastructure Classified Road
- R5 Residential
- RV1 Primary Production

FIGURE 6.1

Land Zoning Singleton LEP

File Name (A4): R01/4166_041.dgn
20180511 13.21

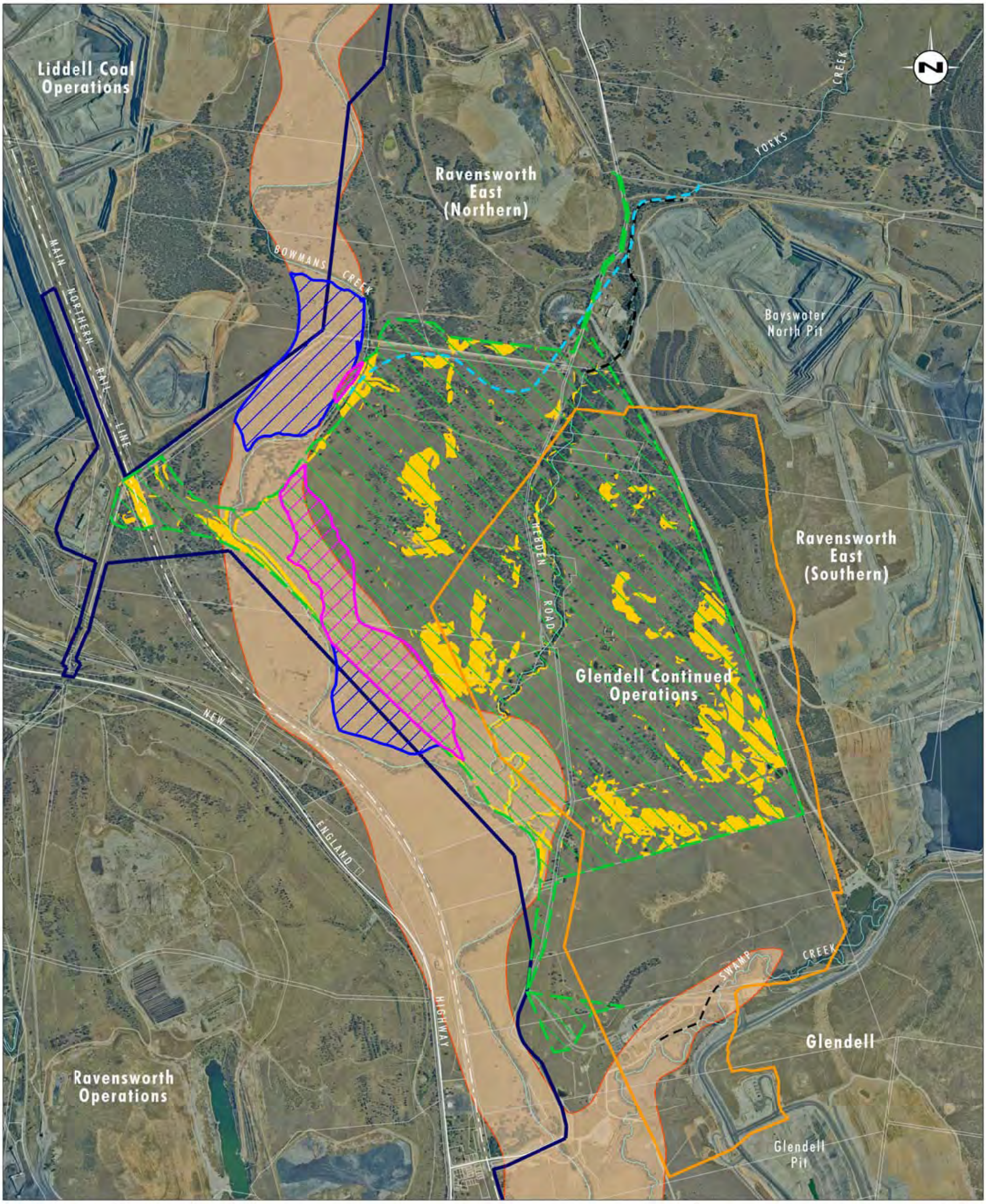


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017), NSW Department of Planning and Infrastructure (2013)

0 0.5 1.0 1.5km
1:30 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Verification Area
- Slope >10%
- Mapped BSAL Upper Hunter SRLUP
- Verified BSAL within Verification Area
- Contiguous BSAL
- Existing Creek Diversion
- Proposed York Creek Diversion

FIGURE 6.2

BSAL in Verification Area

File Name (A4): R01/4166_046.dgn
20180424 9.20

6.2 Commonwealth Approval Process

The EPBC Act prescribes the Commonwealth's role in the environmental assessment of impact, management and protection of areas of national environmental significance and biodiversity conservation. The EPBC Act is administered by the DoEE.

Under the EPBC Act the approval of the Commonwealth Minister for the Environment is required for any action that may have a significant impact on matters of prescribed national environmental significance (MNES). The MNES are:

- World Heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Threatened species and communities listed under the EPBC Act
- Migratory species listed under the EPBC Act
- Nuclear actions
- Marine areas or reserves
- A water resource, in relation to coal seam gas development and large coal mining development, and
- Commonwealth land.

The Project is a coal mining development that will interact with water resources and some listed threatened species and communities are known to occur, with others having the potential to occur within the Project Area. The Project will not have a significant impact on any other MNES. Aspects of the Project will be referred to the DoEE for a decision on whether or not it is a controlled action that requires approval under the EPBC Act.

A Strategic Assessment under Part 10 of the EPBC Act for the Project is currently progressing as part of the Upper Hunter Biodiversity Plan and associated Upper Hunter Strategic Assessment (UHSA). This is a joint Commonwealth and State assessment under Part 10 of the EPBC Act that will fulfil the ecological impact assessment requirements of the Project should the UHSA be finalised and the Upper Hunter Biodiversity Plan endorsed in time to include this Project. It is therefore requested that the SEARs include the ability for the proponent to use either Part 7 of the BC Act (refer to **Section 8.11**) or the UHSA/ Biodiversity Plan if it becomes available for the purposes of assessing the impacts of the Project on biodiversity.

Appendix A contains a summary of the stakeholder engagement process undertaken to date and an analysis of the issues raised in relation to the Project.

6.3 Native Title

While the Project includes development on a relatively small parcel of land that is Crown land, native title has been extinguished on all areas of Crown land that will require a mining lease or under the Mining Act or other approval. The provisions of the *Native Title Act 1993* therefore have no application to the Project.

7.0 Preliminary Environmental Assessment

7.1 Environment and Community Context

As discussed in **Section 3.0**, for the purposes of the PEA, the term Project Area refers to the study area which includes the project area for the Mount Owen Continued Operations Consent, the project area for the Glendell Consent and the additional area associated with the Project. The Potential Additional Disturbance Area associated with the Project (i.e. areas potentially disturbed which are not approved for disturbance or are already disturbed as a result of existing and historical development) is up to approximately 1050 ha (refer to **Figure 7.1**). Not all of this area will be disturbed as a result of the Project as a decision on the location of the MIA for the Project is yet to be finalised and areas within the Potential Additional Disturbance Area will remain undisturbed.

The key surface disturbing activities associated with the Project are:

- the Glendell Pit Extension
- Hebden Road realignment and associated construction laydown areas
- MIA heavy vehicle access road and works associated with the bridge over the realigned Hebden Road, Bowmans Creek and Main Northern Rail Line to Liddell Coal MIA (if required) and associated construction disturbance.
- new Glendell MIA or temporary MIA facilities pending use of Liddell or Mount Owen MIAs and associated construction laydown areas
- works associated with the realignment of the overland conveyor between Ravensworth East and Liddell Coal
- surface water management infrastructure including dams, channels and pipelines
- Yorks Creek Diversion
- final landform drainage (refer to **Section 3.10.2**) and
- upgrades to the WMS and GRAWTS infrastructure (refer to **Section 3.6.3**).

As discussed in **Section 3.3.1**, the in-pit overburden emplacement area will also extend beyond the Glendell Pit crest and Glendell Pit Extension crest to assist with final landform drainage and visual amenity.

As the Project is further defined during the EIS assessment process, a detailed proposed Project Disturbance Area will be defined to inform the assessment for the Project.

7.1.1 Topography and Drainage

The Project Area is situated centrally on the floor of the Hunter Valley (Central Lowlands) and occurs within the wider Hunter River catchment which covers approximately 22,000 km^2 of land bordered by the Liverpool Ranges, the Great Dividing Range, the Mount Royal Range and the Barrington Tops. The Project Area is situated approximately 87 km from the coast and 150 km from the western extremity of the Hunter catchment at the Great Dividing Range.

The Project Area is typical of the Central Lowlands of the Hunter Valley, which are characterised by undulating to low rolling hills formed on weak sedimentary rocks with low local relief (Kovac and Lawrie 1991). The topography of the Project Area is characterised by an undulating and hilly landscape extending to lower areas associated with the creek lines that traverse the Project Area. Elevations range between 70 mAHD in the south and 400 mAHD in the northern extent of the Project Area, north of Mount Owen Mine. The Glendell Pit Extension will affect land with elevations of between approximately 70 mAHD and 130 mAHD (excluding areas of the Ravensworth East emplacement areas impacted by the Glendell Pit Extension). The topography and key drainage lines in the Project Area are shown in **Figure 7.1**.

Approximately 18 km to the south of the Project Area are the dissected sandstone plateaus of Wollemi and Yengo National Parks, while approximately 30 km to the north, the foothills of the Barrington Tops and Mount Royal Range adjoin the Hunter Valley floor, which is bounded by the Hunter Thrust System (Peake 2006). To the east and west of the Project Area extend the highly eroded Permian lowlands of the floor of the Hunter Valley. The topography across the majority of the Project Area is generally flat to gently undulating with 0 to 5 degree slopes with the exception of Ravensworth State Forest and those steeper slopes created by the existing approved mining operations.

The Project Area is located within the Bowmans Creek catchment. Bowmans Creek is a tributary of the Hunter River. Mining in the proposed Glendell Pit Extension is primarily within two sub-catchments of Bowmans Creek, namely Yorks Creek and Swamp Creek. The Project will result in changes to the approved final landform which will also impact on Bettys Creek. The Project will not have any direct impacts on the Glennies Creek Catchment. Areas associated with the alluvial plains of Bowmans Creek, Yorks Creek, Swamp Creek and Bettys Creek are generally flat to gently sloping.

7.1.2 Soils

Detailed soil surveys within the Potential Additional Disturbance Area have been undertaken. The soil survey found six soil orders, namely Chromosol, Dermosol, Kandosol, Rudosol, Tenosol and Sodosol. Each soil order and detailed soil survey descriptions are presented in **Appendix B.**

The distribution of the identified soils in the Potential Additional Disturbance Area is shown in **Figure 7.2** Sodosol is the dominant soil order in the Potential Additional Disturbance Area, taking up almost 80% of the area. Tenosols cover approximately 13% of the area, while Chromosols can be found in approximately 2% of the Potential Additional Disturbance Area. The other soil types each occupy approximately 1% or less of the Potential Additional Disturbance Area. The soils associated with the Bowmans Creek, Yorks Creek and Swamp Creek Alluvium (Chromosols, Tenosols and Dermasols) are the more fertile soils in the Potential Additional Disturbance Area. These represent approximately 16% of the Potential Additional Disturbance Area.

The assessment for BSAL is only required to be undertaken within the parts of the Project Area where there is no mining lease covering all strata potentially affected by the Project (Verification Area - refer to **Section 6.1.2**). Five detailed test pit sites located in the Bowmans Creek upper floodplain terrace have been assessed as meeting the BSAL assessment criteria. The total area of BSAL within the Verification Area is approximately 40.4 ha, or 7% of the area under assessment. The majority of this BSAL area is situated to the east of Bowmans Creek, with a small parcel sited to the north of the creek (refer to **Figure 6.2**). This smaller BSAL area within the Verification Area occupies only 1 ha, and thus does not comply with the minimum size criterion of 20 ha, however, it is expected that the BSAL is continuous in the area outside but adjacent to the Project Area. Adjacent BSAL in the area outside of the Verification Area has been estimated based on the original SRLUP mapping and slope analysis.

umwelt

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)
Note: Contour interval 5m

0 1.0 2.0 3.0km
1:60 000

Legend
Project Area
Proposed Glendell Pit Extension
Existing Creek Diversion

FIGURE 7.1

Existing Landform

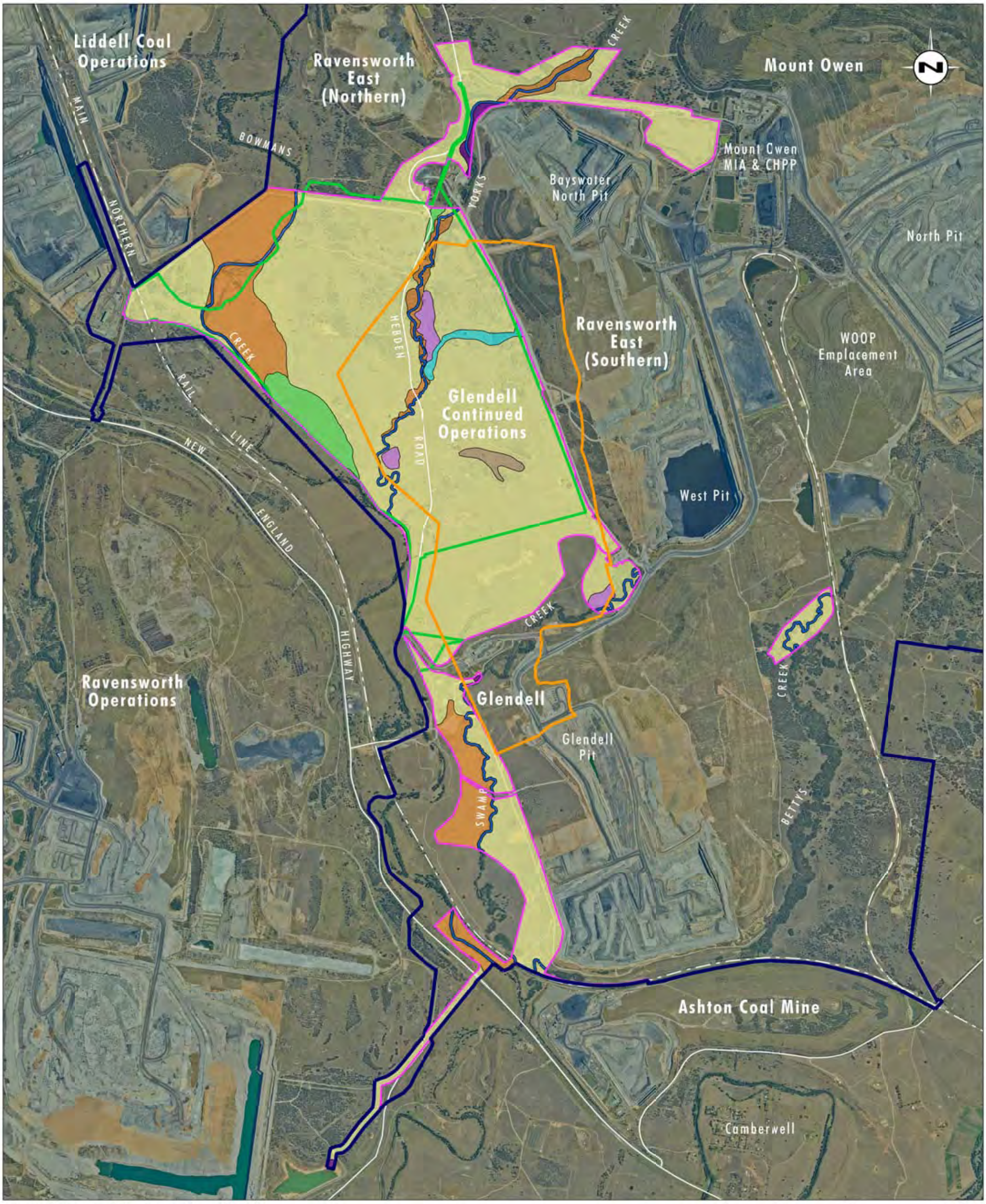


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)
Note: Cadastre data from Glencore (2017)

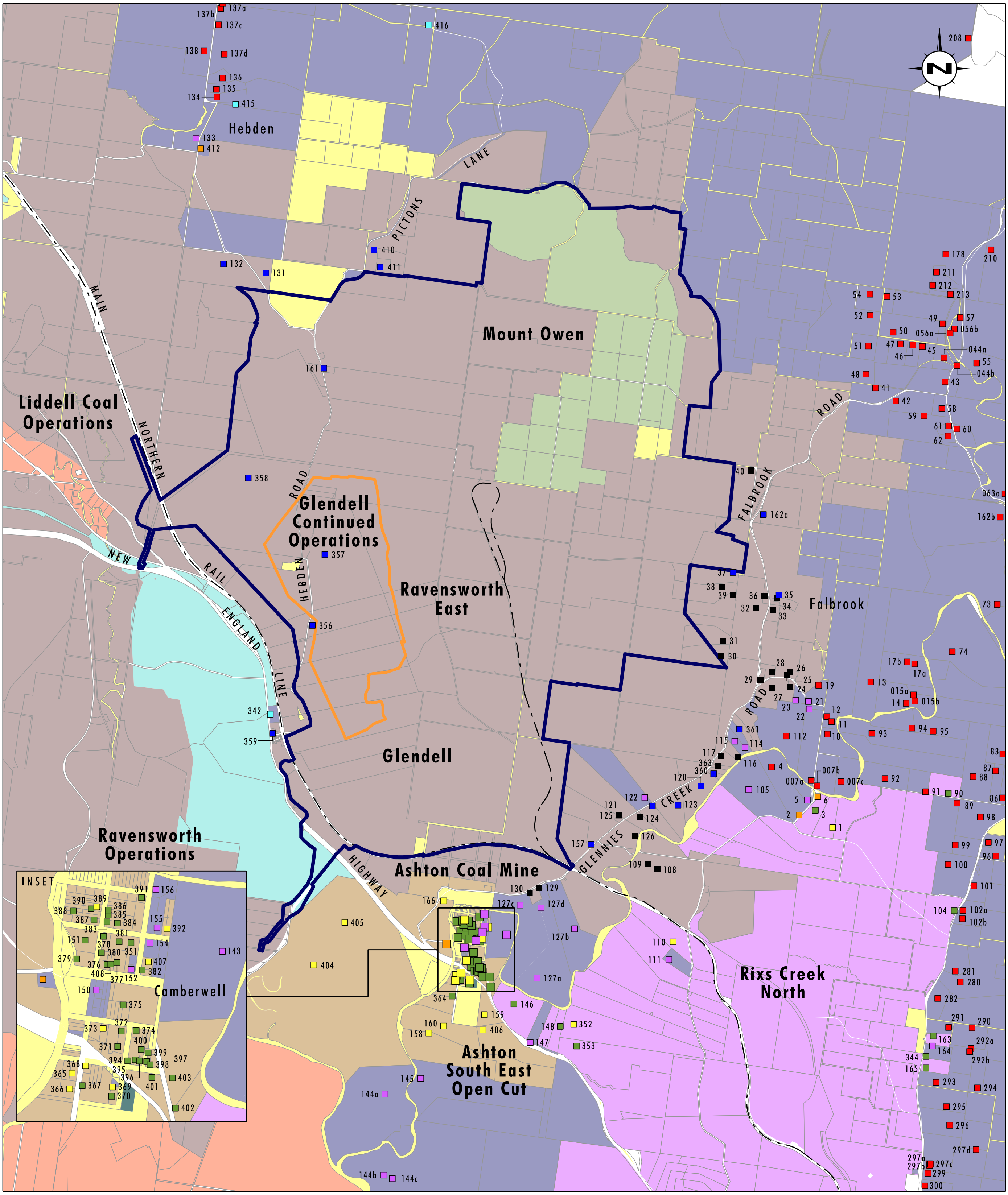
Legend

- Project Area
- Proposed Glendell Pit Extension
- Potential Additional Disturbance Area
- Proposed Verification Application Area (VAA)
- Sodosol
- Tenosol
- Rudosol
- Kandosol
- Chromosol
- Dermosol
- Creek Line
- Disturbed

FIGURE 7.2

Soils within the Potential Additional Disturbance Area

File Name (A4): R01/4166_045.dgn
20180515 16.28



Data Source: Glencore (2018), Department of Finance & Innovation (2017)

0 1 2 4km

Scale 1:90 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Ashton Coal
- Bloomfield Collieries
- Coal and Allied
- Crown Land
- Glencore
- Government Authority
- AGL Macquarie Pty Ltd
- Private
- State Forest
- Community Infrastructure
- Glencore Owned
- Glencore Owned - Vacant
- Other Mine Owned
- Other Mine Owned - Vacant
- Private
- Private - Subject to Acquisition Rights
- Private Infrastructure

FIGURE 7.3

Land Ownership

File Name (A4): R01/4166_039.dgn
20180515 14.01

7.1.3 Land Ownership

The land within the Project Area is owned by Glencore or associated entities with the exception of some Crown land, Ravensworth State Forest and the road reserve for Hebden Road for which Singleton Council is the Roads Authority. A small parcel of Crown land is located within the proposed Glendell Pit Extension area. A claim under the *Aboriginal Land Rights Act 1983* has been lodged over this parcel of Crown Land. Land ownership in the area is shown in **Figure 7.3.**

The schedule of Lands for the Project is provided in **Appendix C.**

7.1.4 Land Use

The land uses within the Project Area and surrounds is dominated by mining operations. Glencore operates the Mount Owen Complex, Integra Underground operations to the south-east, Liddell Coal Operations to the north-west and Ravensworth Surface Operations to the south-west (refer to **Figure 7.3**). Ashton Coal Mine is located to the south of the Project Area while Rix's Creek North is located to the south-east of the Project Area (refer to **Figure 7.3**).

Other land uses within the surrounding area include grazing and rural residential holdings and the Hebden and Wild Quarries to the north-west of the Project Area. The Bayswater and Liddell Power Stations are located further to the west of the Project Area. With a variety of landscapes and climates, the Upper Hunter region supports a diverse range of agricultural industries. Similarly, Singleton and Muswellbrook LGAs have a long history of agricultural land use, particularly in regard to cropping and grazing. Cropping within the Project Area and immediate surrounds 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.

Where not used for mining related activities, land owned by Glencore and its subsidiaries within and surrounding the Project Area is utilised for cattle grazing and rural residential leases (subject to environmental conditions). The cattle grazing operations are currently managed and operated by Colinta Holdings Pty Limited, a Glencore subsidiary. The small area of Crown land located within the proposed Glendell Pit Extension is occasionally leased for (generally) short term grazing uses.

There are a number of rural localities within proximity to the Project Area including Hebden to the north, Goorangoola to the north-east, Falbrook and Middle Falbrook to the east and south-east (refer to **Figure 1.1**). Camberwell (refer to **Figure 1.1**) is located approximately 1 km from the southern boundary of the Project Area where the majority of the existing residences are mine owned or have acquisition rights under approved mining development consents. Other rural residential land holdings are present within the surrounding area. These are predominantly located to the south-east of the Project Area (refer to **Figure 7.4**).

The Ravensworth State Forest is located in the north-eastern corner of the Project Area, the New Forest area is located to the north of the Project Area and the Southern Remnant Offset is located between the existing North Pit and the Mount Owen MIA. Surrounding these State Forest areas is the existing Mount Owen Biodiversity Offset Areas (refer to **Figure 7.3**). Adjoining the State Forest to the south is a Travelling Stock Reserve (TSR89694) managed by the NSW Local Land Services (LLS). There are no direct impacts on Ravensworth State Forest, existing Offset Areas or the TSR as part of the proposed Project.

The Potential Additional Disturbance Area is currently used for low intensity grazing. Approximately 40.4 ha of land within the Potential Additional Disturbance Area have been identified as being BSAL (refer to **Section 7.1.2**). The identified BSAL is located on alluvial flats associated with Bowmans Creek.

7.2 Key Issues

A Preliminary Risk Assessment has been prepared for the Project and is attached as **Appendix D.** The Risk Assessment has included consideration of project specific and cumulative impacts. The identification of issues for consideration has been informed by the draft Scoping Tool prepared for the SIA Guidelines and draft guidelines on Scoping an EIA prepared by DPE (DPE, 2017).

The consideration of stakeholders' views obtained from consultation undertaken to date (refer to **Appendix A**) was also considered in the identification of key issues.

Key issues are issues where there is a reasonable likelihood that the Project will have a material impact on the matter, and detailed assessment is required to fully understand such impacts and identify project-specific mitigation. Based on the Preliminary Risk Assessment, the issues with a medium or high risk ranking have been identified as being key issues requiring detailed assessment as part of the EIS to be prepared for the Project:

- acoustic amenity (noise and blasting)
- air quality (predominantly particulate matter but also potential impacts associated with blast emissions)
- water resources:
  - groundwater
  - surface Water
- historic heritage, including archaeology (predominantly Ravensworth Homestead but also potential blasting impacts on other heritage items in the area including the former Chain of Ponds Inn and Ravensworth Public School)
- Aboriginal cultural heritage
- visual amenity
- biodiversity (impacts associated with vegetation removal, diversion of Yorks Creek)
- land use (impacts on soils and topography and land use, including impacts associated with final landform)
- traffic and road access
- greenhouse gas
- social impacts
- economic impacts

The above issues were identified based on consideration of the Project's potential to impact on the community and environment.

The scopes of the assessments to be undertaken for these issues as part of the EIS are discussed in **Section 8.0**.

7.3 Other Issues

''Other Issues" are issues where the Project is:

- unlikely to have a material impact on the matter (either as a result of the Project directly or cumulatively) or
- the measures to manage the impact are well understood and routinely used on similar projects and
- there is no significant stakeholder concern regarding the matter and the Project.

"Other Issues" typically do not require a detailed stand-alone assessment and can be dealt with in the main text of the EIS and/or as components of key issue studies. **Section 9.0** address the matters which, based on the Preliminary Risk Assessment (refer to **Appendix D**), are considered to be 'Other Issues' for the purposes of the Project. It is proposed that these matters will be dealt with as sections of the EIS and/or other specialist studies for key issues.

8.0 Key Environmental and Social Issues

The following sections detail the approach to the assessment of key issues for the Project (refer to **Section 7.2**). The EIS will include specialist reports addressing each of these issues, which have generally been identified as issues for consideration by at least some stakeholders in the engagement process undertaken to date. Stakeholder consultation and submissions received on the recent Mount Owen Continued Operations Project and consultation undertaken for the Mount Owen Continued Operations Modification 2 Project has also been considered in the identification of these being key issues for the Project.

8.1 Noise

The Project is located in an area with a number of mines contributing to the noise levels experienced at nearby receivers, particularly around the Camberwell and Falbrook areas. The Project will include overburden emplacement activities higher than current operations and these have the potential to result in higher noise levels being experienced at certain locations. The Project will result in operations at Glendell moving away to the north from Camberwell but towards the Hebden area (refer to **Figure 1.1**). While the intensity of operations at Glendell will increase as production rates increase, there will be a corresponding reduction of activity within Bayswater North Pit and North Pit.

A comprehensive noise impact assessment will be undertaken for the Project in accordance with the NSW Noise Policy for Industry (EPA, 2017) (NPfI). The noise impact assessment will include:

- a review of noise monitoring data and previous noise assessment undertaken for the existing operations at the Mount Owen Complex and recent assessments for the Mount Owen Continued Operations Project and Mount Owen Continued Operations Modification 2 Project
- a review of the Project-noise trigger levels in light of the NPfI
- predictive noise modelling of the Project
- processing of model results into suitable contour plots and summary tables including any predicted exceedance data
- assessment of modifying factors related to low frequency and tonal noise, and assessment of potential for sleep disturbance
- consideration of feasible and reasonable noise mitigation strategies
- an overview of the cumulative noise impacts from the Project, the approved Mount Owen Continued Operations Project and Mount Owen Continued Operations Modification 2 Project and other relevant adjacent mining and nearby industrial operations
- consideration of the NSW Voluntary Land Acquisition and Mitigation Policy
- an assessment of the road traffic noise impact in accordance with relevant assessment procedures based on the traffic movements associated with the extension of the mine life as a result of the Project, and
- an assessment of construction noise impacts (including associated traffic noise).

The noise impact assessment will be independently peer reviewed as part of the preparation and finalisation of the assessment.

8.2 Blasting

Blasting will be undertaken on a regular basis for both overburden removal and coal extraction.

The EPA sets guidelines for blasting based on human comfort levels and potential damage to structures. The guidelines have been adapted from the Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (ANZECC 1990) (ANZECC Blast Guidelines).

Further to the ANZECC guidelines, vibration criteria are also required for infrastructure within the surrounding area so that potential impacts can be managed. The relevant criteria for blasting vibration on infrastructure such as power lines, bridges and roads will be determined in consultation with relevant agencies and/or the infrastructure owner and by reference to relevant Australian and International Standards.

As with existing operations, blasting will be managed to meet specific impact criteria set by the guidelines and other criteria adopted to manage potential impacts from blasting on other structures not covered by the ANZECC Blast Guidelines. A comprehensive blast assessment will be undertaken as part of the EIS to identify how blasts are to be managed at the operations to ensure the relevant criteria under the ANZECC Blast Guidelines and other standards are met.

Modelling of blasting impacts (vibration and overpressure) will be undertaken to identify any potential impacts as a result of the Project on surrounding residences, the Integra Underground Mine, existing and proposed infrastructure and any sensitive environmental features and heritage items (including Ravensworth Homestead for the period it will remain *in situ* prior to relocation). This modelling will be used to identify any updates that may be required to the existing site blasting rules to provide for blasting impacts to be appropriately managed.

The Blast Assessment will also include an assessment of exclusion zones during blasting and associated impacts. Hebden Road and parts of the proposed realignment of Hebden Road will be located within 500 m of areas where blasting will occur in the Glendell Pit Extension. Sections of road within 500 m of any blast will be required to be closed to manage potential risks associated with flyrock. The Blast Assessment will include consideration of measures to mitigate the impact of road closures on road users.

8.3 Visual Amenity

The Mount Owen Complex is located within a rural environment in close proximity to several other mining operations. The character of the immediate visual environment of the Mount Owen Complex is strongly influenced by the existing mining operations. The proposed in-pit overburden emplacement area associated with the Glendell Pit Extension is likely to be a visually prominent feature for vehicles traveling along the New England Highway. The in-pit emplacement area and Heavy Vehicle Access Road will also be immediately adjacent to sections of the realigned section of Hebden Road. The increased height of overburden emplacement areas associated with the Project is likely to result in increased visibility at some residences, all of which currently have visual impacts associated with existing operations at Mount Owen Complex or other operations.

A detailed visual assessment will be undertaken using a combination of digital terrain modelling, view-shed analysis and the preparation of photomontages to determine any potential viewing locations and assessment of the potential impacts at these locations as a result of the Project. The approach to visual assessment undertaken in the EIS will be to assist key stakeholders in establishing informed opinions regarding the likely impacts. The photomontages will include an image of the current view from pre-determined (representative) viewing locations and an image representing what the view will be from each viewing location at various stages of the Project. This approach has been effective in communicating the nature of likely impacts for similar Projects and will be used in targeted consultation with potentially impacted residents as well as community forums such as the CCC and the information sessions planned prior to submission of the EIS.

Where impacts are identified, the need for visual management and mitigation measures will be considered and assessed. Key mitigation measures will be similar to those currently implemented as part of the Mount Owen Complex operations and include roadside vegetation planting, progressive rehabilitation and development of an appropriate landform that incorporates natural landform design principles.

8.4 Traffic and Transport

The local road network within the vicinity of the Project includes the New England Highway, Hebden Road and the Old New England Highway (should Liddell Coal be used as the MIA for the Project). Traffic associated with the current Glendell Mine accesses the site via a dedicated access road from Hebden Road, situated approximately 2 km from the New England Highway and Hebden Road intersection.

As discussed in **Section 3.8**, the Project includes realignment of an approximately 5 km section of Hebden Road to accommodate the proposed Glendell Pit Extension and Yorks Creek Diversion. Mount Owen is currently constructing new dual lane bridges on Hebden Road over Bowmans Creek and the Main Northern Rail Line, approved under the Mount Owen Continued Operations Consent. These works are planned be completed prior to the commencement of the Project.

The Project will not result in any increase in the operational workforce at the Mount Owen Complex, however, the transition of workforce from Mount Owen to the Glendell Mine as mining ceases in the Bayswater North Pit and then the North Pit may alter the traffic movement along different sections of Hebden Road and at MIA intersections. The Project will also extend the life of operations at the Mount Owen Complex. These changes may affect traffic flows at different intersections on Hebden Road and the Old New England Highway at different stages of the Project. Construction work associated with new infrastructure (refer to **Section 3.12**) will also result in higher traffic flows during construction periods.

A traffic impact assessment will be completed as part of the EIS for the Project to assess the impacts of these changes. The traffic impact assessment will include:

- a review of existing traffic count data for the nearby or potentially affected road network
- an assessment of the existing road network that will be used in the construction and operation phases. This will include road widths, intersection treatments, compliance with current standards, existing traffic volumes and vehicle classification using the road network
- an assessment of the adequacy of intersections and the general traffic routes to accommodate the proposed increase in vehicle numbers during construction, and
- assessment of the traffic and transport impacts during both the construction and operational phases of the Project including:
    - level of service on the road network
    - impacts of the Project on the road network and travel times, including the proposed realignment of Hebden Road, and impact of road closures due to blasting
    - physical condition of the roads related to the Project including capacity of the networks
    - potential road safety issues

- potential cumulative impacts associated with any other approved mining and/or other projects in the area, and
- identification of any impact mitigation measures required.

As discussed in **Section 3.6**, the Project will not result in any changes to the approved capacity of the Mount Owen rail loop or changes to the approved volume of coal moved through this facility. The assessment of train movement impacts will therefore be limited to the extended life of the rail loop.

8.5 Historic Heritage

Historic heritage is commonly used to describe heritage that is not Aboriginal heritage (although many historical heritage places have Aboriginal associations and values) and can include buildings, structures, archaeological sites/relics, works (roads, bridges etc.), precincts/conservation areas, rural landscapes and movable items.

The potential impacts of the Project on historical heritage items will be considered as part of the EIS. Based on existing knowledge of the area and the current layout of the Project, the key known heritage feature that will be impacted by the Project is the Ravensworth Homestead (refer to **Figure 3.1**), which was constructed in the 1820s. The Ravensworth Homestead is listed as a local heritage item under the Singleton LEP. The wider Ravensworth property is also of importance to the local Aboriginal community due to its association with early conflict between Colonial settlers and the Aboriginal people who resided in the area. A number of other known heritage structures occur in the vicinity of the Project including the former Chain of Ponds Inn and Ravensworth Public School.

The Project includes the relocation of the Ravensworth Homestead to an as yet unidentified location. The intent of the relocation is to conserve the physical structure whilst providing improved accessibility to the Homestead. As discussed in **Section 5.0**, the Ravensworth Homestead Advisory Committee has been established to identify and investigate different relocation and end-use options for the Homestead. The site and end-use identified for relocation will be selected based on it being able to ensure the long term preservation of the structure, preferably through beneficial reuse, whilst maintaining the heritage fabric as best as practicable, and also being accessible to the public.

The historic heritage assessment for the Project will be prepared in accordance with the relevant professional standards and guidelines, including the *NSW Heritage Manual 1996, Archaeological Assessments and Assessing Heritage Significance* and with consideration of the principles contained in the *Burra Charter: the Australia ICOMOS Charter for Places of Cultural Significance*. The assessment will consider the Project's impacts on the Ravensworth Homestead and any other heritage items identified as being potentially impacted by the Project.

The assessment will include the following:

- historical research focusing on any areas identified with potential historical heritage or archaeological significance. The research may include archival research in the State Library of NSW, State Records, Regional Libraries, a review of Singleton Council records and maps (if available) and a review of any available air photographs and parish maps
- consultation with local historical societies where appropriate
- consultation with former landholders (and, in the case of Ravensworth Homestead, former owner/s)
- targeted historical land title searches to identify any areas of high historical heritage or archaeological potential

- survey of the proposed disturbance area to identify any potential historical heritage items
- preparation of a detailed historical and archaeological context, in which to assess the significance of any potential historical archaeological resource or heritage item present within the proposed disturbance area
- preparation of an assessment of the significance of any identified relics and/ or sites in the proposed disturbance area, according to established significance assessment criteria outlined by the Heritage Branch, OEH Assessing Heritage Significance guidelines
- preparation of a Conservation Management Plan, and
- preparation of a Statement of Heritage Impact indicating the likely effect of proposed works on any potential historical archaeological resource or heritage item identified or previously known within the proposed disturbance area and whether further management/investigation is warranted.

The OEH Heritage Division and Heritage Council of NSW will be consulted throughout the preparation of the EIS on the status of investigations regarding Ravensworth Homestead and the potential adaptive reuse options considered and identified by the Ravensworth Homestead Advisory Committee.

8.6 Aboriginal Cultural Heritage and Archaeology

A comprehensive Aboriginal Cultural Heritage Assessment (ACHA) was prepared for the Mount Owen Continued Operations Project in collaboration with the Registered Aboriginal Parties (RAPs) and Knowledge Holder groups to assess the Aboriginal cultural heritage values of the Mount Owen Continued Operations Consent project area. This ACHA also captured values associated with areas outside the Mount Owen Continued Operations Consent project area, including values associated with Bowmans Creek. Aboriginal Archaeological investigations were also undertaken in relation to previous approval processes for the current Glendell Mine. The ACHA and past archaeological studies indicate the wider regional cultural landscape surrounding the Project Area holds high cultural and historical significance to Wonnarua people. The ACHA for the Mount Owen Continued Operations Project also identified management measures developed in consultation with the RAPs and Knowledge Holder groups. These management measures include on site measures to further investigate and manage identified sites, in addition to off-site cultural heritage initiatives to enhance cultural heritage values and knowledge.

The landscape within the Project Area is highly disturbed and fragmented, resulting in much of the past archaeological record already having been lost due to previous agriculture and coal mining. The archaeological sites investigated in accordance with the previous development applications and post consent processes for the Mount Owen Continued Operations Project and the Glendell projects were found to be of low and low-moderate archaeological significance. Consistent with other areas in the Hunter Valley, alluvial terraces associated with creeks were identified as areas having the highest density of Aboriginal artefacts.

Figure 8.1 shows the location of previously recorded Aboriginal sites in the local area, including sites salvaged or destroyed as part of past approved mining activities.

umwelt

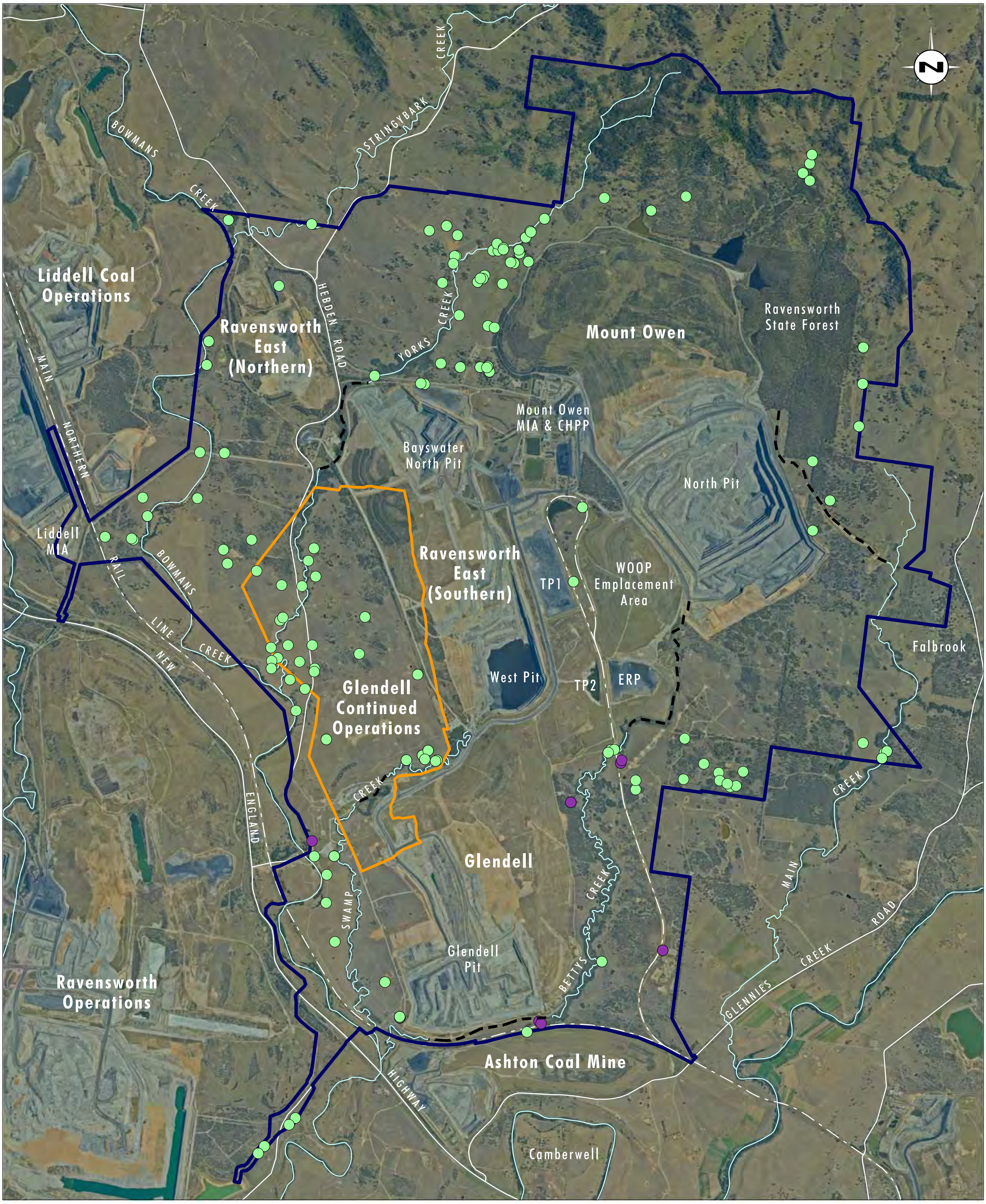


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018), AHIMS (2018)

0 1.0 2.0 3.0km
1:60 000

Legend
- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversion
- Partially Salvaged Site
- Valid Site

FIGURE 8.1

Aboriginal Sites Recorded within the Project Area

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20180515 13.59

The Potential Additional Disturbance Area includes areas known to contain Aboriginal sites due to previous archaeological survey work undertaken at the site. The Project will impact both known Aboriginal sites and unidentified Aboriginal sites and areas of cultural heritage value.

A detailed consultation, engagement and survey process will be undertaken with the Aboriginal community to identify the cultural significance of the areas to be impacted by the Project, including the Potential Additional Disturbance Area. This process will be undertaken in accordance with the *National Parks and Wildlife Act 1974 (NSW)* and the following guidelines to facilitate the development of an Aboriginal Cultural Heritage Assessment Report (ACHAR):

- Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (DECCW 2010)
- Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (DECCW 2010a)
- Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW (DECCW 2010b), and
- Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW (OEH 2011).

The preparation of the ACHAR will also include an Aboriginal archaeological values assessment for inclusion in the EIS.

The formal process of identifying and engaging with RAPs commenced in December 2017; 27 individuals and groups have registered an interest in the Project.

As part of the archaeological and cultural heritage study, a comprehensive field survey will be completed by archaeologists, including field assistance by Aboriginal stakeholders. The fieldwork methodology has been distributed to RAPs for comment and the field survey commenced in early April 2018.

The ACHAR will focus on the Potential Additional Disturbance Area only and will be compiled with detailed input from Knowledge Holder groups and in consultation with the RAPs. The assessment will outline areas and places of cultural significance in addition to any potential impacts associated with the Project. The archaeological assessment report will be integrated with the cultural heritage assessment report, both of which will outline mitigation and management measures proposed to be implemented on site, in addition to a consideration of cultural heritage conservation outcomes. Any sensitive information identified by the Knowledge Holders/RAPs will be provided as separate confidential information with distribution restricted to Glencore and relevant government agencies. The ACHAR will build upon the comprehensive assessment of the parts of the Project Area considered in the ACHAR for the Mount Owen Continued Operations Project.

8.7 Social Impact

As noted in **Section 5.2**, SIA Guidelines have been developed by DPE. Part 3 of the SIA Guideline outlines expectations, requirements and performance objectives for the Scoping (PEA) phase of the EIS process with respect to social considerations and stakeholder engagement. **Section 5.3** contains a summary of the stakeholder engagement process undertaken to date and **Appendix A** contains a detailed analysis of the issues raised in relation to the Project. Stakeholder views and attitudes towards the Project obtained through the Issues Scoping Phase (refer to **Sections 5.2** and **5.3** and **Appendix A**) will be used to inform the engagement strategy and refine the project design during the EIS phase to mitigate (and, where possible, avoid) adverse social impacts associated with the Project.

A comprehensive Social Impact Assessment will be undertaken for the EIS and will further assess and predict the likely consequences and opportunities of the Project in social terms. The SIA will have regard to the SIA Guidelines and will include:

- a social baseline study
- predictions and analysis of the extent and nature of the social impacts, both negative and positive
- an evaluation of the significance of the social impacts, and identification of residual negative social impacts
- recommended mitigation measures for significant negative social impacts and enhancement measures for significant positive social impacts and
- a recommended monitoring and management framework.

The approach to the SIA will include:

- **Profiling** so that the social context of the Project is well understood – including analysis of post impact/historical studies, relevant stakeholders, social indicators, media releases, secondary data and employee/contractor profiles.
- **Scoping** to identify the issues that need to be assessed – including personal meetings/interviews, stakeholder briefings, project presentations, stakeholder/community information sessions, workshops and planning processes as described in **Section 5.0**.
- **Impact Assessment** to assess the impacts of the Project and identify opportunities for positive outcomes.
- **Strategy Development** including development of appropriate strategies to address the identified issues and the engagement of relevant stakeholders on agreed strategies.
- **Monitoring and Management** - incorporation of strategies into stakeholder engagement plans, environmental management plans and operations methods and development of a socio-economic monitoring and evaluation program.

8.8 Economic Impacts

An assessment of the economic impacts of the Project on a regional and State scale will be completed for the EIS, including consideration of the benefits and costs associated with the Project.

From an economic perspective, there are two important aspects of the Project, being:

- the economic efficiency of the Project (i.e. consideration of economic costs and benefits) and
- the economic impacts of the Project (i.e. the economic activity that the Project would provide to the regional and State economy).

A detailed economic assessment will be undertaken as part of the EIS and will include:

- a cost benefit analysis that measures the net benefits of the Project to the State in accordance with the *Guidelines for the economic assessment of mining and coal seam gas proposals* (2015)
- a Local Effects Analysis that measures the net benefits of the Project to the local community

- an economic impact assessment of the construction and operational phases of the Project and
- consideration of the environmental and community impacts of the Project.

8.9 Air Quality

The potential air quality impacts associated with mining in the Hunter valley is a key area of focus by regulators and the community. Recent consultation undertaken for the Mount Owen Continued Operations Project (and Modification 2 Project) and the early phases of consultation undertaken for this Project (refer to **Appendix A**) indicate that potential air quality impacts are a key area of focus for the local community.

A detailed air quality impact assessment (AQIA) will be completed for the Project in accordance with *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (*EPA,2016) (Approved Methods). The AQIA will have regard to the peer review process commissioned by the DPE for the Mount Owen Continued Operations Project as well as the comments raised in the assessment of that project by the Planning Assessment Commission.

In addition to the assessment of impacts associated with particulate matter (including particulate matter associated with diesel combustion), the AQIA will also consider potential air quality impacts associated with blast fumes.

The air quality impact assessment will include:

- a review of air quality monitoring data and meteorological data for the Mount Owen Complex and surrounding areas, including data from the Upper Hunter Air Quality Monitoring Network
- identification of all sources of dust/air pollution such as processing, handling, storage, transport operations or rehabilitation
- undertake modelling to reflect the proposed conceptual mine plans and production rates to assess the impact on local and regional ambient air quality, including the level of impact, potential exceedance levels and frequency having regard to standards and limits. This will be undertaken by:
    - preparing dust emissions inventories for each staged mine plan associated with the Project
    - computer based dispersion modelling of emissions, using local meteorological data for each staged mine plan
    - processing of model results into suitable contour plots and summary tables including predicted frequency of exceedance data (if relevant)
    - comparing model results to the relevant air quality assessment criteria contained in the Approved Methods at nearest sensitive receptors, including consideration of potential cumulative impacts
- determine the Project specific air quality levels (and comparison with predictions and monitored impacts for approved operations)
- assessment of cumulative air quality impacts of the Project, including cumulative emissions of total suspended particulates (TSP), particulate matter less than 10 µm diameter (PM_{10}), particulate matter less than 2.5 µm diameter ($PM_{2.5}$) and depositional dust
- consideration of the NSW Voluntary Land Acquisition and Mitigation Policy

- consideration of other potential air quality pollutants including nitrous oxides (NOx)
- development/update of reasonable and feasible air quality mitigation and management measures, and
- recommendations for changes to the current Mount Owen Complex air quality monitoring program.

8.10 Greenhouse Gas Emissions

A Greenhouse Gas and Energy Assessment (GHGEA) will be undertaken as part of the EIS to determine the projected energy consumption and greenhouse gas (GHG) emissions as a direct result of the Project. The GHGEA will include:

- estimation of scope 1, 2 and 3 emissions associated with the construction of the Project. Greenhouse gas emissions will be calculated from data relating to the energy and materials required for the proposed construction activities
- estimation of scope 1 and 2 life of mine (LOM) emissions generated by the mining operations. Emission sources will include fugitive emissions and energy use
- estimation of scope 3 LOM emissions associated with the operation of the Project. Emission sources will include product transport and product use
- estimation of scope 1, 2 and 3 emissions associated with the decommissioning and closure of the Project. Emission sources will include the energy required to reshape and rehabilitate the mine footprint at the cessation of mining
- a qualitative assessment of the impact of the Project's emissions on the environment
- evaluation of the impact of the Project's emissions on State, national and international greenhouse gas emission targets, including consideration of applicable State and national policies, programs or guidelines where appropriate and
- assessment of the relevant reasonable and feasible mitigation measures to reduce the impact of the Project.

8.11 Biodiversity

The Project will require the clearing of native vegetation and habitats and will impact on biodiversity values within the Potential Additional Disturbance Area. The removal of woodland vegetation and riparian vegetation associated with Yorks Creek and Swamp Creek also has potential to impact habitat corridors in the local terrain.

8.11.1 Existing Environment

The Potential Additional Disturbance Area has been predominantly and historically cleared for agriculture and contains native and exotic grasslands with scattered patches of native regenerated vegetation. Intact mature vegetation occurs along the creeks and tributaries of the area including along Yorks Creek, Swamp Creek and Bowmans Creek.

The broad plant community types that are likely to occur in the Potential Additional Disturbance Area include:

- Narrow-leaved Ironbark-Grey Box Grassy Woodland of the Central and Upper Hunter
- Spotted Gum – Narrow-leaved Ironbark Shrub – Grass Open Forest of the Central and Lower Hunter
- Bull Oak Grassy Woodland of the Central Hunter Valley
- River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley
- Swamp Oak – Weeping Grass Grassy Riparian Forest of the Hunter Valley.

Preliminary mapping of the vegetation communities present or likely to be present in the Potential Additional Disturbance Area are shown on **Figure 8.2.**

Threatened Ecological Communities (TECs) are ecological communities which are at risk of extinction. Under the EPBC Act, there are three categories for listing TECs: critically endangered, endangered and vulnerable. The Potential Additional Disturbance Area is likely to include the following TECs:

- Central Hunter Ironbark – Spotted Gum – Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions endangered ecological community (EEC) listed under the BC Act.
- Central Hunter Grey Box – Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions EEC listed under the BC Act
- Central Hunter Valley Eucalypt Forest and Woodland critically endangered ecological community (CEEC) listed under the EPBC Act.

No threatened flora species listed under the BC Act or EPBC Act have been recorded within the Potential Additional Disturbance Area. Three endangered flora populations listed under the BC Act have been previously recorded close to or within the Potential Additional Disturbance Area being:

- *Cymbidium canaliculatum* (tiger orchid) population in the Hunter Catchment
- *Eucalyptus camaldulensis* (river red gum) population in the Hunter Catchment
- *Acacia pendula* (weeping myall) population in the Hunter Catchment.

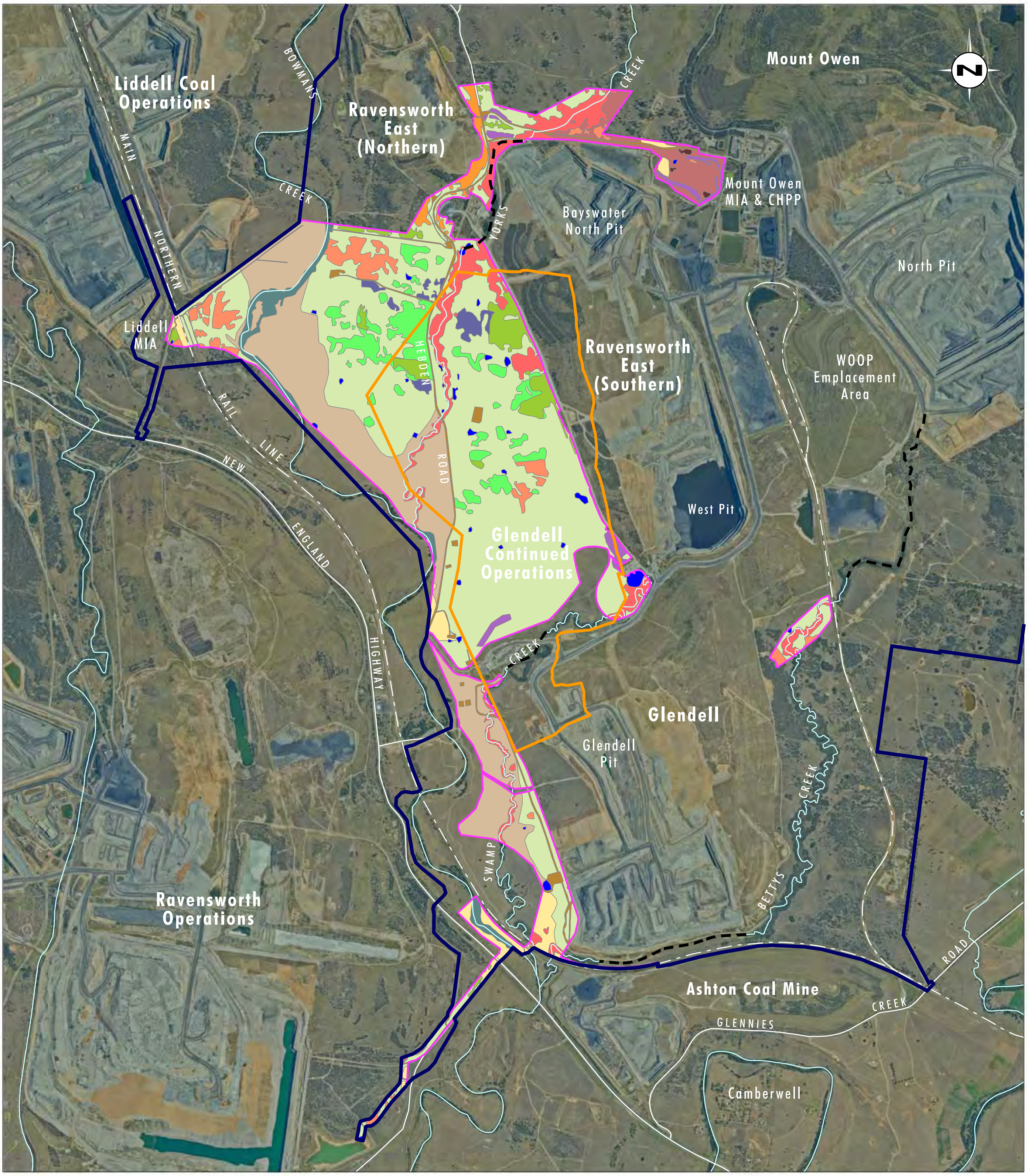

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

0 0.5 1.0 2.0km
1:50 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Potential Additional Disturbance Area
- Existing Creek Diversion
- 42-River Red Gum - River Oak Riparian Woodland in the Hunter Valley
- 485-River Oak Riparian Grassy Tall Woodland of the Western Hunter Valley - Moderate to Good Condition
- 1602-Spotted Gum - Narrow-leaved Ironbark Shrub - Grass Open Forest of the Central and Lower Hunter - Moderate to Good Condition
- 1602-Derived Native Grassland
- 1602-Plantation
- 1603-Derived Native Grassland
- 1603-Narrow-leaved Ironbark - Bulloak - Grey Box Shrub - Grass Open Forest Woodland of the Central and Lower Hunter - Moderate to Good Condition
- 1603-Regeneration
- 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
- Mixed Plantation
- Mixed Eucalypt Plantation
- Dam
- Disturbed Land

FIGURE 8.2

Vegetation Communities within the Potential Additional Disturbance Area

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20180515 16.10

A range of threatened fauna species listed under the BC Act and/or EPBC Act have been previously recorded within the Potential Additional Disturbance Area (refer to **Figure 8.3**) being:

- spotted-tailed quoll (*Dasyurus maculatus*) listed as endangered under the BC Act and vulnerable under the EPBC Act
- brush-tailed phascogale (*Phascogale tapoatafa tapoatafa*) listed as vulnerable under the BC Act
- spotted harrier (*Circus assimilis*) listed as vulnerable under the BC Act
- white-bellied sea eagle (*Haliaeetus leucogaster*) listed as vulnerable under the BCAct
- dusky woodswallow (*Artamus cyanopterus*) listed as vulnerable under the BC Act
- speckled warbler (*Chthonicola saggitata*) listed as vulnerable under the BC Act
- grey-crowned babbler (*Pomatostomus temporalis temporalis*) listed as vulnerable under the BC Act
- varied sittella (*Daphoenositta chrysoptera*) listed as vulnerable under the BC Act
- scarlet robin (*Petroica boodang*) listed as vulnerable under the BC Act
- east coast freetail-bat (*Mormopterus norfolkensis*) listed as vulnerable under the BC Act
- eastern bentwing-bat (*Miniopterus schreibersii oceanensis*) listed as vulnerable under the BC Act and
- southern myotis (*Myotis macropus*) listed as vulnerable under the BC Act.

Other threatened fauna species recorded in the immediate locality of the Potential Additional Disturbance Area that are also relevant to the Project include:

- green and golden bell frog (*Litoria aurea*) listed as endangered under the BC Act and vulnerable under the EPBC Act
- swift parrot (*Lathamus discolor*) listed as endangered under the BC Act and critically endangered under the EPBC Act
- squirrel glider (*Petaurus norfolcensis*) listed as vulnerable under the BC Act
- koala (*Phascolarctos cinereus*) listed as vulnerable under the BC and EPBC Acts and
- little eagle (*Heiraaetus morphnoides*) listed as vulnerable under the BC Act.

No threatened aquatic species or populations listed under the *Fisheries Management Act 1994* (FM Act) have been recorded in the aquatic habitats of the Potential Additional Disturbance Area, however the following are known to occur in the Hunter River Catchment:

- silver perch (*Bidyanus bidyanus*) listed as vulnerable under the FM Act
- Darling River hardyhead (*Craterocephalus amniculus*) in the Hunter River Catchment listed as an endangered population under the FM Act and
- southern purple spotted gudgeon (*Mogurnda adspersa*) listed as endangered under the FM Act.

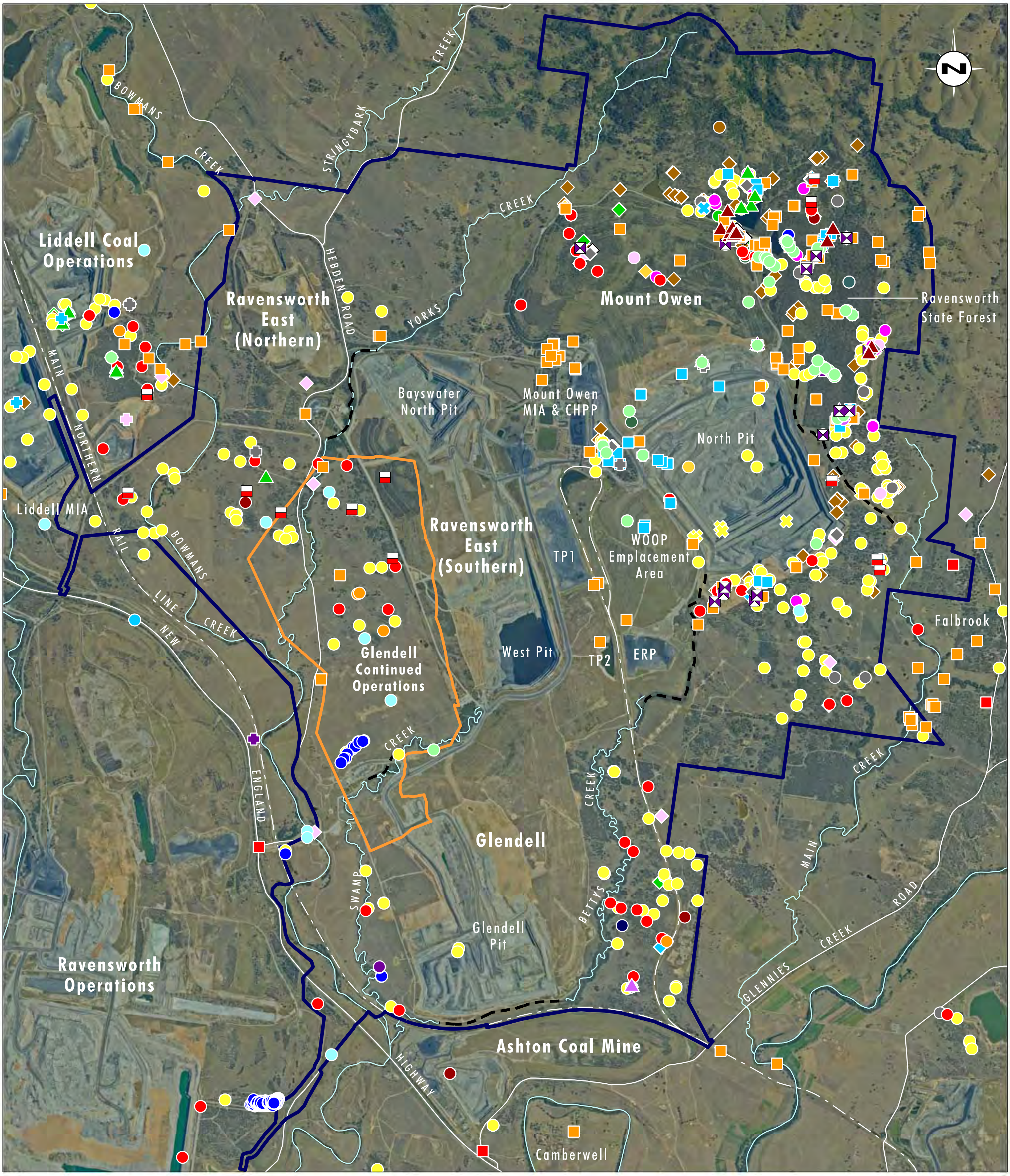

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)

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1:60 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Existing Creek Diversions
- *Acacia pendula*
- *Bothriochloa biloba*
- *Cymbidium canaliculatum*
- *Eucalyptus camaldulensis*
- *Eucalyptus glaucina*
- *Ozothamnus tesselatus*
- Black-chinned Honeyeater
- Black-necked Stork
- Brown Treecreeper (eastern subspecies)
- Blue-billed Duck
- Brush-tailed Phascogale
- Diamond Firetail
- Dusky Woodswallow
- Eastcoast Freetail Bat
- Eastern Bent-wing Bat
- Eastern Cave Bat
- Eastern False Pipistrelle
- Eastern Grass Owl
- Flame Robin
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-crowned Babbler
- Grey-headed Flying-fox
- Hooded Robin
- Koala
- Large-eared Pied Bat
- Latham's Snipe
- Little Bent-wing Bat
- Little Eagle
- Little Lorikeet
- Masked Owl
- New Holland Mouse
- Powerful Owl
- Rainbow Bee-eater
- Rufous Whistler
- Scarlet Robin
- Southern Myotis
- Speckled Warbler
- Spotted Harrier
- Spotted-tailed Quoll
- Squirrel Glider
- Swift Parrot
- Trailing Woodruff
- Varied Sittella
- White-bellied Sea Eagle
- Yellow-bellied Sheathtail Bat

FIGURE 8.3

Threatened Species and Populations within and Surrounding the Project Area

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8.11.2 Assessment Approach

There are currently two potential biodiversity assessment pathways available to the Project:

- Assessment in accordance with the requirements of the BC Act or
- Assessment under the Upper Hunter Biodiversity Plan (Biodiversity Plan) and associated Upper Hunter Strategic Assessment (UHSA).

The most likely assessment approach is an assessment using the Biodiversity Assessment Methodology (BAM) as is required under the BC Act. The biodiversity survey and assessment will be undertaken in accordance with the available guidance and assessment requirements in accordance with the BC Act. This will include targeted surveys for species-credit species and their relevant habitats and the collection of BAM vegetation integrity data. Flora and fauna surveys have been undertaken using BAM during spring and summer 2017-18.

It is noted that the UHSA/Biodiversity Plan process is yet to be finalised by the New South Wales and Commonwealth governments. Should the UHSA/Biodiversity Plan be finalised within a reasonable timeframe for this Project and endorsed by the Commonwealth Minister (and relevant State Ministers approve of biodiversity assessment for the Project being undertaken in accordance with the UHSA/Biodiversity Plan), a 'Statement of Consistency' report would be prepared to demonstrate how both the assessment of impacts on biodiversity, and the proposed offsetting framework for the Project, are consistent with the requirements of the finalised UHSA Biodiversity Plan. Additional survey and assessment would be undertaken for any disturbance areas outside the UHSA Project Areas and any new listings, or changes to species credit statuses, since the preparation of the UHSA reports.

Under both processes, biodiversity impacts on terrestrial flora and fauna will be assessed.

As the BAM and the UHSA do not address aquatic biodiversity, a separate assessment of aquatic, stygofauna and hyporheic fauna will be undertaken drawing upon existing extensive survey, assessment and monitoring data from the publically available assessments of the Liddell Coal Modification 5 Project and ongoing operations, and Ashton Projects as well as the Mount Owen Continued Operations Modification 2 Project. These previous surveys will be supplemented by further habitat assessment surveys and stygofauna sampling undertaken for the Project. The aquatic assessment will address the potential impacts of the Project (including the diversion of a section of Yorks Creek) on aquatic species and communities associated with Bowmans Creek, Yorks Creek and Swamp Creek and their tributaries.

8.11.3 Matters of National Environmental Significance

The Mount Owen Continued Operations Project was deemed a controlled action due to impacts to listed threatened species and communities including the spotted-tailed quoll (*Dasyurus maculatus maculatus*), swift parrot (*Lathamus discolor*), regent honeyeater (*Anthochaera phrygia*), koala (*Phascolarctos cinereus*) and likely significant impacts on water resources associated with Main Creek and Bettys Creek. The Liddell Modification 5 Project was also considered to be a controlled action due to potential impacts on threatened species and communities, listed migratory species and likely significant impacts on water resources. The Mount Owen Continued Operations Project Modification 2 and the Integra Underground Modification were both considered not to be controlled actions.

As noted in **Section 2.4.4** the existing EPBC Approval (EPBC 2013/6978) covers the approved Mount Owen and Ravensworth East operations, including all surface infrastructure and train loading facilities. Any EPBC referral for the Project will cover only those elements that are not already approved under the current Mount Owen EPBC approval or are otherwise exempt from the need for referral due to the operations being determined previously by the Commonwealth Minister not to be a controlled action or due to the activity being approved prior to the commencement of the EPBC Act.

8.12 Agriculture and Land Use

An Agricultural Impact Statement (AIS) is required as part of any EIS that is submitted for a mining project that is SSD. The NSW Government has prepared the Agricultural Impact Statement guidelines (Department of Planning, 2012) and technical notes guidelines (Department of Primary Industries 2013) to facilitate the preparation of an AIS in NSW (collectively referred to as the AIS Guidelines). The AIS Guidelines assist applicants and others to understand the information required to enable an assessment of the agricultural impacts of mining and other resource extraction proposals.

The Potential Additional Disturbance Area associated with the Project is currently used for low intensity grazing. Approximately 40.4 ha of land within the Verification Area on the alluvial flats associated with Bowmans Creek have been identified as being BSAL; however this area is situated outside of the proposed mining footprint. No land within the Project Area is identified as being a CIC.

The broader Project Area is predominantly active mining area or former mining areas in the process of being rehabilitated. The Project Area also includes areas used for biodiversity management purposes, biodiversity and Aboriginal cultural heritage Conservation Areas and areas of Ravensworth State Forest.

As discussed in **Section 6.1.2**, a Gateway application will be lodged in relation to the Project due to the presence of BSAL in the area potentially requiring a mining lease under the Mining Act.

An AIS will be prepared for the Project to assess the potential interactions of the Project with agricultural land uses and on land with potential agricultural value. The assessment will be prepared following the AIS guidelines and will include:

- identification of potential impacts of the Project on agricultural resources within the proposed disturbance area and the surrounding locality
- identification of any potential impact to agricultural productivity within the proposed disturbance area and the surrounding locality
- identification of any other risks to agriculture such as water availability, weed management, noise, air quality and socio-economic based on the outcomes of each relevant specialist study
- identification of the total area of land that is to be disturbed as a direct result of the Project including the identification of the soil and land capability class, agricultural suitability, soil type and carrying/cropping capacity of this land
- identification of opportunities for agricultural land uses as part of the final land use for the Potential Additional Disturbance Area
- review of the potential socio-economic impacts, specifically as they may relate to agricultural support services within the locality of the Potential Additional Disturbance Area. This will be incorporated into the broader social impact assessment and economic assessment for the Project as relevant (refer to **Sections 8.7** and **8.8** respectively), and
- analysis of potential cumulative impacts to agriculture.

Any required mitigation and management measures will also be identified as part of this assessment process.

8.13 Surface Water

The surface water environment in the Project Area and broader area is heavily impacted by current approved and historical mining. These impacts have altered flow regimes, diverted creeks and captured water falling on disturbed areas within mine water management systems. The Project will impact on areas that are already impacted by historical and approved mining operations.

Potential additional surface water impacts associated with the Project include:

- altered flow patterns associated with the diversion of Yorks Creek
- reduced catchment and associated changes to flow patterns in Swamp Creek
- diversions of parts of the former Swamp Creek Catchment in the rehabilitated Mount Owen Complex landform into the Bettys Creek Catchment
- changes to base flows in drainage systems due to changes in catchment areas and groundwater impacts associated with proposed and approved mining
- changes in water licensing requirements
- changes to flows during high flow events associated with creek diversions, changes in catchment areas and new infrastructure located within floodplains, and
- changes in water quality.

A detailed surface water assessment will be prepared as part of the EIS and will include the following:

- likely surface water impacts as a result of the changes to the proposed disturbance area including catchment changes and the potential implications of these impacts on mine water management, downstream watercourses, water users and water licensing
- an assessment of the hydrological and geomorphic impacts associated with the Yorks Creek diversion
- required changes to existing surface water control measures, including diversion drains and mine water management controls
- potential for changes to surface water quality and potential erosion and sediment control measures required
- an assessment of the potential impacts on downstream water users, environments and watercourse stability
- potential changes to the flooding regime due to the Project and potential flood impacts on the proposed open cut pit
- assessment of post mining surface water impacts
- cumulative surface water impacts due to the Project and other existing and approved developments
- identification and description of impact mitigation measures required for the Project.

As part of the assessment, an updated mine site water balance will be prepared which will include consideration of any external water supply or discharge requirements through the GRAWTS. The water balance will:

- account for available water sources
- account for the water demand for the Project
- assess demand and supply requirements and storage requirements under a range of rainfall/evaporation, groundwater make and production conditions
- identify any potential shortfalls in water supply and water sourcing options
- identify any need for controlled discharge via the Hunter River Salinity Trading Scheme (HRSTS) through the GRAWTS
- identify the risk and quantities of any predicted discharge from water storages into the environment
- include a salt balance for the Project and
- include a final void water and salt balance.

8.14 Groundwater

Groundwater impacts associated with the Project arise due to continued and expanded mining operations and the creation of a void associated with the mining of the Glendell Pit Extension. These potential impacts occur in a hydrogeological environment that is significantly impacted by historical mining and approved mining operations.

The Project will extract the same sequence of coal seams that are currently being mined in the Glendell Pit to the south and Mount Owen Mine North Pit (refer to **Figure 3.3**). The coal seams occur within the Permian Jerrys Plains and Vane subgroup and include the Bayswater, Lemington, Pikes Gully, Arties, Liddell, Barrett and Hebden Seams. As discussed in **Section 3.2**, the Camberwell Anticline runs through the proposed Glendell Pit Extension in an approximate north-south alignment resulting in the coal seams dipping away to the east and to the west at the pit boundaries. The coal seams form low transmissivity groundwater systems and are separated by low permeability interburden that forms an intervening aquitard.

Yorks Creek and Swamp Creek pass through the Proposed Glendell Pit Extension and join with Bowmans Creek west of the proposed mining area. Flood plains occur along the alignment of these creek systems that have deposited a relatively thin sequence of alluvial sediments. Studies undertaken for the Project using a variety of datasets including LIDAR imagery, CSIRO and other public data, test pits and drilling indicate that the sediments are comprised of sand, silt and clay and the depth of the alluvial sediments is generally less than 10 m.

A network of baseline monitoring bore and vibrating wire piezometers has been installed within the Permian coal seams and the alluvial sediments for both existing and previous operations at the Mount Owen Complex and adjoining mining operations (refer to **Figure 8.4**). Water level and water quality data have been routinely collected from the monitoring network and 13 years of baseline records are now available to describe the existing conditions at the Project site. The data indicates that the alluvium along Yorks Creek and Swamp Creek has a high clay content retarding the permeability of the aquifer material. The saturated thickness is also generally limited and the water quality in Yorks and Swamp Creeks is generally brackish to saline indicating these systems do not meet the NSW Government definition of a highly productive aquifer. Bowmans Creek has a larger catchment and therefore a slightly thicker sequence of alluvial sediments, although high clay content and brackish water quality have also been identified in bores. Further drilling and installation of monitoring bores along Bowmans Creek has also been undertaken to confirm the thickness of the alluvium in areas not previously assessed and its aquifer potential. Three of the new alluvial monitoring bores have been paired with a deeper bore constructed within the underlying regolith/ weathered zone layer to determine connectivity between the alluvium and underlying bedrock.

The baseline monitoring from vibrating wire piezometers installed has identified water level drawdown within the coal seams due to the cumulative impact of approved activities that surround the proposed Glendell Pit Extension. No nearby landholders reliant on groundwater have been identified.

The proposed Glendell Pit Extension will further depressurise the geological strata directly intersected by the mining activities. The Project will create a zone of drawdown around the mining activity where groundwater levels will decline during the mine life. The depressurisation will also create an area of low pressure within the groundwater system centred on the Glendell Pit Extension that will encourage groundwater to flow through coal seams towards the mining area drawing groundwater from the adjacent water sources. A numerical groundwater flow model will be developed with the purpose of estimating the extent of the zone of influence and the volume of groundwater taken from the affected water sources.

Prior to making predictions the numerical model will be calibrated using water level records collected from the baseline monitoring network installed at the Mount Owen Complex and from adjacent surrounding mining operations. A significant network of monitoring bores exists both within the Project Area and at adjacent mining operations. The model will also be calibrated to estimates (and measurements) of groundwater ingress into surrounding mining areas to reduce uncertainty. The numerical model will build upon an existing regional numerical model developed for Glencore projects in the region representing cumulative impacts from the Liddell, Mount Owen Complex, Integra, Ashton, Rix’s Creek, Ravensworth and HVO mines.

The calibrated numerical model will allow the predicted impacts on the groundwater regime to be quantified and compared to the requirements of the:

- NSW Aquifer Interference Policy
- guidelines released by the Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Developments and
- Australian Groundwater Modelling Guidelines.

The groundwater impact assessment will include the following:

- field investigation programs to:
  - better define the limit of alluvial sediments that could form aquifers
  - determine the thickness of alluvial sediments and interconnectivity with underlying bedrock and
  - electronically monitor groundwater levels in key areas to improve the understanding on the groundwater systems,
- using the baseline datasets to develop a conceptual hydrogeological model that describes the groundwater regime and identifies areas of potential environmental impact resulting from the Project such as:
  - groundwater dependent ecosystems (GDEs)
  - stygofauna habitats

- quality or quantity changes for groundwater flow and
- adverse changes in surface water base flows

- preparation of a numerical groundwater model to provide a quantitative estimate of:
  - groundwater inflow to the mining area
  - the area of influence of dewatering and the level and rate of drawdown at specific locations
  - the potential for any impact on alluvial aquifers and surface water
  - areas of potential risk where groundwater impact mitigation/control measures may be necessary
  - cumulative impacts from the Project along with other surrounding mining operations and
  - identification and assessment of potential post mining groundwater impacts.

The groundwater impact assessment will assess the ability of the Project to comply with government policy related to groundwater and identify any necessary measures relating to the management of the groundwater resource and groundwater flow. The groundwater assessment will also inform licensing requirements regarding interception of and water take from groundwater aquifers.

The groundwater impact assessment will be independently peer reviewed as part of the preparation and finalisation of the assessment.

8.15 Mine Closure and Rehabilitation

As discussed in **Section 3.3.4**, the Project will include the progressive rehabilitation of the disturbed areas as mining progresses to the north.

A rehabilitation and mine closure assessment will be prepared for the Project and will draw on the design parameters and methodology developed for the Mount Owen Continued Operations Project and Mount Owen Continued Operations Modification 2 Project. The assessment will include:

- a review of the conceptual closure criteria and rehabilitation and closure outcomes
- the use of natural landform design methodologies to inform conceptual final landform principles for the Project based on stable natural slopes in the local environment applicable to the materials being used in the rehabilitation
- consideration of land-use options and opportunities for the different areas of the final landform, including the final void. This will include consideration of biodiversity objectives associated with the existing Mount Owen Complex Rehabilitation Strategy, surrounding land uses, existing agricultural suitability of the Project Area and potential future uses
- review of the rehabilitation strategy for the mine, including a review of the ecological rehabilitation measures appropriate to the diversity of habitat to be formed by the landform development where appropriate and

- identification and management of risks associated with:
  - the geochemistry of overburden and washery reject (coarse and fine) material
  - material potential prone to spontaneous combustion
  - fire risks associated with exposed coal seams during operation and closure phases
  - contamination from spills, and
- identification of any additional measures proposed to manage any identified risks to the successful rehabilitation and closure of the mine as a result of the Project.

The rehabilitation and closure assessment will have regard to existing approved landform and rehabilitation commitments for the existing approved operations at Glendell and the broader Mount Owen Complex and assess any proposed commitments in light of existing requirements and commitments. The assessment will also have regard to the comments expressed by the PAC in its assessment of the Mount Owen Continued Operations Project.

9.0 Other Environmental and Social Issues

As discussed in **Section 7.3**, a range of matters have been identified as being 'other issues' for assessment in the EIS. These issues will either be assessed in the EIS or as a component of key issues assessed in specialist reports (refer to **Section 8.0**). It is not proposed that stand alone specialist studies will be prepared for these issues as part of the EIS.

9.1 Odour

The potential odour risks associated with coal mining operations are odours associated with:

- fumes from blasts and
- fumes from coal which is alight through spontaneous combustion or other external heat sources.

Risks associated with blast fumes will be assessed as part of the blasting (refer to **Section 8.2**) and air quality (refer to **Section 8.9**) impact assessments. The low level of risk from blast fume due to management practices does not warrant a stand-alone assessment of odour impacts associated with blast fumes.

The mining operations at the Mount Owen Complex have had a low incidence of spontaneous combustion over more than 40 years of operation. As the Project will be mining the same coal measures as are mined in the Glendell Pit, North Pit, Bayswater North Pit and former Ravensworth East pits, using similar mining methods, the likelihood of the Project to generate odour from spontaneous combustion is considered low. Potential risks associated with spontaneous combustion will be addressed in the Mine Closure and Rehabilitation Assessment prepared for the EIS (refer to **Section 8.15**).

Exposed coal seams in the highwall pose a potential risk of catching fire in the event of a bushfire or other external heat source (e.g. equipment malfunction resulting in fire close to exposed coal seams). The Glendell Pit Extension is not located in an area of high density bushland and pre-strip and overburden emplacement activities will provide a buffer between woodland areas and exposed coal seams. The risk of exposed seams in the Glendell Pit Extension catching fire from bushfires is therefore considered to be low. Regular equipment maintenance and servicing means the risk of equipment fire is also considered to be low. On-site firefighting equipment is also available to extinguish fires quickly after ignition.

The Mine Closure and Rehabilitation Assessment will include measures to manage risks associated with exposed coal seams in highwalls remaining in the final landform.

9.2 Micro Climate

The changes in terrain associated with the project will affect the climate in the immediate vicinity of emplacement areas through changes in shading and wind flow. These impacts are localised and restricted to areas close to overburden emplacement areas. Any microclimate impacts will be limited to the Project Area and are of a small magnitude. These impacts are not considered to warrant a detailed impact assessment.

9.3 Offsite Parking

The project will provide sufficient parking spaces for the operational and construction workforce at all stages of the Project. Parking areas will be located off public roads and in close proximity to mine infrastructure areas and construction areas.

9.4 Built Features (non-heritage) and Services and Facilities

The Project's impact on built features and facilities (other than heritage items) is discussed in **Sections 3.8** and **3.9**. Impacts of these infrastructure impacts will be considered as part of the SIA (refer to **Section 8.7**). Details regarding the staging of works and measures to mitigate impacts to users of the infrastructure and services will be detailed in the main text of the EIS.

9.5 Natural Heritage (other)

There are no features of significant natural heritage present in the local areas that are likely to be impacted by the Project. Impacts on water resources and biodiversity will be considered in stand-alone specialist assessments included as part of the EIS.

9.6 Public Safety

The Project's potential impacts on public safety include:

- changed road conditions associated with the Hebden Road realignment
- increased traffic movements during construction phases
- injury from fly-rock associated with blasting
- health risks associated with blast fume
- risk of fall associated with highwalls
- risk of drowning associated with water supplies and pit lakes in the final landform
- health risks associated with particulate matter from mining operations.

These potential impacts are all well understood and can be managed to acceptable levels through standard and project specific management controls. All impacts will be considered in specialist studies prepared for the EIS. **Table 9.1** identifies the specific studies which will address the above public safety risks.

Table 9.1 Public Safety and where it will be assessed in the EIS

Impact/issue	Specialist Study
Changed road condition	Traffic (refer to **Section 8.4**)
Increased traffic during construction phase	Traffic (refer to **Section 8.4**)
Fly rock	Traffic (refer to **Section 8.4**) and Blasting (refer to **Section 8.2**)
Blast Fume	Air quality (refer to **Section 8.9**) and blasting (refer to **Section 8.2**)
Risk of fall associated with highwalls	Mine Closure and Rehabilitation (refer to **Section 8.15**) and operational mine safety design requirements
Risk of drowning associated with water supplies and pit lakes	Mine Closure and Rehabilitation (refer to **Section 8.15**) and operational mine safety design requirements
Health risks form particulate matter	Air Quality (refer to **Section 8.9**), Social Impact Assessment (refer to **Section 8.7**) and Economic Assessment (refer to **Section 8.8**)

9.7 Housing

The operational workforce at the Mount Owen Complex will remain largely unchanged throughout the life of the Project. There will be a moderate increase in workforce associated with construction activities. The SIA (refer to **Section 8.7**) will consider the availability of accommodation in the local area and potential impacts on accommodation supply. Impacts are considered likely to be small as the Singleton and Muswellbrook areas have a high supply of short term accommodation available to service construction activities associated with the local mining and associated service industries.

9.8 Bushfire

The Project will not increase the risk of bushfire. The new MIA (if required) will be designed to meet relevant bushfire protection standards.

9.9 Undermining/Subsidence

The Project will not result in subsidence or exacerbate subsidence impacts associated with the former Liddell Underground operations.

10.0 Project Schedule

The current schedule has the development application for the Project being lodged in late 2018.

While the current Glendell Consent approves operations to the end of June 2024, the current mine plan schedule has resources being fully extracted in 2022. The efficient continuation of mining operations into the proposed Glendell Pit Extension would require the Project to be approved by early 2020. This would enable construction of the new MIA or temporary MIA facilities and associated infrastructure works to be finished and to enable decommissioning of the existing Glendell MIA to occur in sufficient time to prevent delays to the mining schedule.

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APPENDIX A

SIA – Scoping Report

Inspired people | Dedicated team
Quality outcomes

GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

SOCIAL IMPACT ASSESSMENT
SCOPING REPORT

FINAL

GLENCORE

GLENDELL CONTINUED OPERATIONS PROJECT

SOCIAL IMPACT ASSESSMENT SCOPING REPORT

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
Glencore

Project Director: Dr Sheridan Coakes
Project Manager: Sarah Bell

Report No. 4166/R05/SIA/V4
Date: May 2018

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	Date	Name	Date
Final	Dr Sheridan Coakes	May 2018	Dr Sheridan Coakes	May 2018

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Figures

Tables

Appendices

1.0 Overview

1.1 Introduction

This report documents the outcomes of the scoping phase of the Social Impact Assessment (SIA) undertaken by Umwelt (Australia) Pty Ltd (Umwelt) on behalf of Glencore, and forms part of the Preliminary Environmental Assessment (PEA) for the Glendell Continued Operations Project (Project).

1.2 Operational Context

The Mount Owen Complex is 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 comprises the mining operations at the Mount Owen Mine (North Pit), Ravensworth East Mine (Bayswater North Pit) and Glendell Mine (Glendell Pit). The Mount Owen Complex also includes a coal handling and preparation plant (CHPP), and coal handling and transport infrastructure (refer to **Figure 1.2**).

Mt Owen Pty Limited (Mount Owen) operates the Ravensworth East (mining in the Bayswater North Pit) and Glendell (mining in the Glendell Pit) mining operations at the Mount Owen Complex with mining operations at Mount Owen (mining in the North Pit) operated by Thiess Pty Ltd pursuant to a contractual arrangement with Mount Owen. The Mount Owen Complex is surrounded by Integra Underground, Liddell Coal and Ravensworth Operations, which are also operations owned and operated by subsidiaries of Glencore Coal Assets Australia Pty Limited (Glencore) and its joint venture partner. Glencore and the joint venture partner also hold a number of exploration licences surrounding the Mount Owen Complex.

The area has been heavily dominated by coal mining and power station operations for many decades with rural and rural-residential land located to the north-east, east, south-east and south of the Mount Owen Complex.

The Mount Owen Complex has been through a range of development approval processes over the years. In 2011, Mount Owen undertook pre-feasibility studies into the continuation of open cut mining operations at Mount Owen and Glendell Mines. Approval for continuation of operations at Mount Owen was received for the Mount Owen Continued Operations Project on 3 November 2016 (SSD 5850), which secures further mining operations in the North Pit to 2031. Glendell Mine operates under a separate consent (DA 80/952) originally granted in 1983. Mount Owen are currently looking at an extension of mining operations in the North Pit which would extend the life of operations to approximately 2036-7 (Mount Owen Continued Operations Modification 2 Project). This application will be lodged in Quarter 2 2018. Section 2.0 of the PEA contains a summary of existing approved operations at the Mount Owen Complex.

1.3 The Project

The Project seeks to develop Glendell Mine beyond its current approved mining extent into tenements owned by Glencore and its JV partner to the north of the existing Glendell Pit (refer to **Figure 1.1**). This proposed extension of the current open cut mining operations at Glendell Mine would extract an additional 140 million tonnes (Mt), approximately, of run-of-mine (ROM) coal down to the Hebden Seam. This extension of the Glendell Pit is referred to as the Glendell Pit Extension. The Project would extend the life of mining operations at Glendell to approximately 2044. ROM coal from Glendell will continue to be processed by the Mount Owen CHPP and associated infrastructure and utilise the Mount Owen Rail Loop for coal transport. Mount Owen also has approval to transport 2 Mtpa of ROM coal to the Liddell CHPP for processing and rail loading, which is proposed to continue.

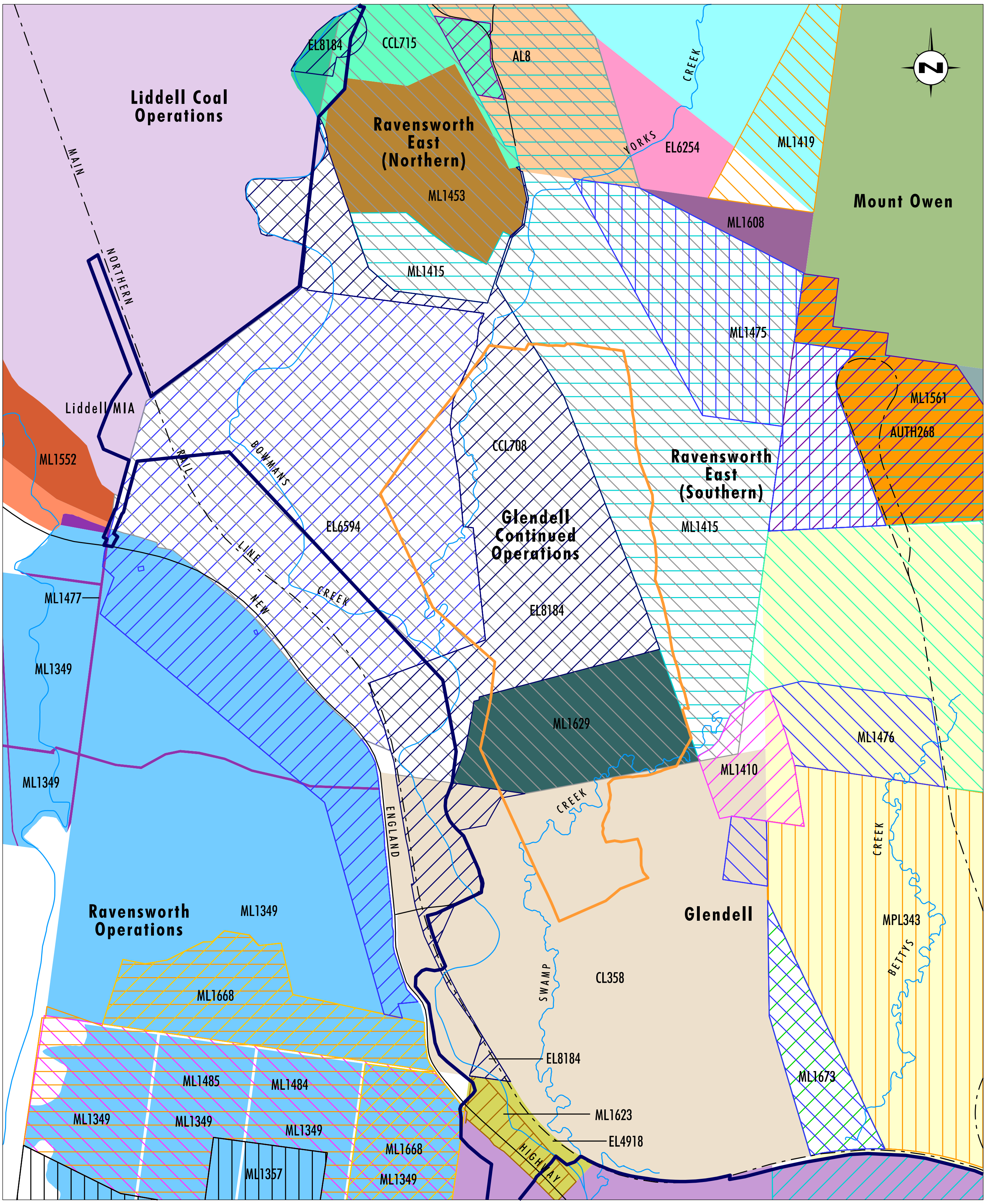
The Project will necessitate the realignment of a section of Hebden Road, diversion of Yorks Creek and the relocation of Ravensworth Homestead. The Project will also require the demolition/relocation of the existing Glendell Mine Infrastructure Area (MIA) and construction of a new MIA or utilisation and augmentation of either the existing MIA at Liddell Coal or the Mount Owen Mine MIA (or a combination of these options). Depending on the MIA option chosen, a Heavy Vehicle Access Road may also be required for accessing the MIA.

Key aspects of the Project include:

- extending the life of Glendell to approximately 2044
- increasing the maximum approved extraction rate at Glendell from 4.5 Mtpa up to 10 Mtpa later in the Project
- ongoing utilisation of existing infrastructure at the Mount Owen Complex to 2045
- construction of a new MIA, use of Mount Owen MIA or utilisation of the existing Liddell MIA, which also requires the construction and use of a temporary MIA
- construction of a replacement water pipeline from Mount Owen Complex to Ravensworth Operations (Narama Dam) – existing pipeline will be impacted by proposed Glendell Pit Extension
- rehabilitation of areas disturbed by the Project
- relocation of Ravensworth Homestead
- diversion of part of Yorks Creek,
- relocation of 11kV and 33kV powerlines, and
- relocation of part of Hebden Road

The proposed pit extent is set back in excess of 200 metres (m) from the high bank of Bowmans Creek.

The key Project features are shown on **Figure 1.2.** Further details regarding the Project are contained in Section 3.0 of the PEA.



Data Source: Glencore (2018), Minview (2018)

0 0.5 1.0 2.0km
1:40 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- AL8
- AUTH268
- AUTH423
- AUTH429
- CCL708
- CCL715
- CL358
- CL382
- CL383
- EL4918
- EL6254
- EL6594
- EL8184
- ML1313
- ML1349
- ML1355
- ML1357
- ML1398
- ML1410
- ML1415
- ML1419
- ML1453
- ML1475
- ML1476
- ML1477
- ML1484
- ML1485
- ML1529
- ML1533
- ML1552
- ML1561
- ML1597
- ML1608
- ML1623
- ML1629
- ML1668
- ML1673
- ML1694
- MPL343

FIGURE 1.1

Mining Authorities

File Name (A4): R05/4166_089.dgn
20180510 12.02

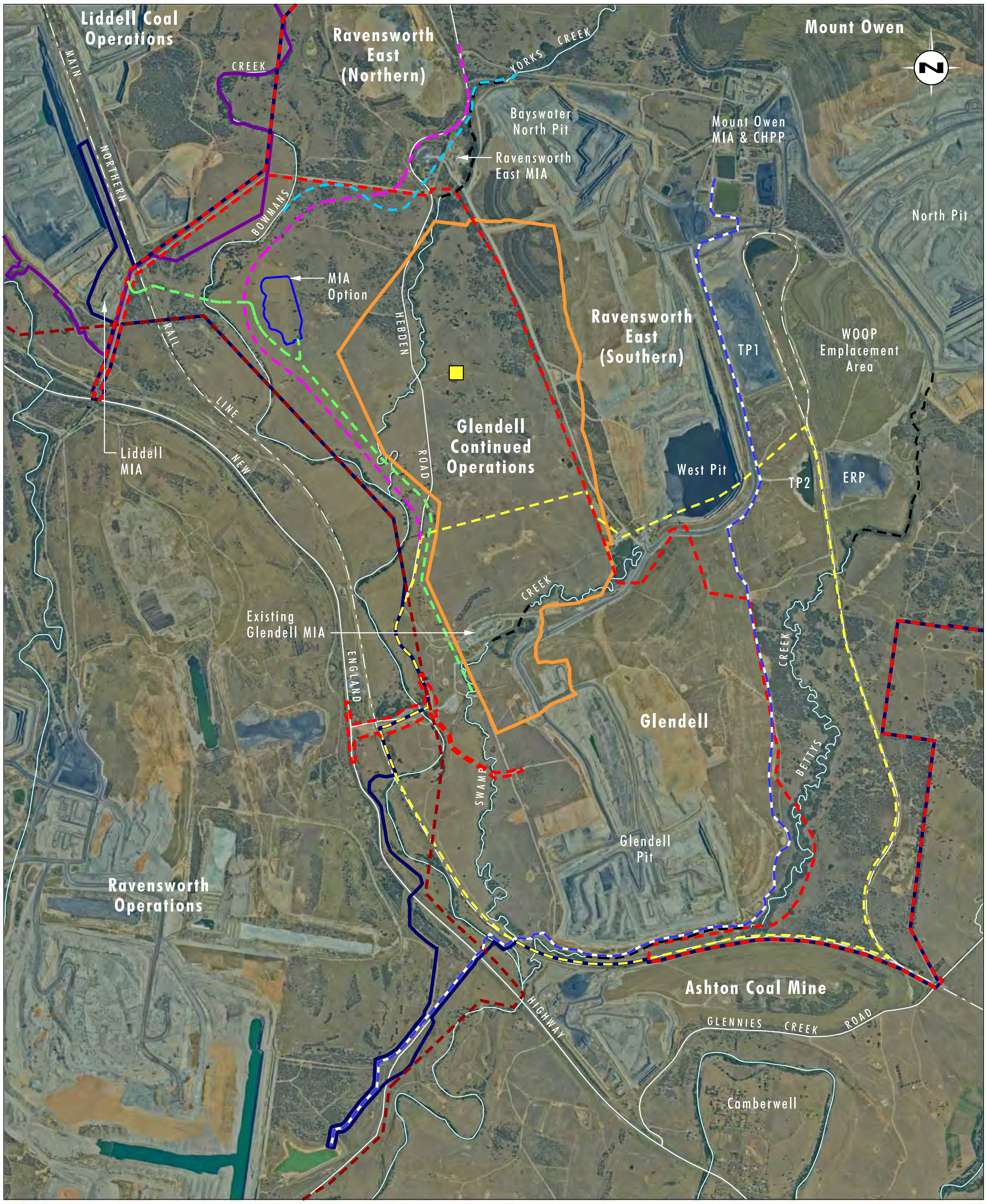


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2018)
Note: Ravensworth Homestead to be relocated.

0 0.5 1.0 2.0km
1:45 000

Legend

- Project Area
- Proposed Glendell Pit Extension
- Liddell Consent Boundary
- Mount Owen Consent Boundary
- Glendell Consent Boundary
- Ravensworth Consent Boundary
- Ravensworth Homestead
- Existing Creek Diversion

Project Features:

- New MIA Option
- Indicative GRAWTS Pipeline
- Proposed Heavy Vehicle Access Road
- Proposed Yorks Creek Diversion
- Proposed Hebden Road Realignment

FIGURE 1.2

Key Project Features

2.0 Methodology

2.1 Guideline requirements

The scoping phase of this SIA was conducted in accordance with the SIA Guideline (NSW Government Planning and Environment (DPE), 2017), and as such has aimed to:

- identify and understand the Project's area of social influence, and
- apply scoping methodology to identify potential material social impacts and the level of assessment required for the Environmental Impact Statement (EIS).

The assessment and reporting has been led and conducted by Umwelt's qualified and experienced social team.

2.2 Understanding the Project's area of social influence

A community capitals framework was used to collate and analyse the Project's area of social influence. Under this framework the diverse strengths and assets within a community are considered, as well as vulnerabilities and gaps, in order to gain a picture of a community's relative resilience. Assets and vulnerabilities are themed within the five categories of natural, economic, social, physical and human capital, as per **Figure 2.1**.

Figure 2.1 Community Capitals Framework

Source: Coakes and Sadler (2011), p.330

In order to develop a detailed understanding of the area of social influence, a range of mapping and profiling strategies have drawn on both primary and secondary data. The key methods and information sources utilised are described in **Table 2.1**.

Table 2.1 Methods for scoping area the area of social influence

Method	Description	Information sources
Stakeholder mapping and analysis	Identification of key stakeholder groups, analysis of relationships to project, determination of engagement approach	Existing Glencore stakeholder database Local government website Media analysis
Community asset mapping	Identification of capitals across 5 key areas Analysis of the values associated with community assets	Interviews with key stakeholders Documentary review - secondary reports and resources
Community profiling	Overview of localities and analysis of demographic data	ABS Census 2016 Social Health Atlas, NSW and ACT Dec 2017
Media analysis	Summary of representative sample of media articles since December 2014 that relate to the Glendell Operation.	Online media search of Australian newspapers - ABC, Singleton Argus, Northern Daily Leader, Newcastle Herald

2.3 Stakeholder Identification and Analysis

SIA involves the cooperation and coordination of a number of 'social partners' or 'stakeholders'. As Burdge (2004) outlines, stakeholders may be affected groups or individuals that:

- live nearby the resource/Project
- use or value a resource
- are interested in its use and/or
- may have to relocate.

As part of the SIA and engagement program for the Project, stakeholders that are likely to be involved in the assessment process have been identified. These stakeholders have been grouped as depicted in **Figure 2.2**.

Figure 2.2 Stakeholder Groupings

Potentially affected people and groups have been identified by way of stakeholder analysis, building on research undertaken for the preliminary social baseline profile (in preparation) and review of existing company stakeholder databases. Section 2.2 of the SIA Guidelines (DPE, 2017) provides the following examples of general categories of people to engage, including:

- existing and migrating residents, landholders and businesses, particularly those near the project location and those in nearby towns and within the region
- Aboriginal people and groups, especially those with a cultural connection to the project location; and including traditional owners or custodians who can speak for Country, native title holders or registered native title claimants and relevant Local Aboriginal Land Council/s
- employees, contractors and suppliers
- community, industry, business, cultural and environmental organisations, advocacy groups and peak bodies
- public and private service and infrastructure providers and regulatory agencies (especially local, state and federal government funded education, health, community and social services and
- elected representatives and other community leaders.

In considering the above groups, for the purposes of the SIA the following stakeholders (refer to **Table 2.2**) have been identified as important to engage**.**

Table 2.2 Identified Project Stakeholders

Stakeholder Group	Stakeholders
Proximal Neighbours – Landholders and Tenants	**Hebden Residents and Road Users** **Near neighbours – Camberwell, Falbrook, Middle Falbrook, Glennies Creek** **Tenants in Glencore owned residences** Key individuals (who made a submission either to the DPE or Planning Assessment Commissions (PAC) (now Independent Planning Commission (IPC)) in relation to the Mount Owen Continued Operations Project):
Community Consultative Committees	**Mount Owen Complex and Integra Underground Mine Community Consultative Committee (CCC)** Liddell Coal Operations CCC
Functional Stakeholders	**Mount Owen, Ravensworth East and Glendell operational workforces** **Customers/Suppliers** **Joint Venture Partners**
Local Government	**Singleton Council** **Singleton Heritage Committee** Muswellbrook Shire Council Cessnock Council
State Government	**Department of Planning and Environment (DPE)** **DPE – Resource Regulator (RR)** **Office of Environment and Heritage (OEH) – Heritage Division and Biodiversity** Environment Protection Agency (EPA) **Department of Primary Industries - Water** Hunter New England Health Office of Agricultural Sustainability and Food Security Roads and Maritime Services Transport for NSW Other government agencies (as required)
Federal Government	**Commonwealth Department of Environment and Energy/Office of Water Science (DoEE)**
Aboriginal Groups*	**Wonnarua Nation Aboriginal Corporation (WNAC)** **Wanaruah Local Aboriginal Land Council (WLALC)** **Plains Clans of the Wonnarua People (PCWP) - as the Native Title Claimant** **Hunter Valley Aboriginal Corporation (HVAC)**
Community Groups	Hebden Hall Committee
Industry and Business Groups	**Hebden Quarries** **Singleton Business Chamber** **Liddell Coal Operations** **Ashton Coal Mine** **Integra Underground Mine** **Infrastructure owners** **Ravensworth Operations** **Hunter Valley Operations** **Bloomfield Collieries** **Colinta Holdings** Hunter Business Chamber Muswellbrook Business Chamber

Stakeholder Group	Stakeholders
Heritage / Historical Interest Groups **	**Ravensworth Homestead Advisory Committee (RHAC)** **Singleton Historical Society & Museum Inc** **Individual members of the Singleton Council Heritage Committee** **Heritage Council of NSW** **Historic Houses Association of Australia** Minister for Heritage (NSW) (Gabrielle Upton) National Trust of Australia Australia International Council on Monuments and Sites (ICOMOS)
Members of Parliament (both State and Federal)	Member for the Upper Hunter (NSW) (Michael Johnsen MP) Member for Hunter (Joel Fitzgibbon) Member for Cessnock (Clayton Barr)
Environment and Special Interest Groups	Centre for Sustainable Ecosystem Restoration Hunter Communities Network Hunter Environment Lobby North East Singleton Wild Dog Association (NESWDA)* Wybong Action Group Denman Aberdeen Muswellbrook Scone Healthy Environment Group (DAMS HEG) North East Forest Alliance Singleton Shire Healthy Environment Group Minewatch - Community Group Lock the Gate Alliance Land and Environment Planning North East Forest Alliance The Australia Institute Nature Conservation Council
Local Community	Interested residents in the wider community
Service Providers	**Local schools (e.g. Mount Pleasant Public School)** **Hebden Rural Fire Service** Other related Government services (Emergency, Education, Health, Welfare, Child care, etc.)
Media	**The Singleton Argus** Muswellbrook Chronicle Newcastle Herald Hunter Valley News ABC News
Local Community	Interested residents in the wider community

Note: Stakeholders in bold have been engaged as part of the Scoping Phase.
* *Aboriginal groups will also be consulted outside of this process via Aboriginal Cultural Heritage Assessment (CHA);*
*** Heritage groups will also be consulted via the Heritage Impact Assessment (HIA)*

Targeted engagement during the scoping phase has been undertaken with stakeholders that are most proximal to the Project and who are located in the Local area and/or within Singleton LGA. However, subsequent phases of the SIA will seek broader involvement across the stakeholder groupings identified in **Table 2.2**.

In relation to proximal neighbours, a total of 126 residences have been defined as relevant to the Project. However, only 65 of these residences are located in the Hebden, Camberwell, Glennies Creek, Falbrook and Middle Falbrook localities and are privately owned (refer to **Table 2.3**).

Table 2.3 Potentially Impacted Residences

Localities	No. of Private Residences	No. of Glencore Owned Residences that are Tenanted	No. Other Mine Owned Residences that are Tenanted
Hebden	24	0	0
Camberwell	11	0	37
Glennies Creek	7	8	1
Middle Falbrook	23	7	1
Falbrook	0	9	0
Total	**65**	**24**	**39**

The population of the study area includes a high proportion of people in the 50 to 59 year cohort, and lower numbers of people in the 20 to 29 years cohort, when compared to nearby Singleton which exhibits a median age of 36 years (Australia Bureau of Statistics (ABS), 2016).

Given other Glencore project activities in the area (e.g. Mount Owen Continued Operations Project Modification 2 Project); engagement with stakeholders has been ongoing since April 2017. Engagement was also a key component of the SIA and EIS for the Mount Owen Continued Operations Project, with consultation with local landholders and key stakeholders also undertaken as part of these processes (refer to **Section 3.5.2** for further details).

2.4 Scoping potential social impacts

A participatory approach was adopted, to provide opportunities for informing and engaging with stakeholders about the Project, and for stakeholders to provide feedback about potential social impacts. Data on perceived social impacts were collected according to the methods described in **Table 2.4**.

Table 2.4 Methods for scoping social impacts

Method/Approach	Description	Targeted Stakeholder Group
Community Information Sheet (CIS No.1) (Nov, 2017) – Glendell Continued Operations	Community information sheet outlining the project and inviting feedback and questions was mailed to households in the local area and to key stakeholders.	Tenants Landowners Key stakeholders Residents in Local Area
Personal interviews/meetings	Individual meetings held in person or via phone, utilising a semi-structured interview guide/questionnaire (refer to **Appendix A**). Stakeholders contacted proactively via contact numbers. Where contact numbers were not available, letters have been mailed to inform the stakeholder about the Project and including attachment of CIS No.1.	Landowners Business owners Aboriginal groups Service providers Cultural and heritage groups
Focus group meetings	Group meetings to discuss the project and collate feedback about issues, concerns and aspirations.	Heritage groups Business Chamber
Online Survey	Online survey to identify potential project issues and impacts emailed to Chamber membership	Local Business Chamber members

Method/Approach	Description	Targeted Stakeholder Group
Government Briefings	Meetings with relevant local, state and Commonwealth government agencies to provide an overview of the project and project parameters, to discuss the assessment process and other relevant matters.	Local Government State Government Commonwealth Government
Community Consultative Committee	Project overview presented to the Mount Owen Complex and Integra Underground Mine CCC	CCC Members
Communique	Communique on Ravensworth Homestead to be issued in May 2018 outlining the formation of the RHAC and the process to date. Also inviting any further submissions for the relocation of Ravensworth Homestead.	Tenants Landowners Key stakeholders Residents in Local Area
Ravensworth Homestead Advisory Committee (RHAC) *	Monthly meetings of the RHAC to explore potential options for relocation of the Ravensworth Homestead. The Committee is independently chaired by Lindy Hyam. Meetings commenced in December 2017, with 6 committee meetings undertaken to date (December 2017 to April 2018). A number of key informants have been invited to inform the group process through presentations relating to heritage values, potential relocation and options selection. These informants have represented the following organisations/groups: Historical Houses Association of Australia Plains Clan of the Wonnarua People (PCWP). Two separate newspaper advertisements were also placed in the Singleton Argus. The first advertisement was for the establishment of the RHAC and the subsequent advertisement sought expressions of interest and ideas for the relocation of Ravensworth Homestead.	The Committee comprises 8 representatives from: • Local Area / proximal landholder • Former owners of the Homestead • CCC member • Heritage Groups/Organisations e.g. Singleton Historical Society, Tocal Homestead • Business Groups e.g. Singleton Chamber of Commerce • Glencore
Site Open Day	Engagement event hosted on site in December 2017 which included exhibition of project material, tours of the Mount Owen Complex and discussions with the project team. Approximately 20 community stakeholders were in attendance.	Residents from the Local area and key stakeholders

* Individuals from key sectors of interest were approached for involvement. Along with the Committee representatives as listed in Table 2.4; Singleton Council, the Singleton Heritage Committee, and Arts Upper Hunter were also approached seeking representation. However, each declined to nominate a representative.

Table 2.5 provides a summary of the number of stakeholders engaged during the scoping phase up to 1 April 2018. Consultation following this date has not been included in this scoping report, however will be ongoing throughout the SIA process. It is important to note that contact has been made with approximately 50 landholders either personally by phone or via email and/or letter where telephone contact details have not been available. A total of 17 tenants residing in proximity to the Project site have also been mailed letters of invitation to participate in the engagement program to date.

The first of a series of Community Information Sheets (No.1 – Project overview) has also been distributed to all landholders in the local area and key stakeholders to outline the Project and seek community input via a personal interview. Contact details of members of the Project team have been provided in this sheet to facilitate involvement.

From a key stakeholder perspective, interviews have also been offered to key service providers in the area, namely Mount Pleasant Public School and the Rural Fire Service; as well as businesses in the local area and members of the business community within the wider Singleton LGA. Four Aboriginal Groups (including the Native Title Claimant Group) have also been engaged through personal interviews.

A total of 19 stakeholders with an interest in heritage issues have been consulted through personal interviews and group meetings. Furthermore, briefings have also been undertaken with Singleton Council and key State government agencies as described in Section 5.0 of the PEA.

Table 2.5 Summary of Stakeholder Engagement (SIA Scoping Phase) by method

Stakeholder Group	Method of Engagement
Proximal Landholders Glennies Creek Camberwell Hebden Middle Falbrook Bridgman	Personal and telephone interviews Letters Emails
Proximal Tenants	Personal letters
Local Business Business Chamber (Committee) Business Chamber members Businesses in the Local Area	Project Briefing Online Survey (currently in implementation) Personal Interviews
RHAC Members	RHAC Meetings
Heritage/Historical Interest	Focus Groups
Aboriginal Groups	Personal Interviews
CCC Members	Project Briefing
Local Government Singleton Council	Project Briefings (x2)
State Government DPE DPE – RR	Project Briefings
Federal Government DoEE	Project Briefing
Members of Parliament Michael Johnsen Scot MacDonald Joel Fitzgibbon	Project Briefing (Michael Johnsen only) Personal letters
Service Providers	Personal Interview
Local Landholders and Key Stakeholders	CIS No. 1 – distributed to 200 stakeholders

Table 2.6 also provides further detail of stakeholders contacted and those who have participated in the scoping phase.

Table 2.6 Engagement statistics – Scoping phase

Stakeholder Group	No. contacted	No consultations (interviews/focus groups. Undertaken)	No. participants in interview or focus group^	No. declined	No. requesting information be sent	No. unable to be contacted and materials mailed
Proximal Landholders	50	20	32	6	3	21
Service Providers (in the local area)	2	1	1	1	-	-
Businesses (in the local area)	2	2	4	-	-	-
Singleton Business Chamber Committee members	7	1	7	-	-	-
Aboriginal Groups	4	4	4	-	-	-
RHAC Members	6	6	6	-	-	-
Heritage stakeholders	13	2 focus groups	13	-	-	-
TOTAL	**84**	**36**	**67**	**7**	**3**	**21**

^Interview responses may reflect the views of two or more people interviewed in a group setting

Quantitative and qualitative information collected through the engagement process has been analysed to inform the analysis as outlined in **Section 4.0**.

The next phases of the EIS and SIA programs will involve further engagement with these groups and other key stakeholders relevant to the Project, as outlined in **Figure 2.2** and **Table 2.2**.

3.0 Area of social influence

According to the SIA Guidelines in order to scope potential social impacts, an understanding of the Project's area of social influence is needed.

The SIA for the Project will include a social baseline study that documents the existing social environment, conditions and trends relevant to each of the social impacts identified during scoping. It provides a benchmark against which direct, indirect and cumulative impacts can be predicted and analysed and an understanding of pre-existing social pressures.

The social baseline study will include:

- description of the Project's area of social influence, building on the description prepared in this document, and
- quantitative and qualitative indicators and descriptors relevant to each potential social impact, building on any relevant indicators identified during scoping, and sourced through a combination of primary and secondary data sources.

A comprehensive baseline social profile is currently in development, however for the purpose of the SIA scoping report, a summary profile has been provided to obtain a preliminary understanding of the social environment and community context in which the Project is proposed. It identifies:

- the potential affected area
- key demographic indicators
- services and businesses within the area and
- key assets and values within the area.

This profile will be further developed to ensure that all baseline data relating to potential project impacts can be appropriately assessed (refer to **Section 4.0**).

3.1 Geographic Context

The main local communities of interest for the purpose of the SIA are located within the Singleton LGA. Localities neighbouring the proposed project area are summarised in **Table 3.1**.

Table 3.1 Localities relevant to the Project

Locality	Population	% Female	% Male	Median age (years)	Average No. of people per household	Total Occupied Dwellings
Hebden	42	51.2	48.8	39	2.3	**9**
Glennies Creek	37	54.3	45.7	48	1.9	**20**
Camberwell	83	50	50	37	2.5	**28**
Falbrook	27	43.8	56.3	32	1.5	**12**
Middle Falbrook	92	51	49	36	2.7	**34**
Singleton LGA	22,987	49.1	50.9	36	2.7	**7741**

Source: ABS 2016 Census data (ABS, 2016)

However the potential social impact of the Project may extend more broadly. In this regard, Singleton is an important nearby economic and service hub for the above communities with a population of almost 23,000 people. Although some residences near the proposed Project sit within the Muswellbrook LGA, Singleton is the main retail and service centre for the area. Residents also access services, employment and resources in Muswellbrook, Maitland, and Newcastle.

A survey undertaken of the Mount Owen Complex workforce in 2013 (Coakes Consulting, 2013) also highlights key residential and expenditure locations for employees and contractors associated with the Mount Owen Complex, including the Glendell mine operation. In summary, the report indicated that:

- Singleton (33%), Maitland (22%), Muswellbrook (10%) and Cessnock (7%) were key locations in which employees and contractors resided
- Mount Owen Complex workers directly contribute around $60M to various local economies annually (63% of which is spent in Singleton and Maitland)
- Singleton and Maitland benefit most from the Mount Owen Complex workforce contribution to local communities, through the highest household expenditure, use of local suppliers and greatest participation in community groups and
- Singleton and Maitland host the highest usage of health services and education institutions by Mount Owen Complex workers and other family and household members.

The above data will be further updated in the SIA to assist in further defining the area of social influence relevant to the Project. However, in summary, the geographic social area of influence for the SIA is likely to include:

- **Project Area:** covers all aspects of the existing and approved Glendell operation, broader Mount Owen Complex and the additional areas directly impacted by the Project
- **Local Area or Locality:** the surrounding statistical state suburbs (ABS, 2016) of Hebden, Glennies Creek, Camberwell, Falbrook and Middle Falbrook as outlined in **Table 4.1**
- **Singleton LGA:** the LGA in which the Mount Owen Complex operates
- **Maitland and Muswellbrook LGAs:** these are socially linked to the Glendell operation and Mount Owen Complex as locations where a large percentage of the workforce reside and are active in their home communities
- **The Upper Hunter Region**: defined as the State Electoral District (SED) to gain an understanding and appreciation of the wider region and
- **The State of NSW**: to afford a comparative assessment.

3.2 Historic Context

The Central Lowlands of the Hunter Valley is the traditional country of the Wonnarua people, one of the approximately 600 different clan groups or 'nations' present in Australia at the time of European contact. Although early records on traditional tribal boundaries are limited, it is understood that the country of the Wonnarua was centred on the Upper Hunter Valley. With the arrival of European settlers in the nineteenth century, traditional patterns of Aboriginal life were quickly and dramatically altered, with the spread of disease and rapid influx of new technologies and materials.

The Patterson's Plains area had been opened to several people from 1813 onwards, including the first free settler John Tucker who settled with his family in 1814. The earliest recorded journey that reached the Singleton area occurred during October and November in 1817. The expedition included William Parr and Benjamin Singleton. Benjamin Singleton returned to the area on another expedition in 1818. Two trips were made into the area in October 1819 and March 1820 by John Howe (Chief Constable of Windsor from 1813 to 1825) looking for a line of road for an overland route between Sydney and Newcastle. John Howe, Benjamin Singleton and the others who took part in these two expeditions, reached the Hunter River in the vicinity of Whittingham after 10 days in March 1820.

In 1821, Henry Dangar was commissioned to undertake a survey of the Hunter Valley to assess its suitability for settlement and farming, with the survey of the lower Hunter Valley and Upper Hunter Valley completed in 1822 and 1826 respectively. Settlement in the region followed closely behind Dangar's 1821 survey party, with settlers occupying land as far north as Singleton by October 1821. Early reports describing the suitability of the land for pastoral pursuits resulted in the establishment of large scale pastoral holdings.

Wool production, dairy farming and wheat growing were the predominant industries at this time. Horse breeding also became a thriving industry as early as 1822. Wheat production went into decline in the mid-1800s owing to the disease rust which struck severely in 1857. The late 19th century saw the decline of cropping along river flats as they were converted to dairying on pastures improved by pump irrigation. The pastoral and dairy industries continued to dominate into the 20th century. Coal was known to exist in Singleton and its surrounding areas since early exploration. The development of coal resources comprises an important part of the region's history of coal mining and began on a limited scale in the early 1900s, prior to a rapid expansion in the 1950s, with the establishment of large open-cut mines.

Coal mining and electricity generation have become major industries in the Singleton area since the 1950s with the first wave of collieries built to meet export demand at Liddell, Foybrook and Liddell State. Since the mid-twentieth century, coal mining operations expanded from the Cessnock/Maitland area to the triangle bounded by Singleton, Muswellbrook and Denman using highly mechanised, open cut surface mining techniques.

Mining operations at the Ravensworth East Mine (previously known as Swamp Creek Mine), date back to the early 1960's. Ravensworth East Mine was acquired in 1997 by Peabody Resources Ltd (Peabody) after an extended period of care and maintenance. In 2002, Xstrata Coal Pty Limited (Xstrata), (formerly Enex Resources and now Glencore) purchased Ravensworth Operations Pty Limited (Ravensworth Operations), which included Narama Mine (now part of Ravensworth Surface Operations) and Ravensworth East Mine.

Mining operations within the Mount Owen Mine commenced in 1993 under the management of Hunter Valley Coal Corporation Pty Limited (HVCC). Xstrata acquired Mount Owen Mine in 2003 and HVCC then became Xstrata Mount Owen (XMO). Xstrata has managed Mount Owen Mine, Ravensworth East and Glendell Mines as the Mount Owen Complex since 2004. In 2013 Xstrata merged with Glencore and the Mount Owen, Ravensworth East and Glendell Mines are now managed by Mount Owen, formerly XMO, now a subsidiary of Glencore.

Of particular European heritage significance in the Project area is the Ravensworth Homestead Complex which is currently located within Glencore's mining lease. The Ravensworth Homestead was constructed in the 1820's and was originally built and owned by Dr James Bowman, who was married to Mary Macarthur (daughter of John Macarthur). The property was operated principally as a sheep station, also running some cattle. Throughout time ownership of the homestead has changed a number of times. The property was purchased by the Marshall family in the 1930's and was in the family for approximately 70 years. In 1997, Glencore purchased the property from the Marshall family.

3.3 Governance

As noted in **Section 4.1**, at a local government level, the Project sits within the Singleton Local Government Area (LGA), which covers an area of 4,893 km^2 and has a population of approximately 23,000 people. As previously noted, some of the key localities associated with the Project however, particularly Hebden, sit close to, or share borders with, the Muswellbrook Shire Council.

Singleton Council comprises nine Councillors and one popularly elected Mayor. Services provided by Singleton Council include development planning and building, support and regulatory services to local business and industry, child care, library, youth programs and events, roads, waste and recycling, water and other residential services.

Adopted in 2017 the Singleton Community Strategic Plan 2017–2027 is the blueprint for the future of Singleton in the coming years, setting the course for a vibrant, progressive, sustainable, connected and resilient community. The plan outlines the Council's focus to improve, manage and promote growth within the region, across five key focus areas of pillars - People, Places, Environment, Economy, and Leadership.

Within these five categories there is a clear focus on meeting the needs of the community by:

- providing more educational services
- improving established services
- maintaining and improving facilities and infrastructure
- implementing more strategies around water and land management
- developing the region's tourism industry
- providing support and funding for local business
- attracting new investment to increase the diversity and resilience of Singleton's economy and
- providing improved communication and connectivity with community.

These values illustrate a desire to ensure a vibrant, cohesive and resilient community, while also encouraging growth, improvement and opportunity.

At a State level, the Project falls in the Upper Hunter State Electorate which has been represented by National Party Member Michael Johnsen since 2015.

Nationally, the Singleton region is represented by Joel Fitzgibbon (Australian Labor Party member) in the Federal seat of Hunter. The Labor Party has been in opposition at the federal level since the 2013 election.

3.4 Community Context – Capitals Analysis

Considerable research has been undertaken to consider what makes a community strong and resilient to change (see Coakes and Sadler, 2011). The potential of a community to adjust to and manage change is usually referred to as its resilience or its adaptive capacity.

An appropriate social profile for the Project should identify those key community assets which are imperative to establishing community resilience over time and address how community capacity can be enhanced to enable a community to better manage its key capitals and assets, so that robust adaptive capacities may be developed against sudden shocks, changes or threats to community way of life.

According to a number of sustainable society experts there are five key capital areas that should be assessed to define levels of community resilience (e.g. Beckley et al. 2008; DFID 1999; Ellis 2000; Hart 1999). This summary of community capitals, within the area of social influence, draws on a resilient community model, in which capitals are described within five key areas – natural, economic, social, human and physical.

For the purposes of this scoping report, the study area comprises the communities in closest proximity to the proposed project, including Camberwell, Glennies Creek, Hebden, Middle Falbrook and Falbrook. Data for Singleton, the nearest regional town and important hub for the area, are also included for comparison purposes.

Table 3.2 summarises key social and economic indicators for the Singleton and Muswellbrook LGAs compared to NSW.

Information obtained through consultation in relation to each of the five capital areas is summarised in the following sub-sections to provide an appreciation of landholder and key stakeholder perspectives, with a more detailed breakdown of different capital indicators across the Local area and Singleton LGA presented as relevant.

Table 3.2 Summary Capitals Analysis across Singleton and Muswellbrook LGAs and NSW

	Singleton (LGA)	Muswellbrook (LGA)	NSW
Economic Capital			
Top three industries of employment (%)	Mining (23.4%) Health Care and Social (7.7%) Accommodation and Food Services (7.6%)	Mining (21.9%) Retail Trade (8.8%) Health Care and Social Assistance (8.2%)	Health Care and Social Assistance (12.5%) Retail Trade 9.7%) Construction 8.4% Education and training (8.4%)
Largest occupation of employment (%)	Technicians and trades workers (17.8%), Machinery operators and drivers (17.3%)	Technicians and trades workers (20%)	Professionals (23.6%)
Unemployed (%)	6.1	8.2	6.3
Labour force Participation (15-85 years) (%)	64	59	59
Median weekly household income ($)	1,682	1,346	1,486
Tenure - owned (%)	30.63	26.28	32.24
Tenure - mortgage (%)	38.02	31.32	32.25
Tenure - rented (%)	28.42	38.91	31.75
Median monthly mortgage repayments ($)	1,950	1,733	1,986
Housing stress - renters	22.80	30.20	27.90
Low income families (with children)	10	17.30	9.9
Learning or Earning at ages 15-24 years (% of people aged 15-24yrs that are in education system or earning money	83.6	74	85
People receiving an unemployment benefit	4.8	7.9	4.0

	Singleton (LGA)	Muswellbrook (LGA)	NSW
Human Capital			
Population	22,989	16,080	7,480,231
Median Age (years)	36	35	38
Post-Secondary education (%)	45	38	49
Family composition (families with children/families without children %)	41/36	44/37	38/37
Age Pensioners (aged 65+) (%)	67.1	73.1	67.6
No Year 12 or Higher Education (%)	61	66	41
Highest level of educational attainment at Certificate Level III or IV qualification (%)	29	27	17
Rates of Respiratory Disease (per 100 persons) (2011-2012)	31.9	27.7	27.4
Estimated number of people aged 15 yrs and over with fair or poor self-assessed health/100 persons	14.6	16	14.3
Estimated number of people aged 18 Years and over who rated High or Very High Psychological Distress/100 persons	11	13.7	11
Estimated number of people aged 18 years and over with one of four risk factors (current smokers, high risk alcohol, obese, no or low exercise in the previous week)/100 persons	82.3	85.9	78.2
Residential Aged care places (per 1,000 population aged 70 years and over)	92.5	50	83.4
Early childhood development: AEDC, Developmentally vulnerable on one or more domains (%) - 2015	20.9	23.8	20.2
Allied health care instances at home (2014/2015) ASR/per 1000	8.6	7.2	2.7
Disability support pensioners (%)	4.6	6.5	5.2
Profound or severe disability and living in community 0-64 years (%)	2.8	3.6	3
Fertility rate (2013-2015) (%)	2.1	2.2	1.9
Median Age at death (years) (2010 - 2014)	80	78	81

	Singleton (LGA)	Muswellbrook (LGA)	NSW
Physical Capital			
Occupied private dwellings (%)	89	84	90
Travel to work - one method (largest %)	Car (70)	Car (72)	Car (58)
Residential Aged care places (per 1,000 population aged 70 years and over)	92.5	50	83.4
No Internet (%)	16.3	20.2	14.7
Home and community care program - Total Clients ASR/1000 (2014/2015)	47.1	48.9	36.7
Overcrowding - % occupied private dwellings requiring 1 or more extra bedrooms	2.2	1.8	5
Rent assistance from the Australian Government (%)	12.5	28.7	17.4
Social Capital			
Marital Status (married %)	51	45	49
Poor proficiency in English (%)	0.2	0.2	3.8
Volunteering (%)	21	18	18
Different address 5 years ago (%)	37	41	39
Assistance to persons with a disability (unpaid) (%)	11.3	10.7	11.6
Child care (unpaid) (%)	31	31.8	27.2

Source: ABS Census (2016); Social Health Atlas of Australia - New South Wales & Australian Capital Territory (Dec-2017)

3.4.1 Natural capital

The Singleton LGA comprises a range of natural assets, including mineable resources – particularly coal, as well as natural assets such as Lake St. Clair, Mt Royal, Yengo National Park and Wollemi National Park. Participants in the scoping phase described natural features as key factors in their decisions to live and work in the area. Key natural capital identified by participants included:

- Water ways, such as Glennies Creek, were considered essential for agriculture and also in enhancing quality of life for residents. In this regard, Aboriginal groups consulted also reported that community members had strong intergenerational connections to the land, and that waterways were particularly important assets for these connections

- Agricultural land, particularly farming land that had been developed and managed over a number of family generations

  "It's the farmland - the richness of soil and our generational property." – Landowner

- Wildlife in the area

  "Sound of the wind in the trees, pretty spot to be, love of land, trees, creek, wildlife – beautiful birds, lizards, squirrel gliders, possums, echidnas, quolls – along the ridge would make a good conservation area" – Landowner

3.4.2 Economic capital

Data show that the labour force status is consistent across Singleton and the local area, with rates comparable to the national average. Average annual income suggests high proportions of people within the lower income brackets of nil income and $20,800 to $25,999; and also the higher income bracket of $104,000 to $155,999 per annum.

Mining is the main industry of employment within Singleton and the local area, and reflects the central role of mining to the economy within the social area of influence for the project. Agriculture, Forestry and Fishing is also prominent in the local area.

As noted in **Section 3.1**, a survey undertaken of the Mount Owen Complex workforce in 2013 (Coakes Consulting, 2013) highlighted key residential and expenditure locations for employees and contractors associated with the MOC, including the Glendell mine operation. In summary, Singleton, Muswellbrook and Cessnock were key locations in which employees and contractors resided. Singleton and Maitland benefit most from the Mount Owen Complex workforce contribution to local communities, through the highest household expenditure, use of local suppliers, greatest participation in community groups and highest usage of health service and education institutions by workers and other family and household members.

Some participants, however, noted the heavy reliance on mining in the area and resented their area being referred to as a “mining community” given that a number of participants had no connections to the mine or the mining industry. For others, Singleton LGA was considered a “prosperous shire”, this being considered an incentive to live in the area and important to sustaining local businesses.

3.4.3 Human capital

According to the ABS (2016), the Singleton LGA broadly has a population of around 23,000, with around 40% of the population constituting families with children. Approximately 60% have no qualifications higher than Year 12 with the largest occupations of employment being technicians and trades workers (17.8%) and machinery operators and drivers (17.3%) reflective of an industry focus being mining (23.4%). Approximately 64% of the population participate in the labour force and the unemployment rate for the LGA (6.1%) is slightly lower than the state average of 6.3%. Health care and social services are also a prominent industry of employment (7.7%) as is accommodation and food services (7.6%). Around 30% of the population own their own home, are paying a mortgage (38%) or rent (28%). Housing stress is around 23%.

In relation to health, overall the health and wellbeing of residents in the Singleton LGA was comparatively good compared to Muswellbrook and NSW. For example:

- Rates of respiratory system disease (including asthma and chronic obstructive pulmonary disease) are slightly higher in Singleton LGA (31.9/100) than in the Muswellbrook LGA (27.7/100) and NSW (rate of 27.4/100) (PHIDU, 2017).
- A greater number of persons rated themselves as having fair or poor health in Muswellbrook LGA (16/100) than NSW (14.6) and Singleton LGA (14.3/100), and less adults in Singleton LGA reported high or very high levels of psychological stress (PHIDU, 2017).
- The rate of the adult population that have at least 1 of 4 health risk factors such as smoking, harmful use of alcohol, physical inactivity, and/or obesity, were higher in both the Muswellbrook LGA (85.9/100) and Singleton LGA (82.3/100), when compared to NSW (78.2/100) (PHIDU, 2017).
- There are a higher rate of persons in residential aged care in Singleton LGA (92.5/1,000) than NSW (83.4/1,000) and Muswellbrook LGA (50/1,000) (PHIDU, 2017).

- The proportion of children developmentally vulnerable in one or more domains (physical health and well-being, social competence, emotional maturity, language and cognition, communication) was higher in Muswellbrook LGA (23.8%) than in Singleton LGA (20.9%) and NSW (20.2%) (PHIDU, 2017).

However, hospital admissions are slightly higher in the Singleton LGA than the state average at a rate of 39,553/100,000 and allied health care instances at home also exhibit a higher rate at 8.6/1000 than the state average of 2.7/1000 (PHIDU, 2017).

3.4.4 Social capital

Participants in the engagement process reported that community identity in the study area has changed significantly over the last 20 years – partly due to the influence of mining and partly in line with changes to small rural localities nationally.

Participants reported that while the community previously comprised largely long-term landowners, there are now higher proportions of residents who rent in the area, particularly as many of the properties are owned by Glencore and other mining companies. For example, in Camberwell there are now only 5 residences occupied by owners, with the rest of the properties in the village occupied by renters, which maybe had less connection to the locality.

> *"Community has been destroyed by mining." – Landowner*
>
> *"Hurt when we lost good neighbours. Now we don't know our neighbours." – Landowner*
>
> *"We used to have events in the Hall, used to be a thriving community. Most people are now renters and not interested in neighbours – Community Spirit is lost" - Landowner*

However, more transience amongst community members, was also seen to be a benefit in that younger families were now living in the area and that *"young families invigorate the community"* (Landowner).

Interview participants who reside in the local area often reported intergenerational, family connections to the area:

> *"Born and raised here, have been living in this house my whole life. Remember having no water, but now because of Glennies Creek Dam there is water and irrigation. Have family buried at the local church".*
>
> *"Our family has been here for so many generations. I have a deep love of this land." – Landowner*
>
> *"Properties have stayed this size for a long time and have been in families for years."*
>
> *"Old houses still here, can see sites where families lived, it's family history and Australia's history"*

However, other families are now facing decisions about what to do with their land as they age towards retirement and younger generations have left the area. For some residents these connections remain strong in younger generations and there is a firm commitment to stay in the area.

In relation to history, a number of participants discussed in more detail, the heritage aspects of the locality and the family histories relating to these areas, which included:

- *Dulwich Homestead* – which was built by free settler James Glennie who arrived in the area in 1824 to take up an original grant. The first homestead consisted of a timber slab cottage, gardens and outbuildings; and later (1832) possibly a second timber homestead and school room. The current homestead, circa 1870, constructed by Thomas Ware Smart is Victorian style, single storey brick on sandstone foundations with slate roof, bull nose verandahs and ornate cast iron supports and French windows and shutters.

- *Ravensworth Homestead* – which can be traced back to 1824 when the first huts were built to accommodate overseers and a convict workforce. The stone cottage was built in 1832 and the main house in 1842. The complex also includes a large barn, stable and stone remnants of a convict quarters. The homestead was originally built and owned by Dr James Bowman, who was married to Mary Macarthur (daughter of John Macarthur). The property was operated principally as a sheep station, also running some cattle.

- *Hebden Community* – as outlined by a key landowner, the community has a lot of history with legend saying that Mt Owen was named after a convict that escaped from the homestead. The community has lost many properties, with heritage buildings including Cedarvale (built in the 1900s) and the Old Owensfield homestead (circa 1860) which was used as the old school house.

While there was a perception that the nature of communities and especially the villages of Hebden, Camberwell and Ravensworth, had changed irreversibly, there was a feeling that people who lived in the wider area were committed to the area and willing to support their community, with strengths such as a strong commitment to volunteerism noted.

> *"Singleton as a whole is a great community. There are so many people who do volunteer work and people are friendly." – Landowner*

3.4.5 Physical capital

Within the Singleton LGA physical community assets include 8 public schools, 2 private schools, a TAFE NSW campus, and a community college. The Singleton township also has a range of sporting amenities, retail centre, health facilities, child care providers and a range of service clubs. Singleton Council also provides most of the public utilities, including water supply, town sewerage services, domestic general waste and recycling collection services while energy for the Singleton LGA is provided by Ausgrid (Singleton Council, 2013).

Within the local area, amenities include one school – Mt Pleasant Public School, 2 community halls (Glennies Creek and Hebden Halls), and 2 Rural Fire Service sites (Hebden and Glennies Creek). Hebden Hall was relocated and renovated with support from Glencore and is currently used for a regular play library session, as well as some functions and community activities. Glennies Creek Community Hall is currently not utilised. As one landowner noted:

> *“Neighbours have been bought out. There used to be functions at Glennies Creek Hall, but no longer” - Landowner*

Residents in the affected area generally access retail, health, secondary school and social services in Singleton, only travelling to Maitland or Newcastle to access specialist health services or to purchase other specialised equipment and services. The data that considers types of tenure indicate fairly high rates of renting within the local area, most likely due to the fact that many of the properties within the area are now owned by mining companies and then rented to residents.

Interview participants indicated that they enjoy living in the area because it is out of town and provides them with space, while being easily accessible to the township of Singleton and with good access to larger regional centres such as Maitland and Newcastle.

> *"It's all close here.” – Landowner*

> *"I grew up on the land. It's important to have space around us."*

3.5 Community Issues

3.5.1 Local media analysis

The media summary in **Table 3.3** highlights a mix of media coverage over the past 3 years. These issues provide an indication of potential external responses that the Project may receive at a community level.

Very few issues have been highlighted in the media that relate specifically to the Glendell Mine operation, suggesting the strength of Glendell's communication and liaison with community and key stakeholders over the years.

Recent coverage relates to the activities of the Ravensworth Homestead Advisory Committee (based on media releases produced by Glencore), a recent contractor's death and industrial relations.

Table 3.3 Media Review

Date	Headline/Source/Summary
13 Feb 2018	**Ravensworth Homestead Committee seeking community input** The Singleton Argus *Ravensworth Homestead Advisory Committee is seeking input from members of the local community into future options for the historic Ravensworth Homestead. The committee was formed last year to look at relocation options for the homestead that could facilitate ongoing mining at Glendell open cut. The homestead is listed as having local historical significance. Contact details for community input provided.*
28 Feb 2018	**No one interested in the Planning Assessment Commission public hearings** The Singleton Argus *Opinion piece suggesting that neither proponents nor opponents to modifications or mines are now attending Planning Assessment Commission (PAC) meetings, unlike a few years ago when large crowds attended. Author suggests that this is due to a lack of faith in the PAC process.*
18 Jan 2018	**Death at Hunter Valley open cut coal mine being investigated** The Northern Daily Leader *A 39-year-old contractor died of a heart attached while driving a truck at Glendell open-cut mine.*
13 Dec 2017	**Glencore says enterprise agreements reached at all Hunter mine sites** Newcastle Herald *After six months of industrial action and negotiations Glencore and mine workers' union signed off on mine enterprise agreements for a number of sites, including Glendell open cut.*
6 Oct 2017	**Glencore are looking at options to relocate historic Ravensworth Homestead so they can extend the life of Glendell Open Cut** The Singleton Argus *Glencore is proposing to form an Advisory Committee to look at relocation options for the Ravensworth Homestead. Exploration drilling confirmed mineable reserves in mining tenements to the north of existing operations and Ravensworth Homestead overlies those mineable reserves.*
31 Jul 2017	**Department Planning and Environment fines Glencore $15,000 for a compliance breach** The Singleton Argus *A compliance breach in January this year at Glencore's Glendell mine near Camberwell has resulted in the company being fined $15,000.* *The Department's investigation identified that on January 18, 2017, a pre blast meteorological assessment conducted by the mine had determined that the blast should not be fired, however a decision was made to fire the blast.*

Date	Headline/Source/Summary
7 Jul 2017	**Two day strike planned for Glencore's seven Upper Hunter operations** The Singleton Argus *Workers from seven Glencore operations including five open cut mines will meet at Singleton Showground on Monday morning to hear from Construction Forestry Mining and Energy Union (CFMEU) representatives on the state of negotiations between the union and the company on new Enterprise Bargaining Agreements (EBA).* *Voting on a new EBA was recently held at Glendell mine and Mr Jordan said 96-97 per cent voted against that EBA.*
8 Jun 2017	**Glencore's Hunter coal mines hit by 48 hour strikes** Newcastle Herald *About 1400 Glencore mineworkers have voted for two 48-hour strikes that will hit most of the company's Hunter Valley operations.* *In some of the biggest industrial action on the coalfields for some time, the Construction, Forestry, Mining and Energy Union has endorsed a program of industrial action that includes a 48-hour stoppage on Thursday and Friday affecting five sites, with another 48 hours on Tuesday and Wednesday affecting seven sites.*
7 Dec 2016	**PAC approves relocation of electricity line** World Coal *The NSW Planning Assessment Commission (PAC) has approved an application to relocate a section of electricity transmission line to allow the continuation of coal mining at Glencore's Glendell coal mine.*
9 Dec 2014	**Hebden Hall handover** The Singleton Argus *Keys to a fully-refurbished Hebden Hall were recently handed over to the community by representatives from Glencore's Mount Owen, Glendell and Liddell coal operations. The handover completed a $250,000 project by Glencore and various contractors that involved relocation of the hall and a total restoration that included an extension to the original building.*

3.5.2 Operational Issues - Complaints and Previous Consultation Outcomes

3.5.2.1 Complaints Analysis

Complaints data from Glencore in relation to the existing Glendell mine provide an insight into key issues of concern, particularly for neighbouring landowners and residents.

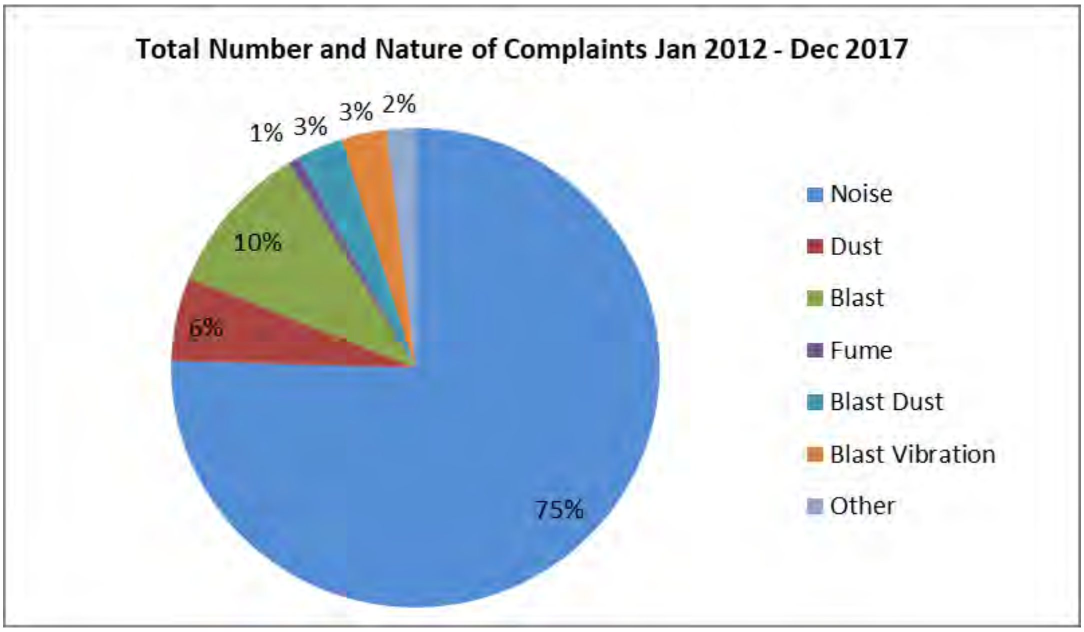


Figure 3.1 Total Number and Nature of Complaints Jan 2012- Dec 2017

Note: Total number of complaints from Jan 2012-Dec 2017 equalled 265

As **Figure 3.1** illustrates, since 2012 noise has been the biggest issue of concern for complainants in relation to the Glendell mine, constituting 75% of complaints received over this time period. Complaints however, while dropping in 2014, have steadily increased in 2015 and 2016, reducing again in 2017 (refer to **Figure 3.2**).

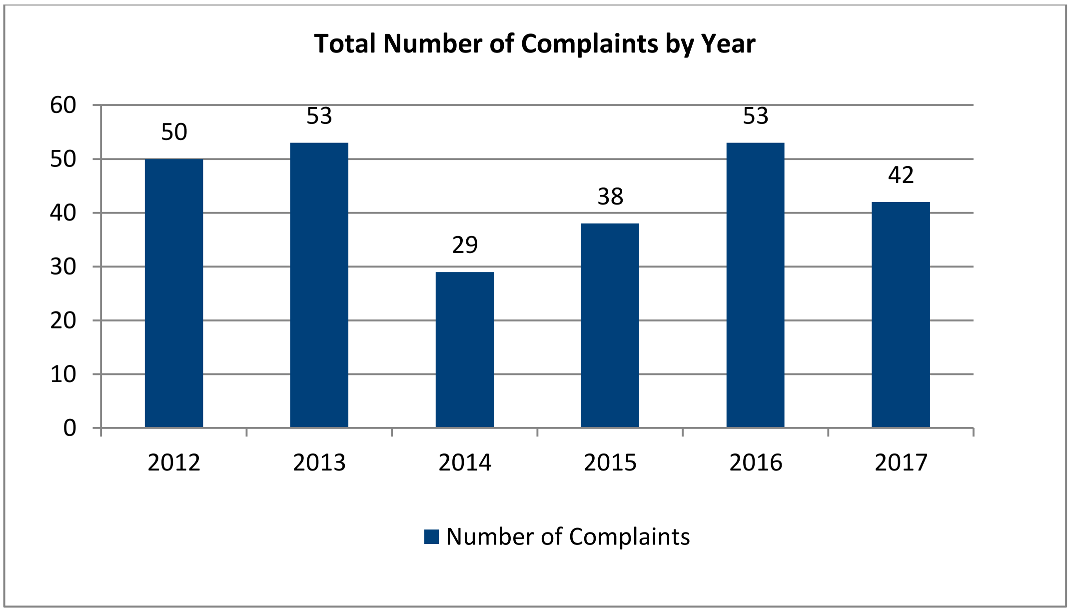


Figure 3.2 Glendell - Total number of complaints by year

Complaints between 2016 and 2017 (refer to **Figure 3.3**), although lower in number (95), were again dominated by a concern about noise and blasting to a lesser extent - blast dust and blast vibration.

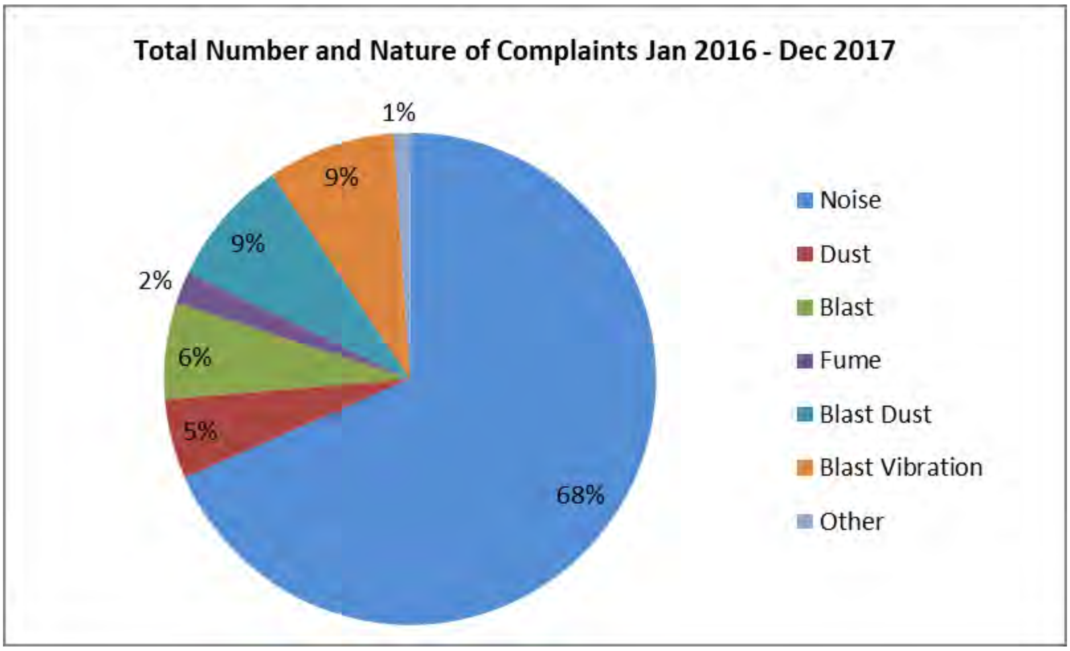
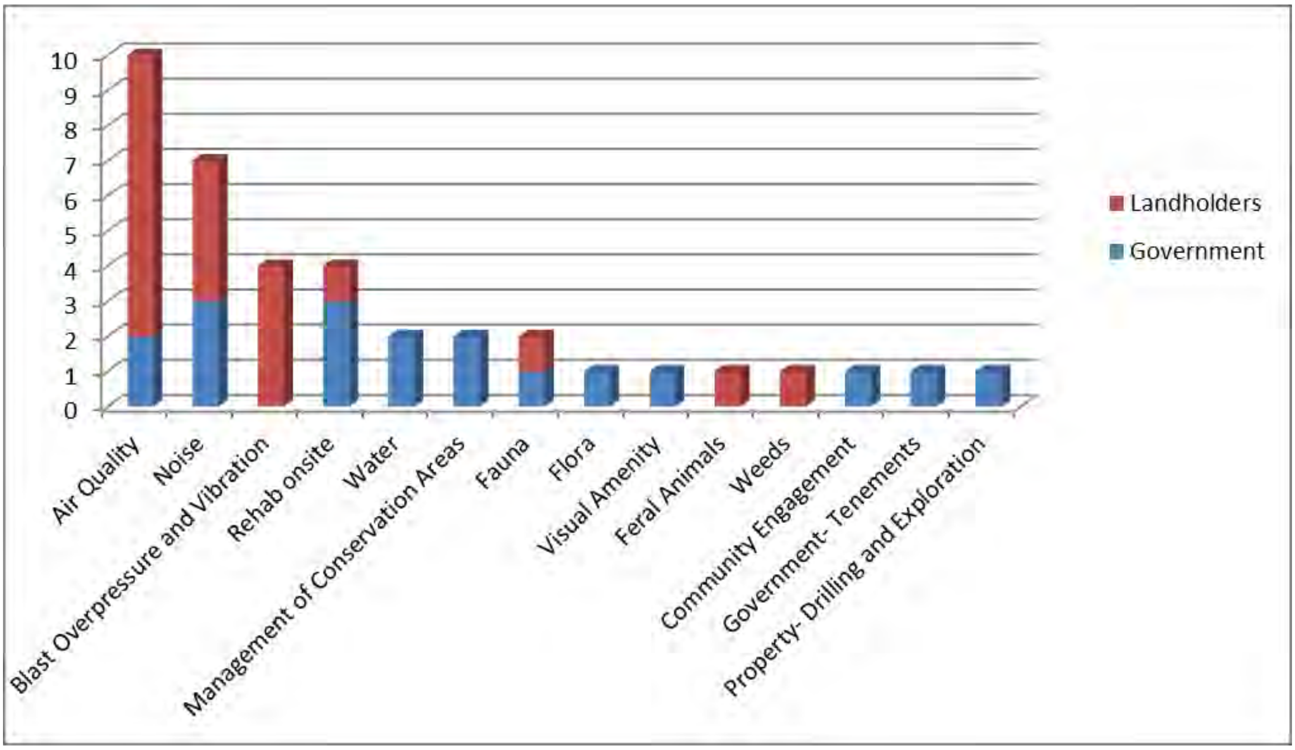


Figure 3.3 Percentage of complaints by nature of complaint (Jan 2016-Dec 2017)

3.5.2.2 Previous Engagement – Mount Owen Continued Operations Project Modification Project

Community engagement activities were undertaken by Mount Owen during April and May 2017 in relation to Mount Owen Continued Operations Modification 2 (MOCO Mod 2). Key stakeholders consulted included Singleton Council, DPE, Division of Resources and Geoscience (DRG) and local landholders to the southeast of the Mount Owen Complex.

In relation to the government consultation (state and local) a total of 18 issues were raised related to the Mount Owen Continued Operations Project Mod 2 Project, with the top three issues relating to noise and rehabilitation onsite, followed by air quality, water and management of conservation areas (refer to **Figure 3.4**). There were 20 issues raised by landholders with air quality identified as the key issue followed by noise and blast overpressure and vibration.



Note: Multiple responses allowed.

Figure 3.4 Preliminary issues raised by residents – Mount Owen Continued Operations Modification 2

It is recognised that there will be some overlap with landholders consulted as part of the Mount Owen Continued Operations Project Mod 2 with those to be consulted as part of the Project, particularly those landholders/residents located in the Middle Falbrook area. The issue analysis for the Mount Owen Continued Operations Project Mod 2 Project thus provides some indication of the issues that may be raised in relation to the Project.

4.0 Perceived Project Impacts

This section outlines perceived social impacts associated with the Project, as identified through the consultation with proximal landholders, local business and service providers, Aboriginal groups and stakeholders with an interest in heritage/historical matters, undertaken to date as part of the scoping phase (as outlined in **Table 2.5**). Briefings have also been undertaken with government representatives at local, state and federal levels and members of the Mount Owen Complex and Integra Underground Mine CCC members. Tenants residing in proximity to the project site were also contacted via letters to invite their participation; however no requests for engagement were received.

The section outlines the range of views obtained to further inform the SIA and broader EIA program in subsequent phases. As noted in **Table 2.5**, personal interviews and surveys were undertaken with landholders, businesses in the local area, Aboriginal groups and service providers.

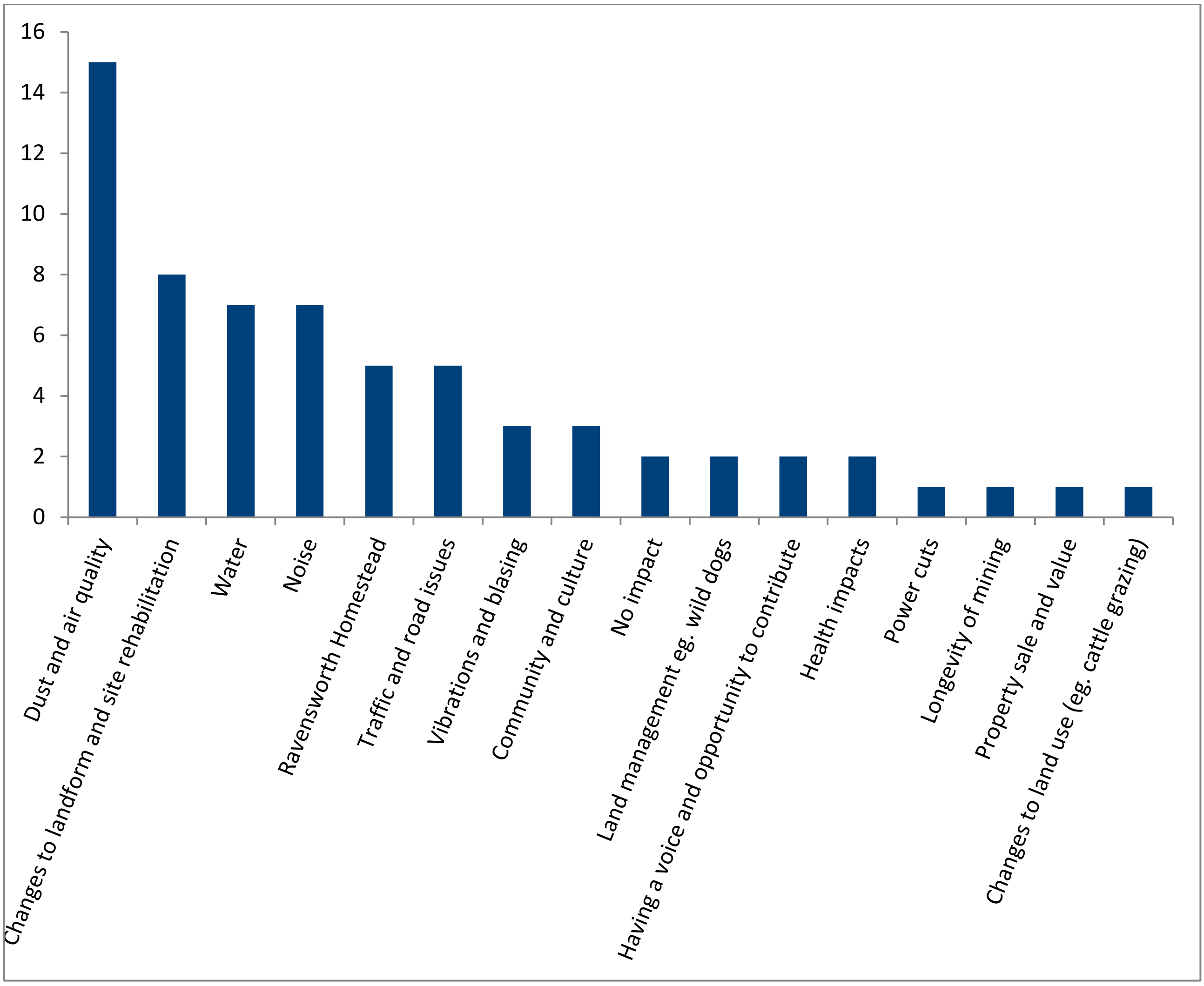
A detailed interview guide was developed to direct stakeholder interviews and to address key aspects noted in the SIA guideline. This information has been used to afford input to the scoping tool that indicates levels of community concern in relation to potential social impacts in relation to the Project. This information has also been used to inform future engagement activities for the EIS and broader SIA program.

In addition, interviews and focus groups were undertaken with stakeholders with an interest in heritage and members of the RHAC.

4.1 Perceived Project issues - Summary

Landholders, Aboriginal groups, local businesses and service providers in the local area were asked to identify (unprompted), their main issues or concerns in relation to the Project, with a range of issues noted. These issues have been collated and coded by impact theme and are presented in **Figure 4.1** below.

The most frequently cited concerns raised by stakeholders in the scoping phase related to dust and air quality, particularly the cumulative effects of this impact across a number of mine sites in the area. Changes to land form and the importance of appropriate site rehabilitation were the next most common project concerns identified. These were followed by concerns about potential impacts on rehabilitation water (including concern about the potential diversion of part of Yorks Creek, potential pollution of water ways and the impacts on drinking water), noise, the potential relocation of Ravensworth Homestead, road access and traffic issues.



Note: Multiple responses allowed. Data is based on the responses of 29 surveys, 49 participants.

Figure 4.1 Potential project impacts (unprompted)

These issues have been further categorised according to the social impact categories identified in the SIA Guideline and are summarised in **Table 4.1** with the majority of perceived impacts relating to surroundings.

Table 4.1 Potential project impacts by SIA impact category

	SIA Category									
	Issue/ Category	Way of Life	Community	Access and Use of Infrastructure, Services and Facilities	Culture	Health and Wellbeing	Surroundings	Personal and Property Rights	Decision making systems	Fears and aspirations
Issues of Concern	Dust and Air Quality					■	■			
	Changes to landform and site rehabilitation						■			
	Water						■			
	Noise						■			
	Ravensworth Homestead		■		■		■			■
	Traffic and Road Issues	■		■						
	Vibration and Blasting						■			
	Community and Culture		■		■					■
	No Impact									
	Land Management eg: wild dogs						■			
	Having a voice and opportunity to contribute								■	■
	Health impacts					■				■
	Power cuts			■						
	Longevity of mining									■
	Property sale and value							■		■
	Changes to land use (eg: cattle grazing)	■					■			■

Participants were then asked to consider a range of pre-identified potential issues relating to mining activities and to rate their level of concern about these issues, where 1 indicated ‘no concern’ and 7 indicated a ‘high level of concern’.

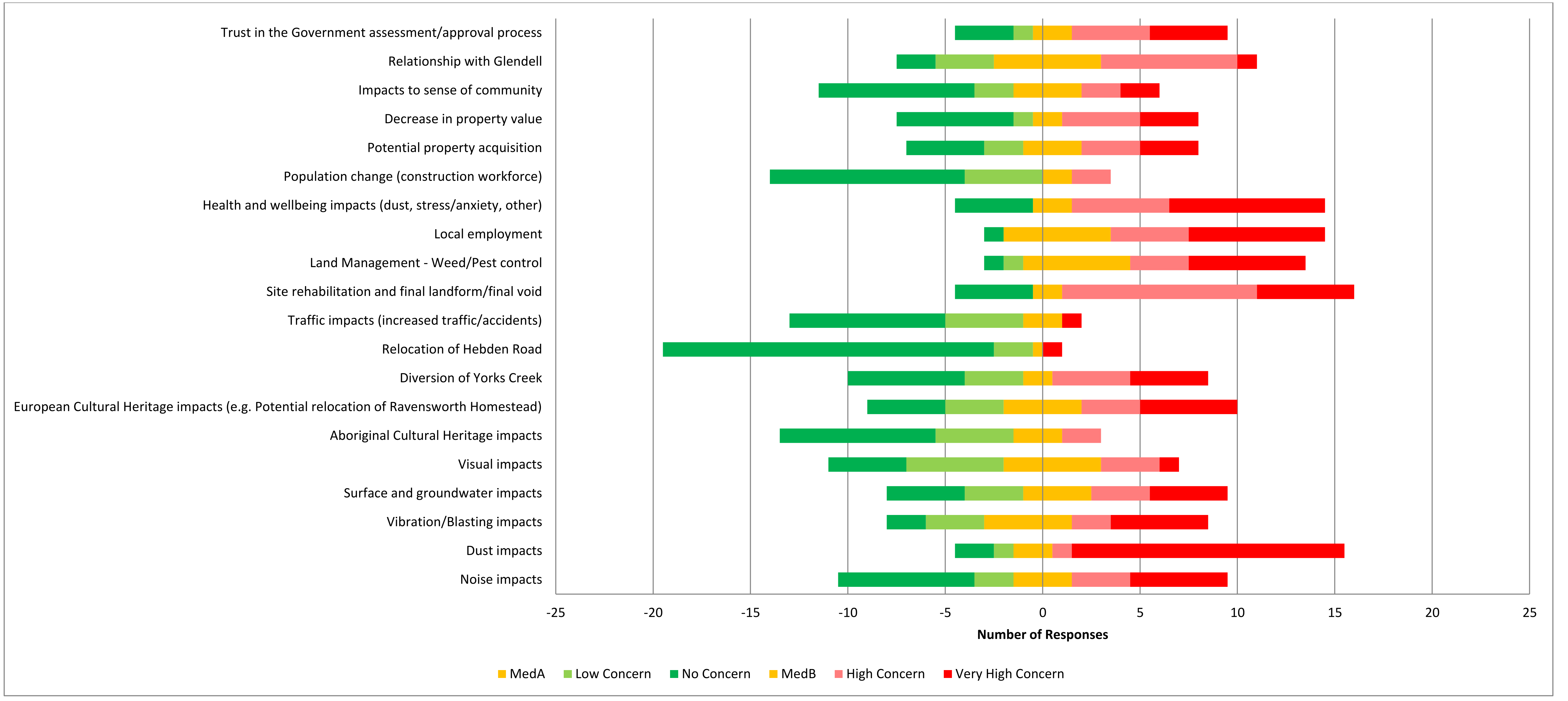


Figure 4.2 Levels of concern relating to potential project impacts (Prompted)

Note: Based on the responses from 22 surveys, which involved 36 participants. Not all participants responded to all prompted impacts

.

As **Figure 4.2** illustrates, when prompted, participants again identified further impacts of dust/air quality, land management and site rehabilitation and final landform in relation to the Project. Other issues of relevance included health and wellbeing, particularly stress/anxiety related to living with environmental impacts such as dust, the positive impact of employment, particularly given previous downturn in the mining sector. Lack of trust in the assessment process was also noted.

A level of concern was also indicated in relation to European cultural heritage impacts, particularly the proposed relocation of the Ravensworth Homestead (refer to **Section 4.4** below), the part diversion of Yorks Creek and surface and groundwater impacts more broadly.

In relation to the proposed relocation of part of Hebden Road, this was identified as a greater issue of concern to business operators and service providers. These stakeholders noted the importance of the new, diverted road being in place before closing off the old road and the need to ensure good access at all times in order to ensure business continuity and access for emergency services. Residents who regularly use Hebden Road noted the importance of the road diversion being managed in a way to minimise disruptions, as a result of road diversion works and due to blasting, with the additional note that power cuts associated with mining and construction should also be minimised. Very few residents were concerned about the proposed additional 1.3 km length. The benefit of improved road infrastructure, consistent with the current Glencore-funded bypass over the rail line was also noted. The following sections provide further detail on each of the issue themes identified.

This data is further illustrated in **Figure 4.3** with average levels of concern recorded by impact theme. It should however be noted that not all prompted impacts were responded to by participants.

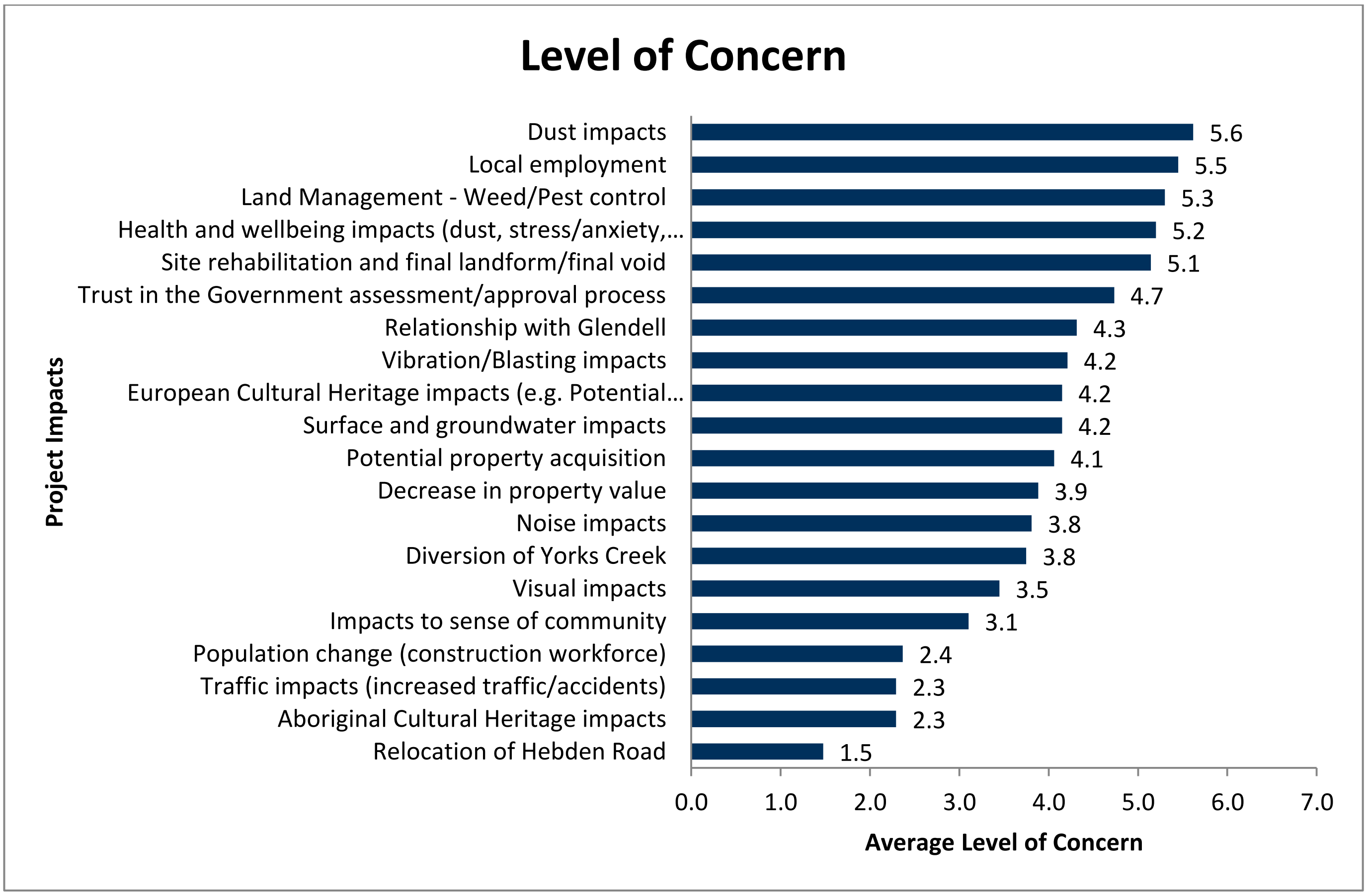


Figure 4.3 Average levels of concern for potential project impacts (prompted)

Note: Based on the responses from 22 surveys, which involved 36 participants. Not all participants responded to all prompted impacts.

4.2 Perceived Negative Social Impacts

Drawing on the qualitative and quantitative data collected during the scoping phase of the SIA, the following issues have been identified as key potential negative social impacts of the Project.

4.2.1 Dust

Dust, and its potential impacts on social amenity and health, was the most commonly cited concern in relation to the Project. Concerns were related not only to the potential additional dust associated with this project, but particularly with the cumulative impacts of dust from Glendell mine and other operations in the area.

It was considered that the proposed expanded area of mining, and duration of mining of the Proposed Glendell Pit Extension, would exacerbate this existing issue, but that there was likely little that could be done to mitigate the problem of dust. Participants recognised that dust accumulates from a number of sources, including various mine sites and from grazing land, particularly during periods of drought.

> *"It is dry and dusty anyway, but there is a lot of coal dust." - Landowner*

Dust was considered problematic for its impacts on health, particularly respiratory issues and asthma.

> *"Our daughter is asthmatic and can't stay here for longer. After a couple of days she feels terrible." – Landowner*

It was also perceived to be problematic for contaminating water supplies, particularly for the many households in the area who rely on tanks as a water source. There was some concern about the lack of knowledge of the effects of coal dust in water supplies, with some landowners suggesting that more rigorous testing of water would be helpful.

> *"The gutters are full of coal dust - water tank cleaning doesn't help with this." – Landowner*

Dust was particularly frustrating for nearby residents, as there was perceived to be little done to mitigate its effect, and it was difficult to pinpoint dust sources by operation.

4.2.2 Rehabilitation and landform

Rehabilitation of the site and the final voids were issues of concern to many participants. Even those participants who considered that rehabilitation strategies had improved in recent years, tended to rate this as a priority issue, noting that it is an important responsibility of Glencore to restore the land after the closure of the operation. Some participants noted that land rehabilitation strategies have improved substantially in recent years, and cited local examples.

> *"They have done it beautifully at Ravensworth." – Landowner*

Some participants felt that there should be a bigger effort to do rehabilitation quickly and that it should be an ongoing process as the operation progresses.

> *"They should be rectifying as they go." - Landowner*

Many people were concerned about long-term damage to the landscape and the capacity for mitigation and rehabilitation strategies to adequately address such damage.

> *"Land is supposed to be returned to how it was before, but it never looks the same." – Landowner*

Participants considered it important that after the completion of the project land should be useable, with some noting the potential for rehabilitated land to be useful grazing land for stock.

"You need to ensure land is usable after the project." - Landowner

4.2.3 Land management – weed and pest control

Land management was noted as an issue of concern for many participants in the scoping phase, as an ongoing issue to be managed and mitigated against, and is of concern to landholders given their ongoing interest in maintaining land productivity and their rural lifestyle.

A number of local residents had experienced issues with wild animals, including dogs and pigs. Dogs were considered a particular threat to livestock. Recent efforts between Glencore, other local business operators and local residents in areas such as baiting were considered important to continue.

"Wild dogs management is important" – Landowner

"Dogs travel a long way and we need coordinated baiting." – Landowner

While participants noted that weed management is difficult in any rural and agricultural setting, they considered it is important that Glencore continue to support mitigation efforts in this area. Weeds such as cestrum, which have deadly consequences for some livestock, were of particular concern. Some participants worried that offset areas, or land owned by Glencore where there was no active project, were often sources of weeds and these should be managed closely.

"The weeds and pests are a problem especially on the offset country." - Landowner

4.2.4 Water

Issues associated with water were particularly sensitive for stakeholders and are important considerations for mitigation. All participants noted the importance of water in sustaining their rural lifestyle – for some people they were concerned about risks associated with the mine's impact on water and for others they were confident that effective mitigation would minimise risks. Water was considered vital to sustaining agriculture, and sources such as Glennies Creek were identified as vital social and physical assets. Connections to water and to the creeks in the area were considered important for Aboriginal people prior to colonial settlement, and the local water assets key to maintaining lifestyles and livelihoods.

"Water is life." - Landowner

Responses to the proposed diversion of Yorks Creek varied substantially. Some participants did not feel that the proposed diversion would be problematic, with one landowner even suggesting it may make an improvement to water flow. Where participants were familiar with successful examples of creek diversion, such as the Bowman's Creek Diversion project by Ashton Coal (which won a NSW Minerals Council Environmental Excellence Award) there was a greater confidence in the ability of this project to mitigate risks associated with creek diversion.

"Bettys Creek diversion was done well." - Landowner

However, for those people who had seen problematic examples of creek diversions, they were not confident that this type of diversion could be done without the risk of significant damage to creek flow. Some people also felt that, as a general principle, natural waterways should not be altered or changed.

"Should you mess with a natural creek?" - Landowner

4.2.5 Noise

Noise was identified as the fourth issue of concern in relation to the Project (unprompted). Some participants outlined issues with operational noise, particularly the loading of trucks; with noise identified as being worse at night and on the weekend.

> *"Noise, especially from trucks loading"*

Cumulative noise was also considered an issue, particularly for residents in the Camberwell and Glennies Creek localities; with a view expressed that it was "*very hard to tell where it is coming from*", given the presence of a number of operations.

A number of participants however felt that noise would improve as the mine moved away and may therefore be less of a concern.

> *"Noise from Glencore will be moving away"*

When the issue was prompted a greater range of response was obtained, with some people concerned or very concerned with noise from operations and others much less concerned.

> *"Noise is not too bad, though we sometimes hear Mount Owen in the mornings."*

4.2.6 Roads and accessibility to neighbouring areas

Concerns regarding road access varied depending on the stakeholder group and the geographic location of the participant. Business operators and service providers expressed particular concern about maintaining the accessibility of the roads, particularly Hebden Road. They noted the importance of the new, diverted road being in place before closing off the old road and the need to ensure good access at all times to facilitate business continuity and access for emergency services.

Residents who regularly use Hebden Road noted the importance of the road diversion being managed in a way to minimise disruptions, as a result of road works and closures due to blasting, with the additional note that power cuts associated with mining and construction should also be minimised, and few were concerned about the proposed additional 1.3 km length.

While potentially-affected residents and business owners noted caution about the impacts of road closures on their way of life, travel to work and to transport children to school, they also noted the potential benefits of an improved road and many referred to the benefits of the Glencore-funded bypass over the rail line currently being constructed on Hebden Road to minimise traffic queuing.

> *"You need to ensure road access." – Emergency service provider*

There were few concerns expressed about additional traffic, but a couple of participants noted that there was often movement of traffic between the various Glencore mine sites.

4.2.7 Value of property and opportunity to relocate out of area

Many participants reported a sense of exhaustion with the impacts of mining, with most residents being in the affected area for multiple mine sites.

> *"I wish you'd all pack up and leave. It just seems to extend, extend, extend." - Landowner*

Those residents who live in the area generally do so because they value living in a spacious rural area with good water access, wildlife and often with strong family and intergenerational connections. For some people with long-term family links to the area, there was a commitment not to leave the area and therefore little concern regarding the issue of property value. For some of these people a bigger issue was ownership of large tracts of land by mining companies, thus decreasing opportunities to expand their own properties or purchase neighbouring properties.

However, many participants perceived that the value of their properties had decreased as a result of proximity of mining operations. For some, particularly those people who were on the verge of new phases of their lives such as retirement, there was concern that they now had limited capacity to sell their homes and move closer to town or to more suitable properties.

> *"If you're near a mine your house doesn't have as much value." – Landowner*

> *"The more mines in the area, the more it [property value] decreases." - Landowner*

Some participants were concerned that their property was not zoned to have acquisition rights, despite still bearing the frustration of issues such as dust; or were uncertain as to whether they had current acquisition rights and what this process would entail.

> *"I'm only in the management area so I don't have acquisitions rights. Now I worry that my property is devaluing." – Landowner*

A small number of participants noted that the proximity to mining did not actually decrease property value, and that property values had actually increased.

> *"Because there is so much offset land there's not much land available to buy and farm - it pushes prices up." – Business operator*

4.3 Perceived Positive Social Impacts

Most landowners and key stakeholders consulted reported that, with the proposed increased timeframe for the Project, they see that the costs associated with dust, water quality and land destruction, outweigh the benefits for people living in close proximity. They suggested that there needs to be a strong emphasis on investing back into the local community, via employment, local economic activity and community and social investment, to redress these costs.

4.3.1 Employment and economic activity

Stakeholders identified that opportunities for employment, particularly for local residents, are an important potential benefit deriving from this Project. For local residents the potential for employment was an important offset to living with impacts such as dust and noise. Some participants noted that the employment opportunities – whether directly with the mine or indirectly – were important for their children and grandchildren and saw these opportunities as an important sustainability issue within the community.

Most importantly, it was considered that economic activity associated with the Project should have maximum benefit for locals, with as much employment and commercial opportunity as possible retained within the Singleton LGA.

> *"It's important to employ local people. I'm against fly in fly out." – Landowner*

As noted in **Section 3.1**, a large majority of the workforce at the Mount Owen Complex reside in the Singleton and Maitland localities, with a high proportion of workforce and supplier annual expenditure also being expended in these areas.

4.3.2 Local development of roads and infrastructure

Stakeholders recalled recent improvements to roads and infrastructure, particularly the overbridge being built over the railway crossing on Hebden Road, and cited these as positive impacts of Glencore's presence in the area.

> *"This [infrastructure] stays to benefit community after operations have finished." – Landowner*

Potential changes to the roads, particularly the diversion of Hebden Road, were well received on the proviso that the road constructed would be good quality, road closures would be minimised, and potential flood-affected roads and crossings would be mitigated.

Contributions of the Project to the development and improvement of local roads (in close proximity to the Project) and infrastructure are important opportunities for residents to realise potential benefits.

4.3.3 Company engagement and investment in community and culture

When asked about their current relationship with Glencore and the company's management of impacts to date, participants generally reported that, while they may have concerns about current projects in relation to dust, noise and damage of landscape, they generally found Glencore staff to be communicative and accessible; and that the level of communication between Glencore staff, and in particular the Glendell mine, had improved in recent years.

> *"Pretty good, especially now. Open dialogue and communication is important." – Landowner*

> *"They keep me informed, that's what I like." – Landowner*

> *"Good – we know who to call if needed"*

> *"Personal visits did not use to happen in the old days, great they do now. Good to get newsletter and had a good visit with Brad and Ned"*

> *"Don't have a lot of contact, but attended Open Day last year which was helpful"*

However, some participants felt that they had to work hard to get mine staff to respond to their concerns, and expressed that they were not always provided with transparent information or an opportunity to really have a voice in influencing decisions.

> *"Now they are more upfront, in the past we have had to chase down information" – Landowner*

> *"Some issues in the past, but good now and they are good neighbours. It works well, if you treat each other with respect" - Landowner*

> *"We get treated like the village idiots – our concerns are not taken seriously and we are not really listened to" – Landowner*

> *"I don't want to fight to get things done. I had to fight to get my tanks cleaned." - Landowner*

Business, service and community organisation representatives noted that their communication with Glencore was generally positive and on an 'as-needs' basis. Certain key stakeholders had not had much contact with Glendell staff recently, and were pleased that communication now seemed to be opening up.

Participants in the consultation were also asked about their knowledge of existing Glencore community investment activities, and to provide their ideas about future investment priorities. Most participants were aware of contributions to groups such as schools, sports groups and community infrastructure. It was generally considered that Glencore is *"a company responsive to community"* (Landowner). A few participants also noted that community investment is a stipulation for mining companies and that this type of contribution is an obligation.

In relation to company investment in the community, there was also an overall view that Glencore contributed to the local community; however there was a feeling that this was expected and that maybe more could be done for the broader Singleton LGA but also maintaining a focus on localities in which operations were based.

> *"I had a good read about the investments at the Open Day and didn't realise there were so many"*
>
> *"Generally if a community group has a fair request for a grant it is supported"*
>
> *"Generous, especially to the Mount Pleasant School – more than other companies which is as it should be"*
>
> *"It needs to be investment in Singleton itself, for the long-term, not just sports jerseys and sports teams"*
>
> *"Too much in Singleton, need to keep it local"*
>
> *"Some people expect the mine to pay for everything. Better to be in partnership. It's great to see that the renovated Hebden Hall is being used"*
>
> *"We see too much money going to Maitland and Newcastle. There is not enough evidence of local benefit"*
>
> *"Really appreciate their sponsorship. The mines don't do enough to let people know about the good things they do – they don't sell themselves enough."*

Key suggestions from stakeholders for future investment of community funds, and also for potential partnership or enterprise models, include:

- Ensuring that this type of investment stays 'local' (for some people this meant within the Singleton LGA, for others it meant within the communities in close proximity to the project);
- Using local health services for mine staff's health checks;
- Procuring locally for environmental and labour services;
- Ongoing support to Mt Pleasant school;
- Support programs that provide positive opportunities for young people;
- Supporting programs that improve the welfare and wellbeing of local people, such as support for people who are homeless;

- Support for local heritage and historical activities;
- Support for community education and the arts; and
- Supporting local services and associations such as community hall groups, Rural Fire Service and hospital.

Some Aboriginal groups, in particular, noted that partnership and collaboration with Glencore had enabled the development of innovative cultural, educational and environmental activities. However, it was also felt by some of these groups that the benefits and advantages were not equally distributed and that there are currently missed opportunities for partnership to develop innovations in health service delivery, employment, arts and community education.

4.4 Potential impacts on the Ravensworth Homestead

As noted earlier, potential impacts of the Project on cultural heritage and particularly the Ravensworth Homestead has been highlighted as a key social impact issue. As outlined in **Section 2.3**, a number of stakeholders with a particular interest in heritage have been engaged in the scoping phase of the SIA to ascertain their views in relation to potential social impacts on the homestead of the Project.

Furthermore, stakeholders have also been invited to participate in an advisory group – the Ravensworth Homestead Advisory Committee (RHAC) – to explore potential options for the homestead to be relocated should relocation be considered an appropriate mitigation and enhancement strategy by the NSW government. Individuals from key sectors of interest were approached for involvement. Singleton Council, the Singleton Heritage Committee, Singleton Historical Society & Museum, and Arts Upper Hunter were approached seeking representation for participation in the RHAC. However, the Singleton Historical Society & Museum was the only group to provide representation.

The RHAC membership includes local landowners, a representative of the Mount Owen Complex and Integra CCC, a representative from the business sector, historical and heritage experts and former owner of the homestead from 1930 - 1997. The RHAC is facilitated by an independent chair and additional advisors have been brought in to discuss key aspects of the Project with the RHAC, including technical, heritage and Aboriginal experts. The group has met at least monthly since December 2017 to discuss values associated with the homestead and to explore potential relocation options and their viability.

In addition, to the above, landholders consulted as part of the scoping phase of the SIA have also been asked to provide their input on the homestead and its future in the locality. In this regard, participants in focus groups and interviews were asked to reflect on the values they associated with the homestead, including their impressions, interactions, experiences of, and relationships with the homestead complex.

Figure 4.4 and **Table 4.2** illustrate the many values and perceptions identified by RHAC members, key heritage stakeholders and Aboriginal groups in relation to the homestead. These values have been further categorised in line with the Burra Charter Values, which relate to historic, scientific/evidential, social and comparative values associated with the homestead. Certain values are represented across multiple value categories. These values reflect the perspectives of those interviewed and will be used to further inform more detailed social and heritage analysis for the SIA.

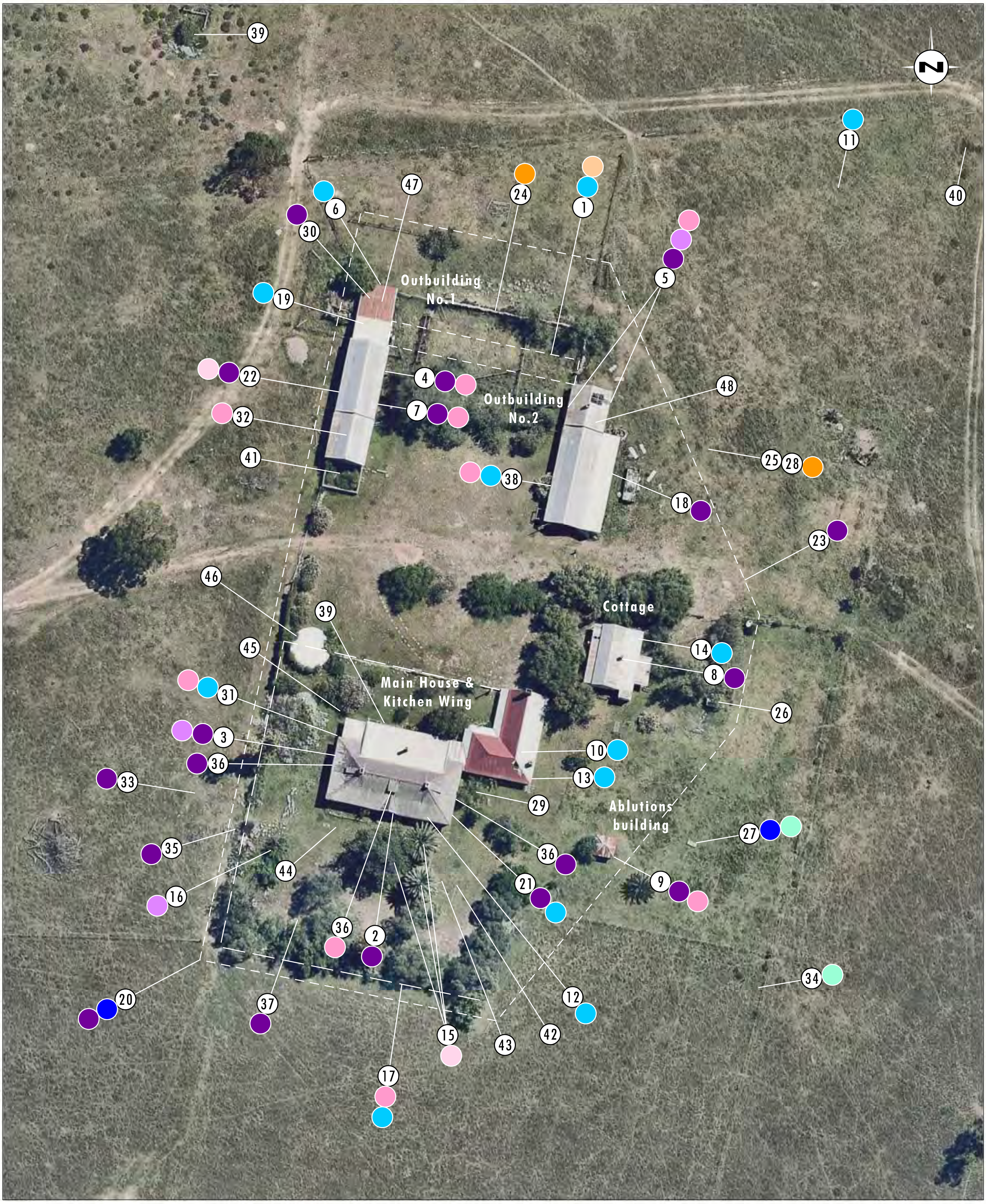


Image Source: NearMaps (Nov 2016)

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Legend

Historical Value:
- People
- Events

Aesthetic Value:
- Design/style
- Craftsmanship
- Technology of construction
- Relationship to context

Scientific Value:
- Research
- Interaction with other buildings

Social Value:
- Commemorative

FIGURE 4.4

Ravensworth Homestead

Table 4.2 Value Description associated with the Ravensworth Homestead values map

Burra Charter Value	Subcategory	Description of Value	Map Ref.
Historic	People	Perception that Bowman and MacArthur were well educated - brought the design with them from the UK. Unusual compound for Australian homesteads.	20
		Family grave - thought to be the grave of the manager's daughter. Potential for other graves, including James Bowman?	27
	Events (subject to further investigation)	Convict quarters - interplay between convicts and homestead	1
		Agricultural history and equipment used e.g. wool bins and round wool table	6
		Early Australian - pantry/store room and meat safe characteristic of early Australian life	10
		Changing land use - from sheep to cattle, with Lucerne hay production	11
		Stages of building - main house circa 1840	12
		Stage of building - original cottage (kitchen wing) circa 1832	13
		Stages of building - additional cottage c.1906 – c.1930	14
		Wool table and wool bins still present.	19
		Dummy windows on western side of main house - reflective of window tax.	31
		Dummy windows on western side of outbuilding 2 - reflective of window tax.	38
		Stone wall around house – majority in good condition made from convict stone	17
		Stranger's room - for passing travellers. Stories important e.g. strangers room where anyone could stay there.	21
Aesthetic	Design/style	Front façade	2
		Natural stone architecture and detail (western side)	3
		Arches - design (three arches)	4
		Built form - hand hewn stone and stone lintels above windows and door	5
		Stables and shearing shed - important arch entrance	7

Burra Charter Value	Subcategory	Description of Value	Map Ref.
		Original features in cottage e.g. fireplace	8
		Unique ablutions block. Four seater dunny - with two small seats and two large seats. When the family lived there a woodheap was next to the toilet and they would take wood inside when they came back from the toilet.	9
		Barn – used to store hay – 1966.	18
		Stranger's room - for passing travellers. Stories important e.g. strangers room where anyone could stay there.	21
		Stables, shearing, dairy in one building.	22
		Idea of long term confidence 1820s-40s era - stone outbuildings	23
		catching pen	30
		Original drive way used to be around fig but Jenny and her husband never used it	33
		Original gate to garden	35
		Trees garden within the direct compound clean boundary - unique that it is in a clearly defined compound/complex	37
		Designers Bowmen and MacArthur well educated - brought the design with them from the UK. Unusual compound for Australian homesteads.	20
	Craftsmanship	Millstone seat (made of rounded stone) used for setting steel wheels	16
		Natural stone architecture and detail (western side)	3
		Built form - hand hewn stone and stone lintels above windows and door	5
	Technology of construction	Stone wall around house – majority in good condition made from convict stone	17
		Wooden beams in outbuilding 1	32
		Ventilation/peaks on main house might have been installed around 1906	36
		Dummy windows on western side of main house - reflective of window tax.	31
		Dummy windows on western side of outbuilding 2 - reflective of window tax.	38
		Arches - design (three arches)	4

Burra Charter Value	Subcategory	Description of Value	Map Ref.
		Built form - hand hewn stone and stone lintels above windows and door	5
		Stables and shearing shed - important arch entrance	7
		Unique ablutions block. 4 seater dunny with 2 smaller seats and 2 larger seats. When the family lived there a woodheap was next to the toilet and they would take wood inside when they came back from the toilet.	9
Scientific	Relationship to Context	2 palms and Moreton Bay fig	15
		Stables, shearing, dairy in one building.	22
		Foundations of convict quarters	24
		Underground brick tank	25
		Old hand pump (no longer there)	28
	Research	Convict quarters - interplay between convicts and homestead	1
	Other	Chook shed.	26
		Outdoor spa remains where grassed depression and old piping is located (Marshall family)	29
		Cattle yards and slaughter shed	39
		Sheep yards with 20 stands, pulled down during WWI	40
		Open water tank	41
		Tennis court	42
		Obelisk (used as surveyors mark)	43
		Lemon tree (now gone)	44
		windmill used to pump water from water tank	45
		Water tank (replaced)	46
		sheering shed	47
		Quarters for convict managers	48

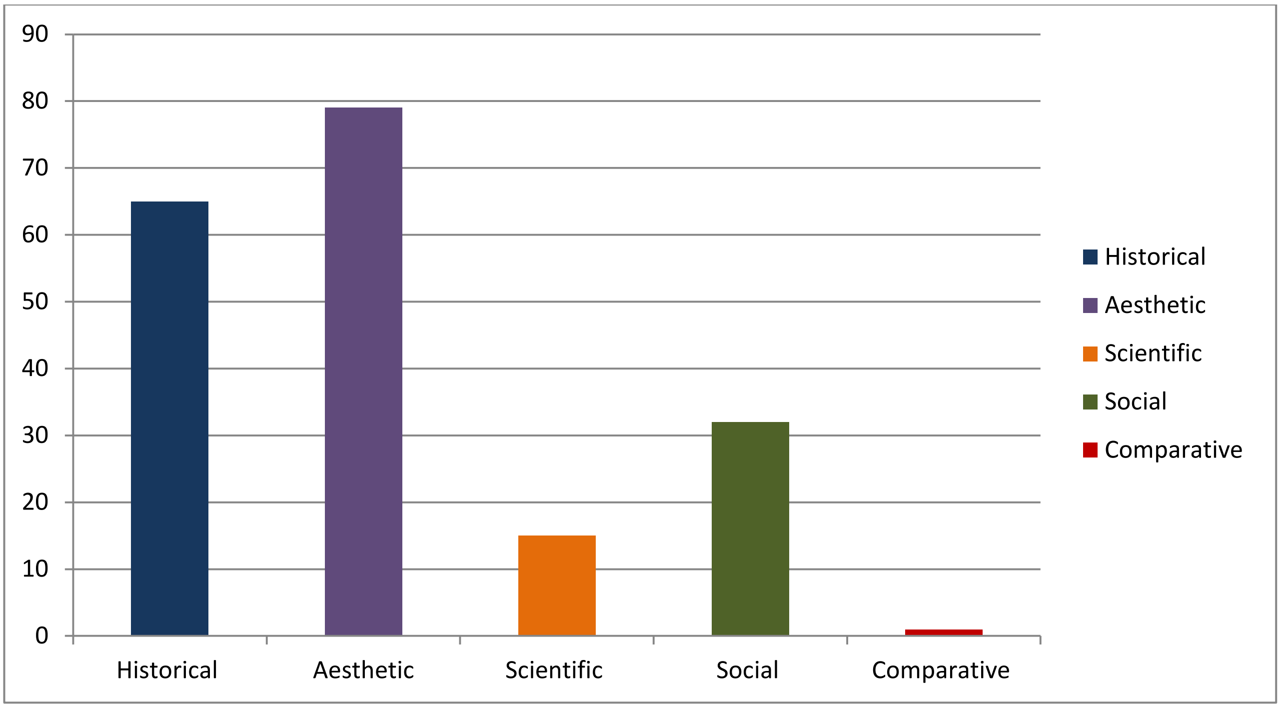

Figure 4.5 Values associated with the Ravensworth Homestead (as categorised using the Burra Charter values and definitions)

Note: Multiple responses allowed. Data based on sample of 19 participants.

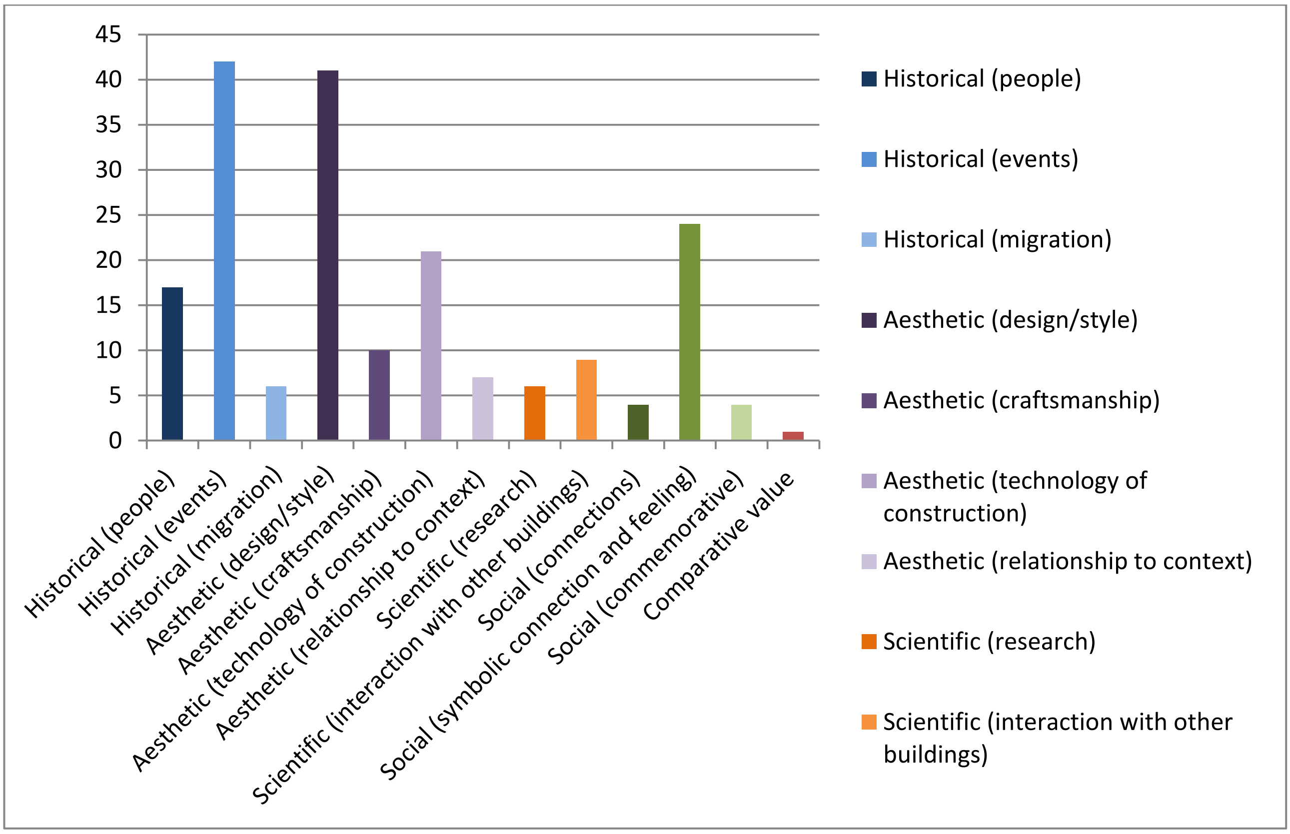

Figure 4.6 Sub-categories of values identified relating to the Ravensworth Homestead

Note: Multiple responses allowed. Data based on sample of 19 participants

As illustrated in the values map (**Figure 4.4**) and **Figures 4.5 and 4.6**, many of the values identified related to the **Aesthetic values** associated with the homestead, namely the design/style of the homestead, its craftsmanship and technology of construction and the relationship of the homestead and its buildings to its original setting, as a working agricultural complex within the region.

> *"Being stone, it's beautifully crafted (hand-hewn stone) and built. It is considered that it may have been designed by 'Verge' – we've lost so much history in the Valley"*
>
> *"The arches in the stable are unique and important"*
>
> *"The four seater dunny is so interesting"*

Historical values were frequently raised, particularly the connection of the homestead with broader historical themes e.g. notable people (Bowman, Macarthur and Russell families and more recently the Marshall family (since the 1930s) and the events or movements around the homestead in a local, regional or national context. For example, we know that a connection existed between the original Dulwich estate and Ravensworth Homestead, which were connected by a bridle path in the time of James Bowman and James Glennie.

In relation to historic value, there was a strong view among the majority of participants interviewed that the homestead is historically important and that it is crucial to preserve its heritage, either in-situ or in a new place, where it can be conserved.

> *"It's the history of Australia" – Local landowner*
>
> *"Enough history is lost, we need to save these things." – Local landowner*
>
> *"The homestead's heritage value is broader than just its buildings; it provides a link to the establishment of community within the region."*
>
> *There are many familial connections within the region so which Ravensworth is a part – it has links back to the Macarthur Family and is one of the oldest buildings of its kind in our region."*

In this regard, many participants consulted, had personal stories, or stories handed down from their families, about events and people's lives at the homestead; with the remembrance of these stories considered very important. These included:

- memories of working on the homestead, helping with shearing, crutching and general farm work
- one participant remembered his mother telling stories from the times she was a teacher to the children living at the homestead
- memories of playing tennis on the grassed area
- attending weddings and parties
- recollections of previous residents and owners, such as Campbell Marshall who was a very well respected Shire President who refused at the time to have a bitumen upgrade to the road near the homestead to ensure there was no perception of self-gain
- visits to the homestead during open events and
- reports of graves at, or nearby the homestead, including the daughter of a former caretaker reported to have drowned, a former manager and potentially Dr James Bowman himself.

As is further defined below, such history was not always positive or favourable with Aboriginal stakeholders with Ravensworth a dark reminder of hostile encounters with early settlers.

Scientific values raised in relation to the Homestead related to the stories of evidence of past activity associated with the homestead (use of convict labour through to changes in agricultural production from sheep to cattle); the existence and detail of original buildings and the interaction between the homestead and other buildings.

"It paints a picture and tells a story of the time"

In this regard the homestead complex appears unique with its original cottage, the new more elaborate homestead building and the ornate stable block and old barn. The complex also has remnants of stones from the old convict quarters (no longer standing) which would have closed the rectangular formation of the compound. While the original Ravensworth cottage was first thought to have been established on the other side of York's Creek, the development of the second cottage and homestead some years later in c.1826 and c.1832 respectively, marked the development of a significant property within the district; and many memories and stories associated with those that resided within its walls or worked on the property.

In relation to past activity, the site/locality also has significance to the Aboriginal community; with views expressed that it was a site of violence, conflict and murder of local Aboriginal people.

"It's history as a brutal site of violence and massacre is important to acknowledge"

The homestead also holds strong social values for the neighbouring community, evidenced by the contribution that the building has made to the wellbeing of its community in a social and economic, commemorative, spiritual and symbolic sense.

From a local landholder perspective, participants interviewed reflected that many of the buildings, and the services, associated with Ravensworth have been lost over time, and that there is little left by which to remember the Ravensworth locality and village. Participants recalled that there had been a number of homes in the area, a school (the old building for which is currently fenced and was a concern for some), shop, post office and wine bar and that the community had been active and connected. The homestead was seen as an important link to the history of Ravensworth and the potential loss of the homestead was embedded in a sense of loss regarding community identity.

"There's so little left at Ravensworth. There used to be a shop, school and people living in Ravensworth."

Lastly the comparative value of the homestead and its complex, and its standing in relation to other local, regional and state homesteads of its kind, was also noted as important to assess and document. In relation to this value category, an application for State listing of the Homestead has also been received by the Office of Environment and Heritage submitted by previous family members, who have strong family ties to the homestead in the early 1900s.

"We go all over Australia and visit these types of places and here we have something really valuable in our own backyard."

4.4.1 Future of the Ravensworth Homestead

Participants in interviews and focus groups were also asked to provide their feedback regarding the future of the homestead, and to share ideas regarding possibilities for relocation. As previously noted, Glencore has also established the RHAC in order to advise on options for the potential relocation of the homestead complex. If relocation were to be approved by Government, Glencore has committed to funding the relocation costs, which are likely to be substantial.

The majority of those consulted expressed that given the current circumstances of the homestead – located within a mining lease, unoccupied, unable to be accessed by the public - that if relocation was undertaken in a way that would afford preservation of the buildings, relocation was an option worth considering. Particularly as most people were concerned about the homestead complex falling into further disrepair and being inaccessible in its current location as a result of mining.

"If you don't move it, it will deteriorate like Wambo – it went to wrack and ruin"

There was a strong consensus amongst participants, which was also reflected by RHAC members and most of the heritage stakeholders consulted, that if relocated the homestead must be kept as a complex, and that its value lay in the relationship and connections between the various buildings (original cottage, homestead, stable and barn). There was also a strong feeling amongst participants that there should be the possibility for public access to the homestead in any future location.

Those participants open to the idea of relocation generally wanted to see the complex stay in the local area, preferably within the Singleton LGA. Ideas relating to relocation within the Singleton area included moving the homestead to a park, setting it up as a venue centre, wine and cheese venue, and using part of the space as an art gallery. Participants noted that Singleton currently lacks this type of venue, but also noted concerns about economic viability of establishing such a venue within Singleton.

Participants acknowledged that if it is not viable to relocate within the local area, there must be some acknowledgement and connection retained to Ravensworth, such as options explored to capture and represent the origin/history, values and stories associated with the homestead. Participants also suggested that the homestead may be more viable as a tourist and multi-purpose centre (e.g. art gallery, museum, shop, accommodation, event venue) at a site within the vineyard region of the Hunter Valley, where tourists are more likely to visit. These and other options are being considered by the RHAC and will be assessed against rigorous heritage, social, environmental and economic criteria.

Participants, who were open to the idea of relocation, also noted the importance of not only facilitating the safe relocation of the buildings, but of considering the long-term sustainability of the complex, highlighting that future planning should consider sustainability of any proposal with consideration given to ongoing maintenance, community access and financial viability in the long-term.

Those people who objected to the possible relocation of the homestead noted concerns about whether it would be possible to relocate the building without causing substantial damage. Others felt that the relocation of the homestead disregarded the important heritage of the Ravensworth area and instead preferred that the homestead remain 'in-situ' and the proposed mining avoid the vicinity of the homestead.

Those who had mixed feelings about potential relocation of the homestead generally reported that it was important to preserve and value the complex. While they would like to see the homestead stay in its current form in its current location, they worried that it could not be adequately maintained or easily accessed in its current location; and that once mining has ceased, continued maintenance and upkeep would not be guaranteed.

5.0 SIA – Next Steps

The scoping phase has identified the key issues of relevance to landholders and key stakeholders in relation to the Project. Key project issues that have been identified include impacts relating to:

- Dust/Air Quality – on social amenity and health
- Site Rehabilitation and Final Landform
- Economic benefits – including local employment, procurement and community investment
- Water
- Noise
- Land Management
- European Cultural Heritage – particularly impacts on the Ravensworth Homestead
- Road and accessibility impacts – relating to the potential realignment of Hebden Road

As detailed assessments of the Project's impacts are not yet finalised, these views are based on stakeholders' perceptions of potential impacts. It is worth noting however that the views of many stakeholders, particularly those proximate to operations, are typically well informed due to their anecdotal experiences of existing mining related impacts.

The next phase of the SIA program will involve:

- a detailed update of the baseline social profile to ensure that baseline data relevant to the impacts identified is obtained
- further validation of the area of social influence utilising updated operational profile data
- provision of feedback to landholders and key stakeholders on the outcomes of the issue scoping phase and communication of the Project Secretary's Environmental Assessment Requirements (SEARs) (once issued) and assessment process
- further research and analysis of issues relating to the Ravensworth Homestead - heritage impact assessment (HIA), historical research and analysis and significance assessment and conservation management planning
- further engagement with local landholders and key stakeholders on key impact issues as noted above. This will involve feedback on the outcomes of assessment studies and provide opportunities for input to the development of appropriate mitigation and enhancement measures
- assessment and prediction of social impacts – against existing baseline conditions and
- identification of appropriate management and enhancement measures to address significant social impacts and any residual effects.

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APPENDIX A

Interview Guide/Questionnaire

Glendell Interview Guide – SIA Scoping Phase

- *Thanks for taking the time to meet with us/talk with us today.*
- *This interview is part of the SIA process for Glendell's Continued Operations Project we're undertaking consultation with nearby residents to obtain their attitudes towards the Project and your experiences of living in the local area and the broader region.*
- *All of the information you provide is confidential and only reported in aggregate form.*
- *We really appreciate your input. If you feel uncomfortable answering any questions, please do not hesitate to let us know.*

Interview details:

Date / Time	
Location	
Interviewer(s)	
Full Name	
Residential Address	
Mobile / Landline Number	
Email Address	

Respondent socio-demographics:

Land use – own/rent	
If commercial - type of business	
If residential - number of occupants	
Length of time living in the property	
Length of time living in the area	
Occupation/Employer/Location	

1) **Are you aware that the DPE has developed a new SIA guideline? Would you like a copy (email/hardcopy)? (discuss how the survey relates to the guideline)**
Yes/No

OPERATIONAL CONCERNS

2) What has been the history of the Glendell Mine in the community – past experiences? Previous contact (who/when/concern)?

3) Are there any issues of concern to you in relation to the existing operation? How has Glendell been managing their impacts to date from your perspective?

Issue	Effectiveness of Management Strategies

PROJECT CONCERNS

4) Did you receive a Community Information Sheet about the Project? (discuss the Project)
Yes/No

Project
Description

- *Increasing the maximum approved extraction rate from 4.5 Mtpa up to approximately 10 Mtpa later in the Project*
- *Ongoing utilisation of existing infrastructure at the MOC to 2045*
- *Relocation of the existing Glendell mining infrastructure area (MIA)*
- *Potential Relocation of Ravensworth Homestead*
- *Diversion of part of Yorks Creek*
- *Relocation of part of Hebden Road*
- *There will be no changes to the workforce as a result of the Project*

5) Do you have any issues/concerns in relation to the Project?

6) I'm going to read a list of potential issues/impacts that may relate to the current Project. For each issue, please indicate the level of concern to you, where 1 = no concern, 5 relates to a high level of concern.

No.	Potential Issue	Level of concern
1	**Noise impacts**	1 2 3 4 5 6 7
2	**Dust impacts**	1 2 3 4 5 6 7
3	**Vibration/Blasting impacts**	1 2 3 4 5 6 7
4	**Surface and groundwater impacts**	1 2 3 4 5 6 7
5	**Visual impacts**	1 2 3 4 5 6 7
6	**Aboriginal Cultural Heritage impacts**	1 2 3 4 5 6 7
7	**European Cultural Heritage impacts** **e.g. Potential relocation of Ravensworth Homestead**	1 2 3 4 5 6 7
8	**Diversion of Yorks Creek**	1 2 3 4 5 6 7
9	**Relocation of Hebden Road**	1 2 3 4 5 6 7
10	**Traffic impacts** (increased traffic/accidents)	1 2 3 4 5 6 7
11	**Site rehabilitation and final landform/final void**	1 2 3 4 5 6 7
12	**Land Management - Weed/Pest control**	1 2 3 4 5 6 7
13	**Local employment**	1 2 3 4 5 6 7
14	**Health and wellbeing impacts** (dust, stress/anxiety, other)	1 2 3 4 5 6 7
15	**Population change** (construction workforce)	1 2 3 4 5 6 7
16	**Potential property acquisition**	1 2 3 4 5 6 7
17	**Decrease in property value**	1 2 3 4 5 6 7
18	**Impacts to sense of community**	1 2 3 4 5 6 7
19	**Relationship with Glendell**	1 2 3 4 5 6 7
20	**Trust in the Govt assessmt/approval process**	1 2 3 4 5 6 7

PROJECT PERCEIVED IMPACTS

7) How well does Glendell listen and respond to community concerns/ deliver on promises?

8) Do you believe that Glendell undertakes good environmental management to address impacts/issues?

9) Do you feel there is a good level of engagement between yourself and the company? Would you like more/less or something different?

10) How well to you think Glendell contributes/invests in the community?

11) Can you recall any projects, groups or organisations supported by Glendell?

12) In what areas could the company provide further support - expertise/resources (time/money) to assist in addressing these areas? Are there any particular projects/programs that could be implemented to address these needs? (see prompts below)

- **Historical aspects**
- **Greening and beautification**
- **Local Business / employment**
- **Services / infrastructure**
- **Education – local school**

13) Are you aware that the Ravensworth Homestead is located on the Glendell site and is currently owned by Glencore?
Yes/No

14) What value does the Homestead hold for you? For the community? (use map to identify key values)

15) What is your level of concern in relation to the relocation of the Homestead? Again, 1 – no concern, 10 – high level of concern.

No concern - 1 2 3 4 5 6 7 - High level of concern

Can you provide a reason for your rating?

____

____

____

16) The Ravensworth Homestead Advisory Group (RHAG) has been established to investigate options to relocate the Homestead. Do you have any suggestions they could consider?

PROJECT COSTS AND BENEFITS

17) In relation to the Project generally, what do you see as the key benefits and costs of the Glendell Continued Operations Project?

Benefits	Costs

VALUES MAPPING

18) How would you describe the local area? What do you like most about living in the area? What's important to you and why? **(Economic, Natural, Social, Physical, Human)**

19) What do you see as the key strengths / assets of the community?

20) What clubs/ sporting groups are you associated with?

21) Where do you access retail services / food stores and health services?

22) Where do you or your family members access schools/education services?

PROJECT ENGAGEMENT

How would you like to receive information as part of the Glendell Continued Operations Project?

	Newsletter		Community meeting		Local newspaper		Email
	Website		Personal meeting		CCC minutes		Open Day
	Letters		Environmental monitoring report		Local radio		Other (specify?):

23) Is there any particular information that you would like to receive about the current Project?

24) Did you receive an invitation to the recent site open day in early December?

Yes/No
If Yes – did you attend the open day?
If you didn't attend was there a reason? e.g. day, time etc

25) Do you have anything to add or is there anyone else that you think we should be talking to?

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APPENDIX B

Biophysical Strategic Agricultural Land Assessment

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Inspired people | Dedicated team

Quality outcomes

GLENCORE

BIOPHYSICAL STRATEGIC AGRICULTURAL LAND ASSESSMENT

Glendell Continued Operations Project

FINAL

May 2018

GLENCORE

BIOPHYSICAL STRATEGIC AGRICULTURAL LAND ASSESSMENT

Glendell Continued Operations Project

FINAL

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Glendell Tenements Pty Ltd

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Report No.	4166/R04
Date:	May 2018

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Document Status

Rev No.	Reviewer		Approved for Issue	
	Name	**Date**	**Name**	**Date**
1	Stuart Macnish	21 Feb 2018	David Holmes	20 March 2018
2	David Holmes	05 April 2018	Bret Jenkins	11 May 2018

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Figures

Tables

Appendices

1.0 Introduction

The Glendell Continued Operation Project (the Project) is a proposed extension of the open cut coal mining operations at Glendell Mine, which is part of the Mount Owen Complex (MOC) owned by Glencore and its Joint Venture partners. The MOC is located in the Upper Hunter Valley near Muswellbrook in New South Wales (NSW) (refer to **Figure 1.1**)

Biophysical Strategic Agricultural Land (BSAL) is land with a combination of soil properties and water resources that enable sustained cropping or improved pasture uses, without significant degradation. Generally, BSAL falls into Land and Soil Capability Classes (LSC) 1, 2 and 3. The Office of Environment and Heritage (OEH) has mapped BSAL at the regional scale for the Upper Hunter Strategic Regional Land Use Policy (SRLUP). This mapping was done at a regional scale and not at a property boundary level. OEH mapping of BSAL in the vicinity of the verification area is shown in **Figure 1.2**. Areas of the Bowmans Creek floodplain and a smaller area associated with Swamp Creek have been mapped as BSAL in the SRLUP, as shown in **Figure 1.2**.

The *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (NSW Government, 2013) (Interim Protocol) provides a guideline for the assessment of BSAL. This Report has been prepared in accordance with the Interim Protocol, to assess the presence of BSAL in areas of the Glendell Continued Operations Project Area (Project Area) that are potentially subject to the requirement for a Gateway Certificate under clause 50A of the *Environmental Planning and Assessment Regulation 2000*. This area is referred to as the Verification Area in this Report.

1.1 Verification Area

The Verification Area is the areas that are potentially impacted by components of the Project but are not subject to a mining lease issued under the *Mining Act 1992*. The Verification Area is shown in **Figure 1.3** and comprises a total area of 605.9 hectares (ha).

Not all of Verification Area will require a mining lease to permit activities proposed as part of the Project and not all of the Verification Area will form part of the Project Area for the development application lodged for the Project. Additional areas of the Project are located within areas where existing mining leases are held in relation to the land to be mined/directly impacted by the Project; these Project areas located within mining leases are not subject to the requirements of clause 50A of the EP&A Regulation and are therefore not subject to the gateway process or a requirement to verify the location of BSAL.

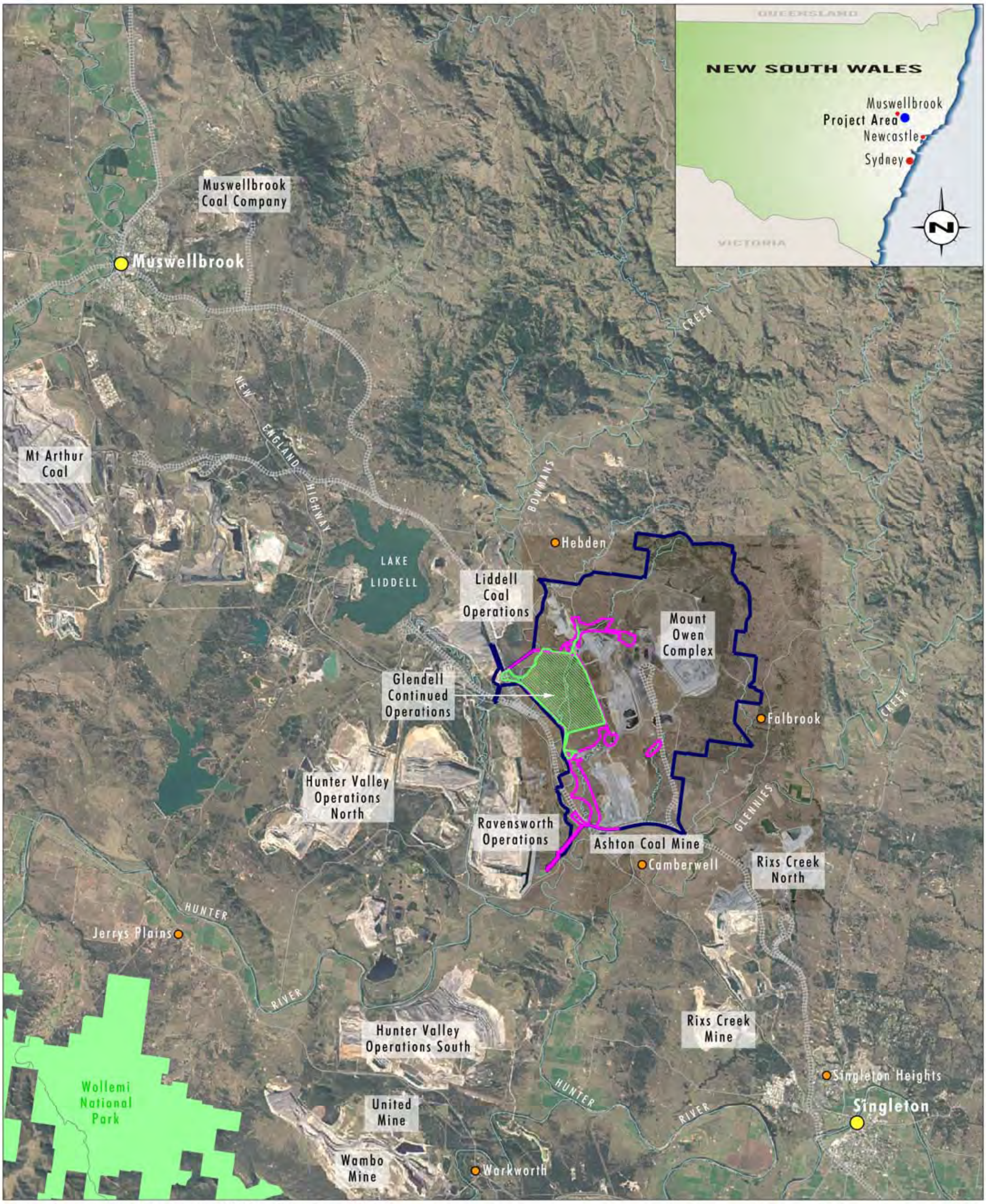

Image Source: Google Earth (2016), Glencore (2017)
Data Source: Glencore (2018), OEH (2013)

0 2.5 5.0 10km
1:200 000

Legend
- Project Area
- Potential Additional Disturbance Area
- Verification Area
- National Park
- Road
- Railway
- Drainage Line
- Towns
- Localities

FIGURE 1.1

Locality Plan

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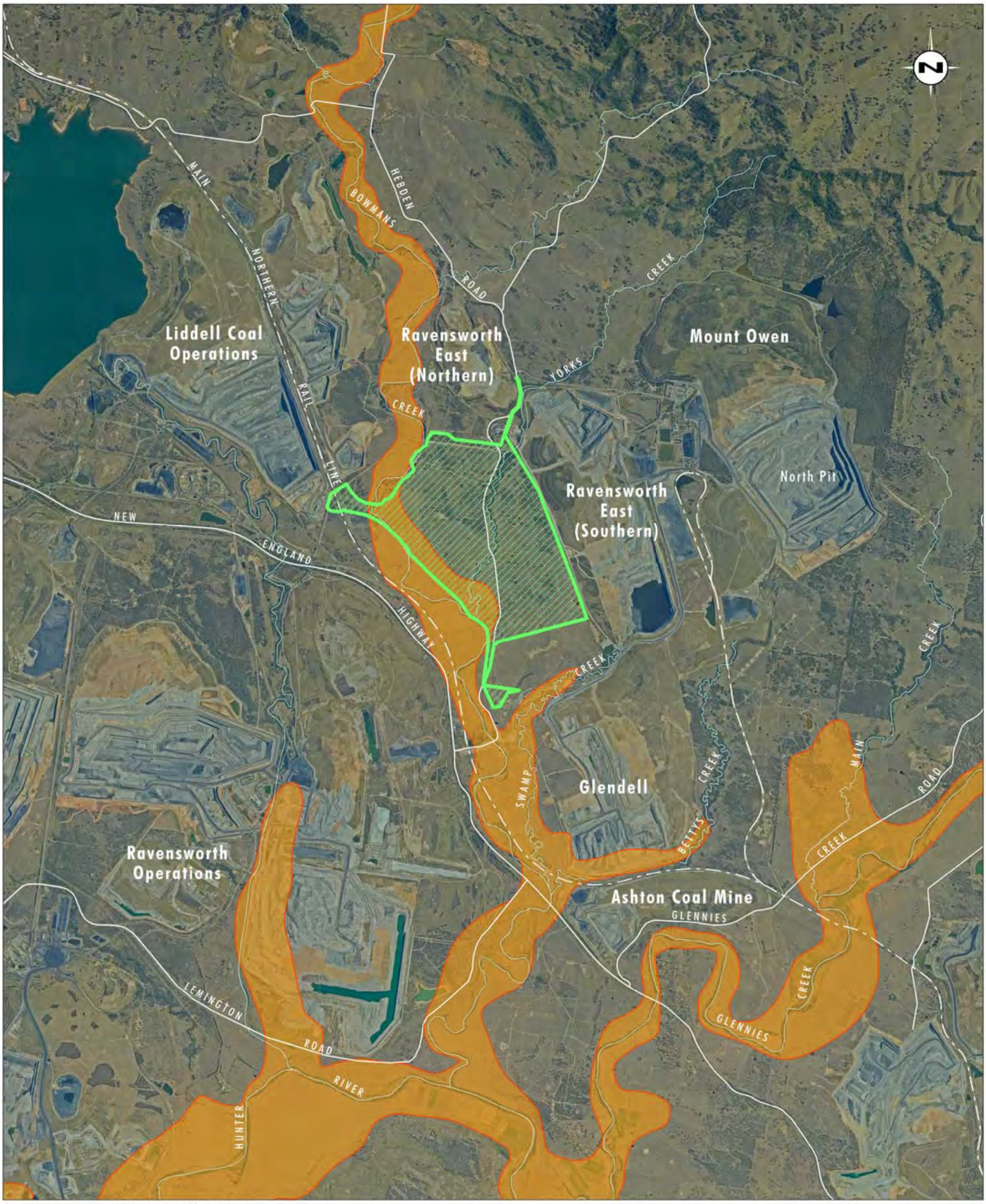

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017), NSW Department of Planning and Infrastructure (2013)

Legend
Verification Area
Biophysical Strategic Agricultural Land (BSAL)

FIGURE 1.2

Potential Biophysical Strategic Agricultural Land Hunter SRLUP Mapping

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20180511 11.15

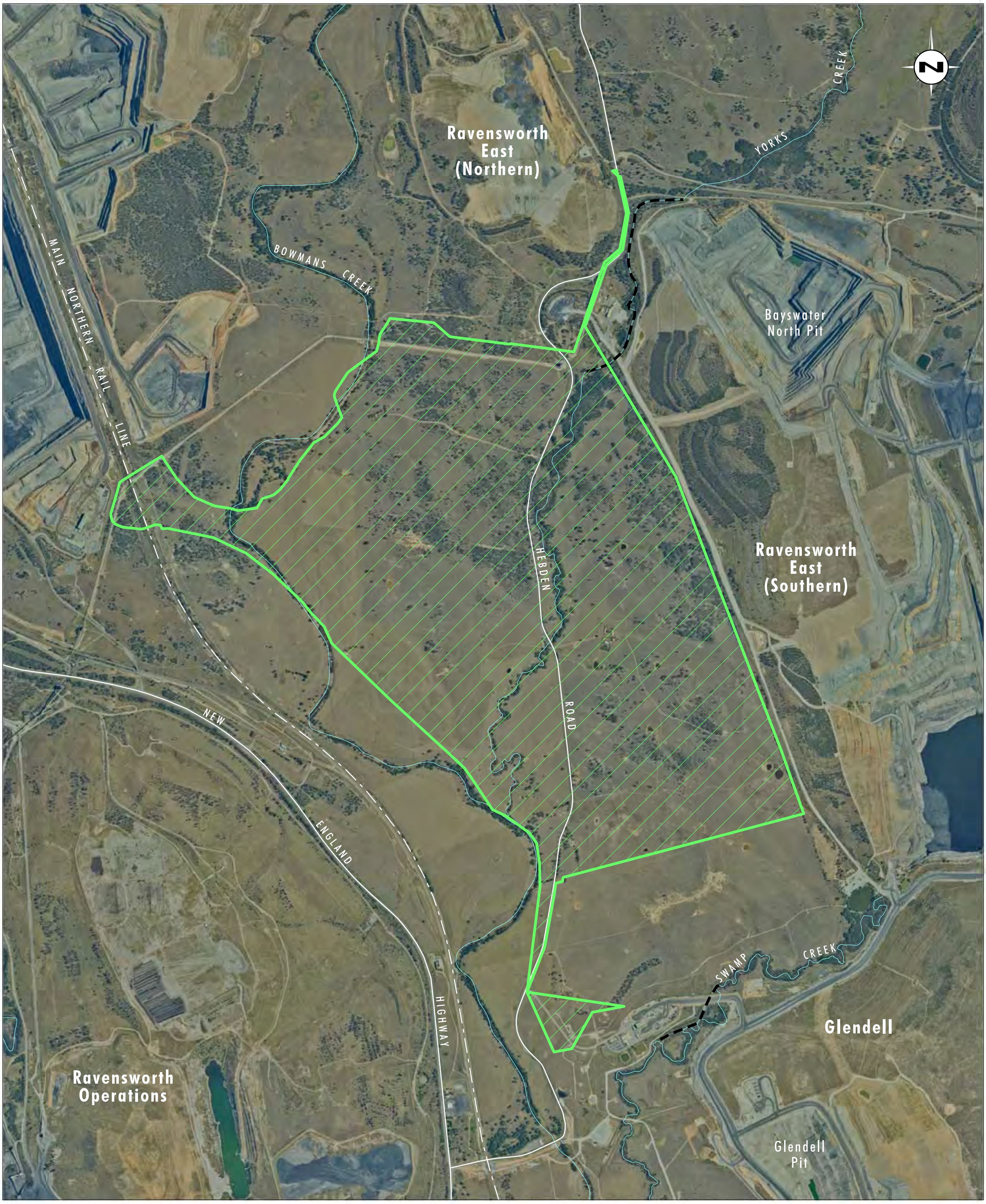

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)

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Legend

Verification Area
Existing Creek Diversion

FIGURE 1.3

Verification Area

1.2 Report Structure

The Interim Protocol requires detailed soil sampling and testing to provide further evidence about soil quality and constraints affecting the soil materials in the Verification Area (NSW Government, 2013). This report provides evidence of the soil types and an assessment of the presence of BSAL in the Verification Area, in accordance with the requirements of the Interim Protocol.

Section 2.0 outlines the Interim Protocol assessment requirements for the BSAL verification process.

Section 3.0 details the assessment methodology undertaken for the BSAL assessment.

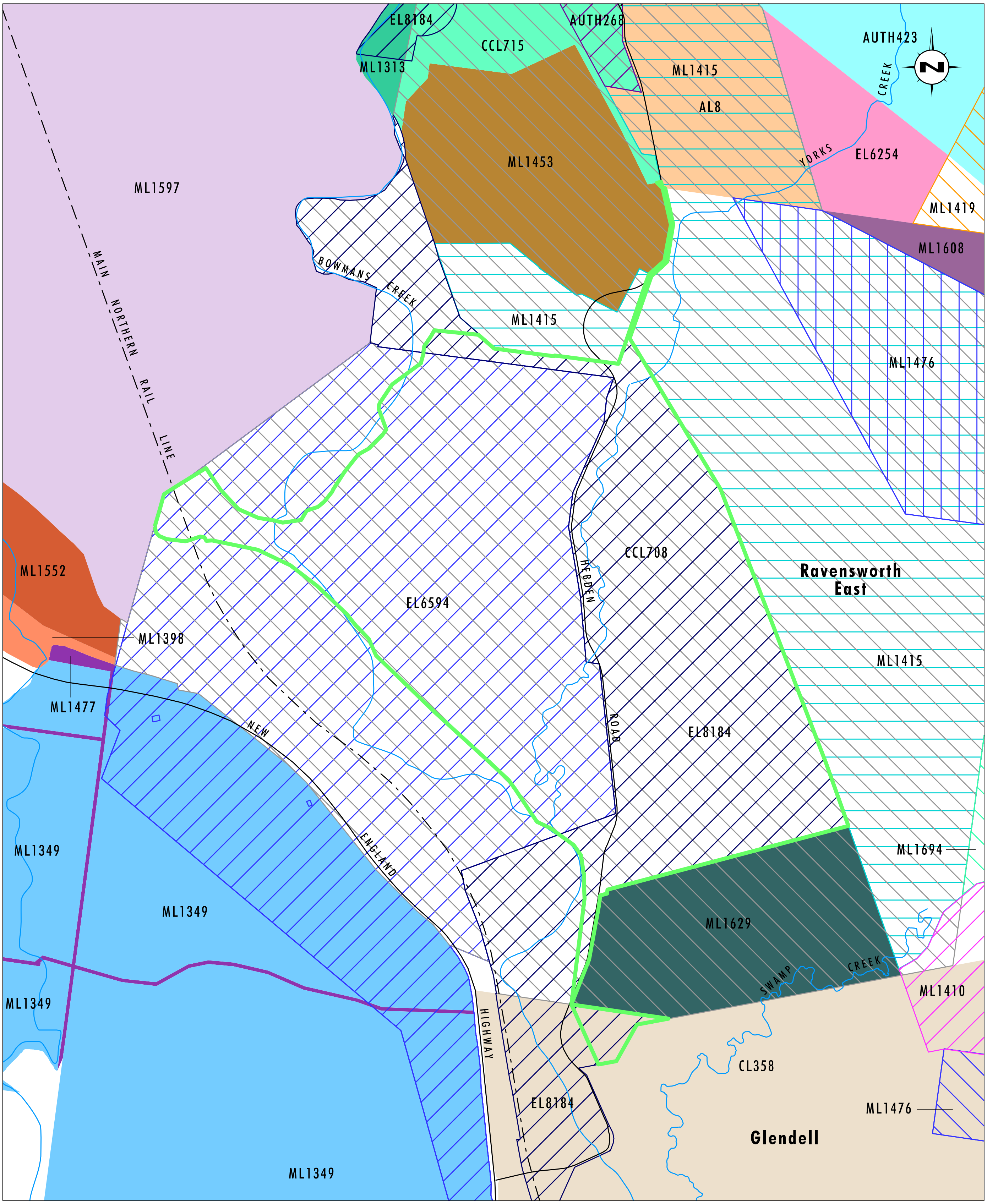
Section 4.0 details the results of the soils assessments undertaken for the verification assessment.

Section 5.0 contains the BSAL assessment findings for the Verification Area.

Section 6.0 summarises the findings of the assessment.

2.0 Interim Protocol Requirements

The Verification Area excludes areas within the proposed expansion area where existing mining leases are in place that will enable mining activities associated with the Project that require a mining lease to occur. As shown in **Figure 2.1**, the Verification Area is located on parts of EL6594 and EL8184. In accordance with the Mining SEPP, ML1597 to the north-west and ML1629 and CL358 to the south are excluded from the site verification. CCL708 covers the verification area however this mining lease excludes the surface in the Verification Area and a new mining lease will be required over parts of this area for the Project to occur.



Data Source: Glencore (2018), Minview (2018)

0 0.5 1.0 1.5km
1:30 000

Legend

Verification Area

Current Mining Lease Titles:

AL8	CL358	ML1349	ML1453	ML1597
AUTH268	EL6254	ML1398	ML1475	ML1608
AUTH423	EL6594	ML1410	ML1476	ML1629
CCL708	EL8184	ML1415	ML1477	ML1694
CCL715	ML1313	ML1419	ML1552	

FIGURE 2.1

Leases within and in Proximity to the Verification Area

File Name (A4): R04/4166_064.dgn
20180511 9.53

2.1 BSAL Assessment Process and Area

The assessment process described in this section follows the Interim Protocol.

As the purpose of the BSAL Verification Process is to identify land with a combination of soil properties and water resources that enable sustained cropping or improved pasture uses. The entire area covered by the Upper Hunter SRLUP is regarded as having access to a reliable water supply. The Interim Protocol assessment process for identifying appropriate soil properties for BSAL is provided in **Figure 2.2** and are addressed in this report. As noted in **Figure 2.2** should any of the criteria not be satisfied then the land is not considered to be BSAL.

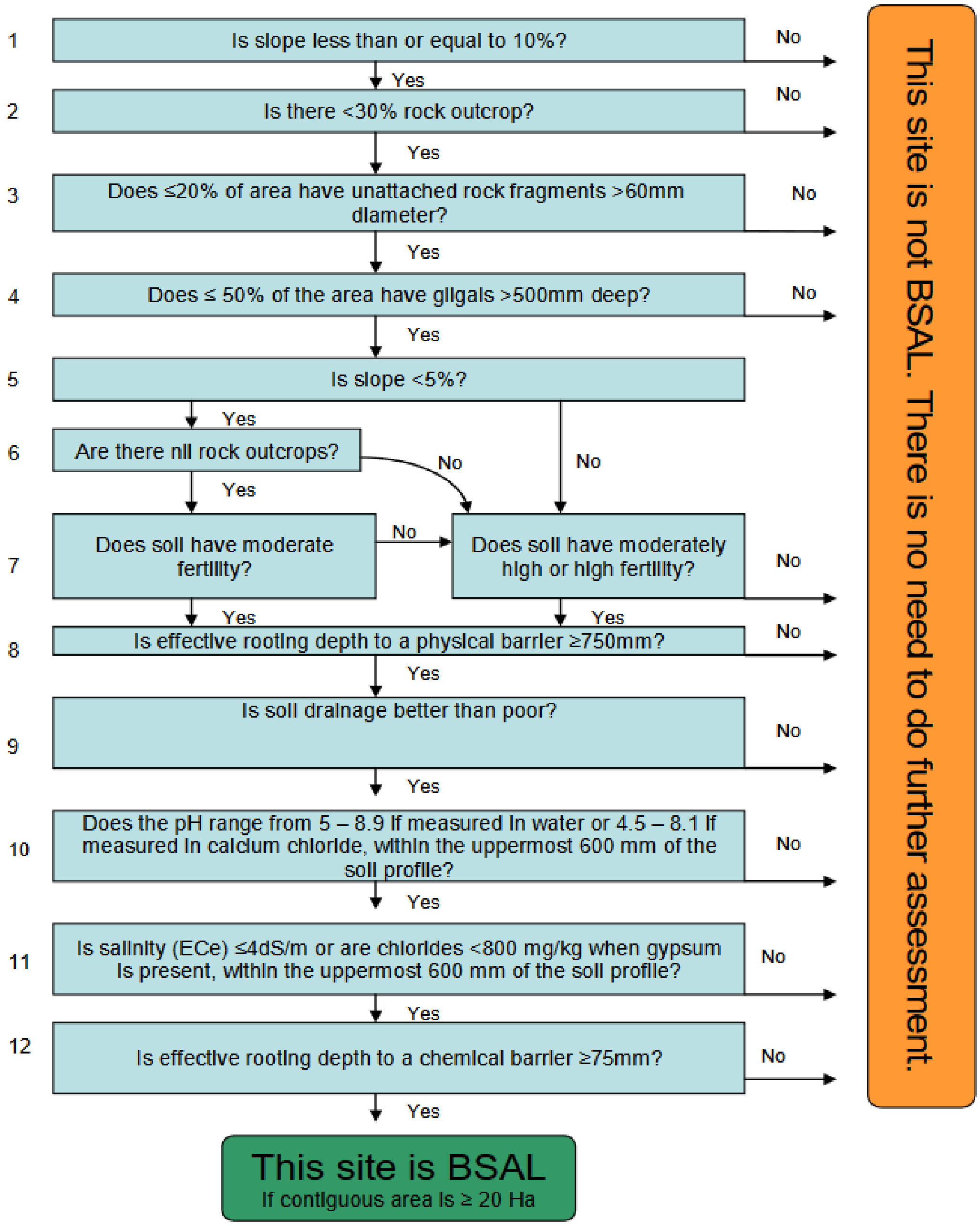


Figure 2.2 BSAL assessment process as per the Interim Protocol

Reproduced from NSW Government 2013

2.2 Mapping Approach

The Interim Protocol requires that the assessment should be conducted for the entire Verification Area. Where BSAL within the Verification Area is part of a larger contiguous mass of BSAL, the boundary of the larger area must be also identified.

The Interim Protocol provides the following inclusions and exclusions from the Verification Area sampling and assessment area:

- *The verification process, following Section 6 of the Interim Protocol (on-site soil assessment), must be conducted across all parts of the Verification Area to which the proponent has access, subject to the exclusions noted below*.

- *Areas to which the proponent has access but are not used for agriculture (such as heavily forested areas) may be excluded from the sampling area. The BSAL status of these areas is assessed using information from adjacent areas, and the similarity of underlying geology, terrain and previous regional mapping*.

Mount Owen has access to the entire Verification Area and the area is currently grazed. There are limited areas of native vegetation along both Bowmans and Yorks Creeks, which have been avoided in relation to detailed soil sampling. In addition, an archaeological due diligence survey was carried out prior to commencing the detailed soil sampling process with the aim to exclude disturbance through soil pits to areas identified as Aboriginal archaeological sites. In accordance with the Interim Protocol, the BSAL status of these areas within the Verification Area has been assessed utilising the detailed information from the areas immediately adjacent to these excluded areas.

2.3 Slope Analysis

In accordance with the Interim Protocol land that is greater than or equal to 10% slope are not considered to be BSAL. An analysis of slope across the Verification Area has been completed and identified approximately 83.3 ha with a slope greater than or equal to 10% (**Figure 2.3**). The slope analysis was undertaken using a digital terrain model created from LiDAR data collected in 2017. The areas identified as having slope >10% are excluded from further detailed assessment consistent with Step 1 of the BSAL assessment process (refer to **Figure 2.2**).

2.4 Risk Assessment

The Interim Protocol refers to a risk assessment process to provide guidance on the appropriate sampling density. Appendix 3 of the Interim Protocol notes that sampling densities should be linked to risk:

- *Sampling density 1 site per 25 to 400 ha for low risk to agriculture.*

- *Sampling density 1 site per 5 to 25 ha for high risk to agriculture*.

The risk criteria in Appendix 3 of the Interim Protocol are drawn from the Guideline for Agricultural Impact Statements (NSW Government, 2015), and were not originally intended for risks to BSAL. It refers to 'agricultural resources or industries' not to the best quality agricultural resources which are included in BSAL. However, if the criteria identified in Tables 7, 8 and 9 of Appendix 3 of the Interim Protocol are applied as written, the consequence of the proposed mining activities in the Verification Area would fit the 'severe consequence' description and the likelihood is 'almost certain'. This would lead to an assessment of 'high risk'.

Based on this risk analysis, a sampling density of approximately 1 site per 10 - 11 ha has been applied to the survey design within the Verification Area. This conforms to the high risk density requirement of 1 site per 5 - 25 ha and is consistent with recent BSAL assessments carried out by Umwelt (Australia) Pty Limited (Umwelt) in the MOC (Umwelt 2015, 2016, 2017).

2.5 BSAL Assessment Criteria

The assessment criteria can be broken up into two parts, as shown on **Figure 2.2**:

1. soil physical and landscape verification criteria – Criteria 1-9 and
2. soil chemical verification criteria – Criteria 10-12.

Details of the soil descriptions and sampling methodology are detailed in **Section 4.0**, and the full results of the BSAL assessment within the Verification Area are provided in **Section 5.0**.

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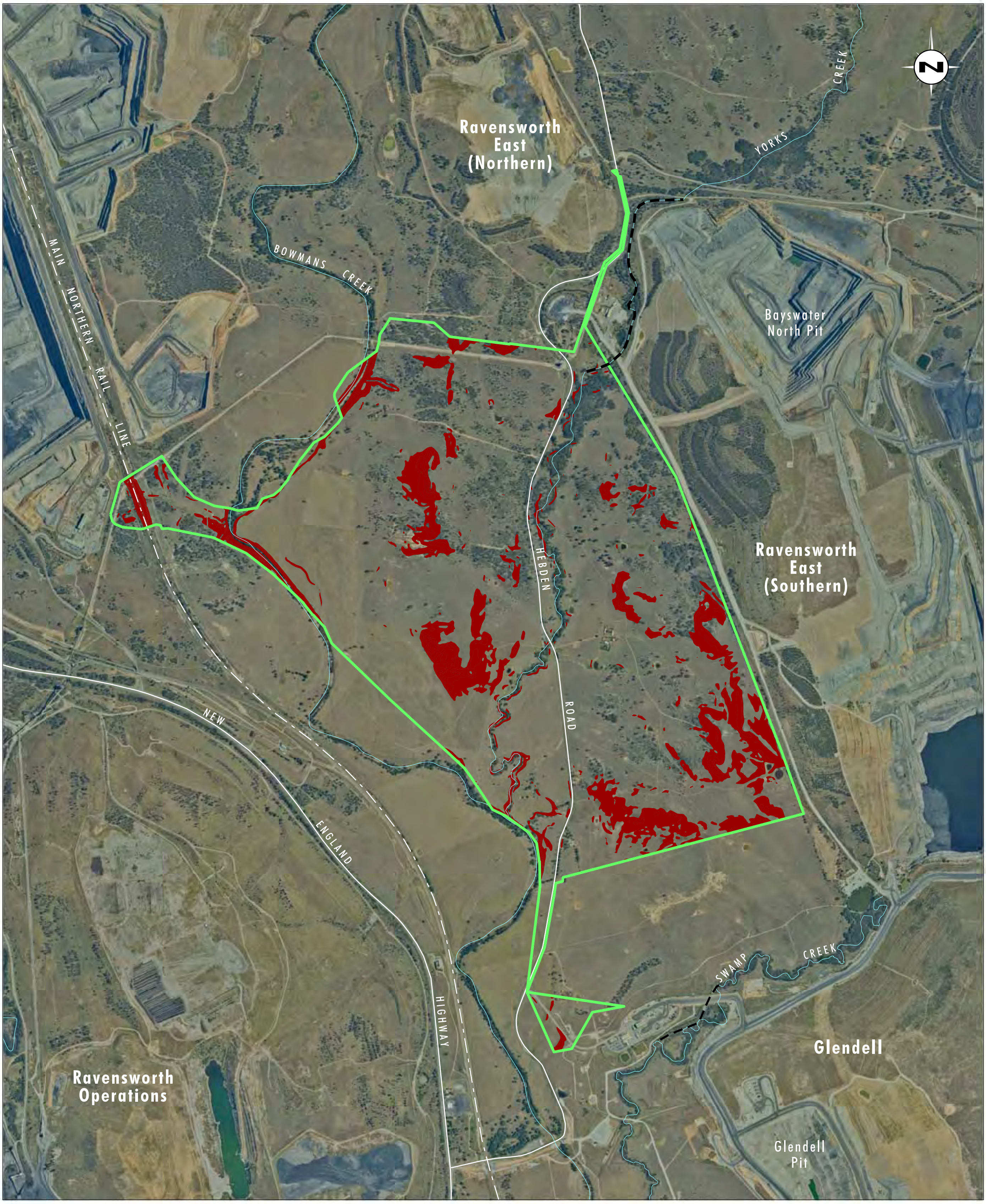

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)

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1:30 000

Legend

- Verification Area
- Slope >10%
- Existing Creek Diversion

FIGURE 2.3

Soil Sampling Exclusion Area within Verification Area

File Name (A4): R04/4166_021.dgn
20180511 9.56

3.0 Assessment Methodology

This section describes the methodology used for the BSAL assessment, including field assessment (soil description, soil sampling) methodology and laboratory analysis.

3.1 Field assessment

3.1.1 Soil Survey Design

The Verification Area has an area of 605.9 ha. 83.3 ha within the Verification Area have slopes greater than 10% (refer to **Section 2.3**), which were excluded from further on the ground assessment.

Based on the size of the Verification Area and the Interim Protocol requirements a survey density of approximately 1 site per 10-11 ha has been implemented.

Umwelt has in the past undertaken BSAL assessments in the MOC (Umwelt 2015, 2016, 2017) and identified one major soil type (Sodosol) and three minor soil types (Kurosol, Rudosol and Chromosol). A soil survey for the adjacent Liddell Coal Operation additionally mapped Dermosol (GSSE 2013). These results confirm earlier soil survey work undertaken for environmental assessment processes associated with the Mount Owen, Ravensworth East, Glendell and Liddell mines over the past 30-40 years.

The Interim Protocol requires a minimum of three detailed soil sampling sites for each soil type (NSW Government, 2013). Based on the initial data review, which has included geology information, publically available soil data as well as the aforementioned studies by Umwelt and GSSE, the occurrence of six soil types was anticipated. Survey sites were selected to provide representative coverage of the Verification Area and to address soil variability across the site based on existing slope, soils and vegetation information. Further, findings from the Archaeological Due Diligence resulted in a relocation of some survey sites and prevented locating detailed sites in some areas.

Initially, 37 sites were assessed and an area of BSAL was identified with another 17 sites subsequently surveyed to provide a higher degree of certainty of the location and extent of this parcel of BSAL.

3.1.2 Detailed Sites

In the initial survey (carried out between 16 and 25 August 2017), 18 detailed sites were excavated using a backhoe (GN2 - GN18, GN32, GN39). In the follow up surveys (11 to 13 October 2017 and 18 to 22 December 2017), another eight detailed soil pits were excavated (GN66-GN71, GN73, GN75, GN80) (**Figure 3.1**)**.** Soil pits were excavated to at least 750 mm in depth, or less, where bedrock was encountered at a shallower depth. Photos of the soil profile and the landscape context (ground cover, vegetation community) for each of the sites were taken.

Soil descriptions were recorded for the full depth of the excavated profile and all descriptions follow the Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009). In accordance with the Interim Protocol the following information was recorded:

- site ID and GPS coordinates
- general site condition, including run-on, run-off, surface condition, ground cover, evidence of erosion
- layer status, depth and boundary conditions

- colour and mottles (Munsell)
- bedrock type (where evident)
- texture
- pH (Raupach)
- structure and fabric
- consistence
- presence of coarse fragments
- presence of roots and
- evidence of drainage condition.

Slopes were recorded with a hand held clinometer and were rounded to the nearest whole number as per the Interim Protocol.

3.1.3 Check Sites

In the initial survey, 19 check sites were surveyed (GN20-GN31, GN33- GN38, GN40) and 9 further check sites (GN64, GN65, GN70, GN72, GN74, GN77-GN79) were assessed in the follow-up survey (Error! eference source not found.).

Check sites were excavated with a backhoe to either 500 mm depth or until the B horizon, whichever occurred first. GPS coordinates, soil profile and landscape photos were taken for all sites. Additionally, the following attributes were recorded on most check sites:

- layer status, depth and boundary conditions
- colour and mottles (Munsell)
- texture
- pH (Raupach) and
- presence of coarse fragments.

GN64, GN70, GN72, GN74, GN77, GN78 were assessed in the follow-up survey and a full profile description for these has been undertaken. However, as they were not analysed in the laboratory these are reported as check sites.

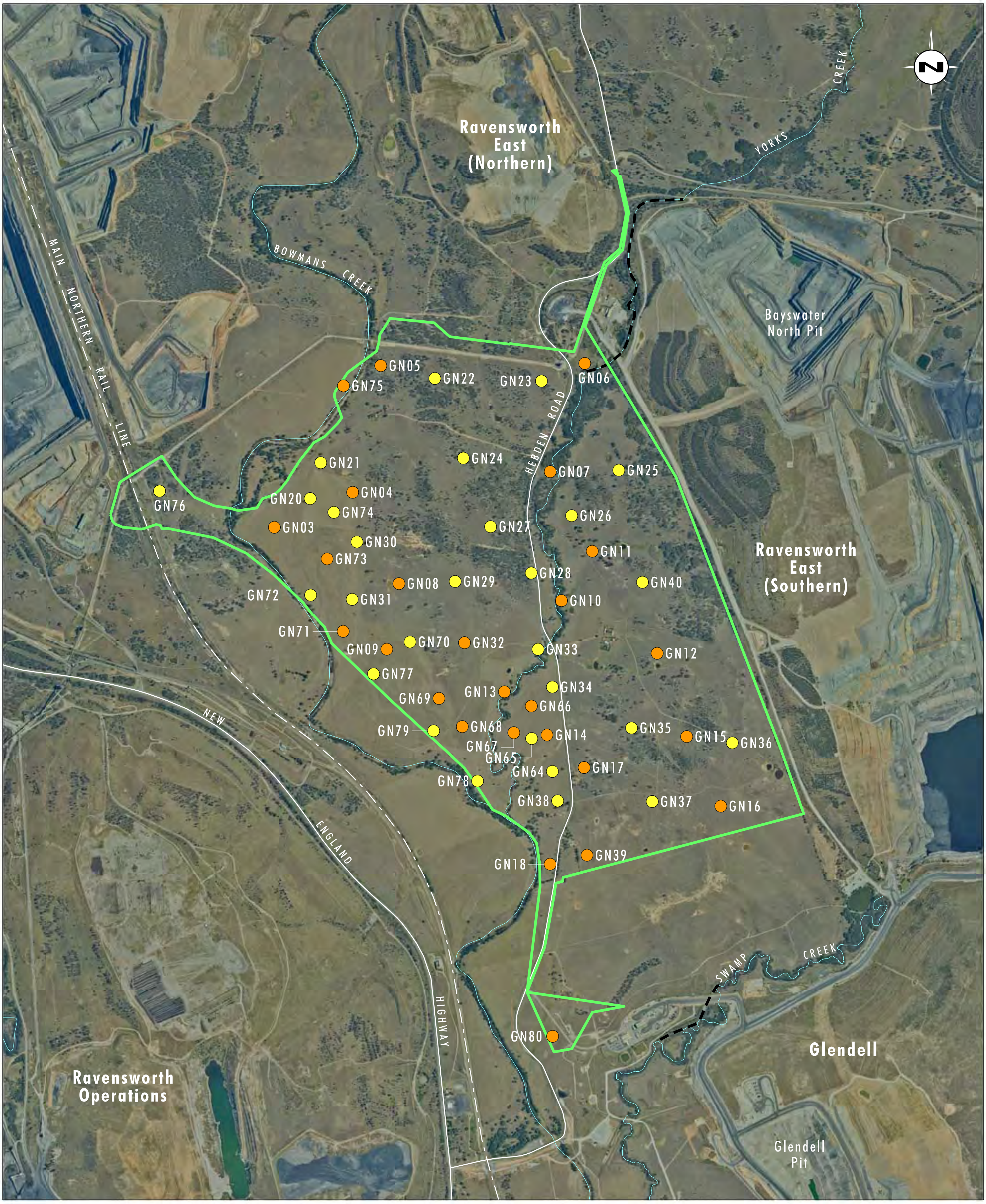


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)

0 0.5 1.0 1.5km
1:30 000

Legend

- Verification Area
- Soil Sampling Sites - Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 3.1

Soil Survey Locations

File Name (A4): R04/4166_022.dgn
20180511 10.06

3.1.4 Soil Sampling

Soil sampling was undertaken for all detailed sites. Soil sampling depths were based on the recommended sampling depths of the Interim Protocol. These depths are:

- 0-50 mm
- 50-150 mm
- 250-300 mm
- 300-600 mm
- 600-1000 mm

Samples must be obtained entirely within a single soil horizon and be identified by soil profile layer, as well as by depth in line with the protocol. For the soils in this Verification Area where horizon boundaries did not conform with the Interim Protocol sampling depths requirements, soil sampling was amended to ensure that samples were taken entirely from within a discrete soil horizon.

3.2 Laboratory Testing

Laboratory testing was conducted to provide data for the following parameters related to fertility and chemical barriers in the profile:

- salinity (EC and ECe)
- pH
- cation exchange capacity (CEC) and Exchangeable Cations (Calcium, Magnesium, Potassium, Sodium)
- exchangeable sodium percentage (ESP) and
- Ca:Mg ratio.

The samples were analysed by a NATA and ASPAC accredited laboratory.

4.0 Results

4.1 Soil Profile Descriptions

The soil survey found six soil orders present within the Verification Area:

- Chromosol
- Dermosol
- Kandosol
- Rudosol
- Tenosol and
- Sodosol.

Each soil order will be discussed below and detailed soil survey descriptions are presented in **Appendix A.** Soil profile classifications for the detailed sites and check sites are presented in **Tables 4.7** and **4.8** respectively.

In addition, soil profile descriptions of soil materials present have been entered into the NSW Soil and Land Information System (SALIS) database.

4.1.1 Sodosol

Brown, Red, Yellow, Grey or Black Sodosols, either Mesonatric or Subnatric, occur on the hillslope and footslope of the rolling hills (**Plates 4.1** and **4.2**). This ASC Order is associated with sandstone or mudstone bedrock or deposited material derived from this geology.

Sodosols are the dominant ASC Order of the Verification Area, making up approximately 84% of the 605.9 ha. Detailed sites which have been classed as a Sodosol are GN5, GN7, GN8, GN12, GN14, GN16, GN18, GN39, GN66, GN68 and GN80. Check sites in the same ASC Order are GN22, GN23, GN24, GN25, GN27, GN28, GN29, GN30, GN36, GN38, GN40, GN64, GN65, GN70, GN74, GN76, and GN78.

Sandstone rock outcrop and surface rocks are scattered throughout the hillslopes, however the densities of these are low and occurrences are random (**Plates 4.3** and **4.4**). Rock outcrops are predominantly flat.

Sodosols in the Verification 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.

Plate 4.1 GN70, footslope, looking south

Plate 4.2 GN39, midslope, looking south

Plate 4.3 Surface rock at GN39

Plate 4.4 Rock outcrop near GN17

This ASC Order has severe limitations for agricultural use due to its dispersion risk and gully erosion is observed within the Verification Area on the midslopes as well as the footslopes (**Plate 4.5**). 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.

Plate 4.5 Gully erosion in Yorks Creek floodplain

As an example for a Sodosol in the Verification Area, the detailed profile description of GN12 is presented in **Table 4.1,** with the GN12 soil profile and landscape setting shown in **Plates 4.6** and **4.7** respectively**.**

Table 4.1 Soil Profile Description – GN12

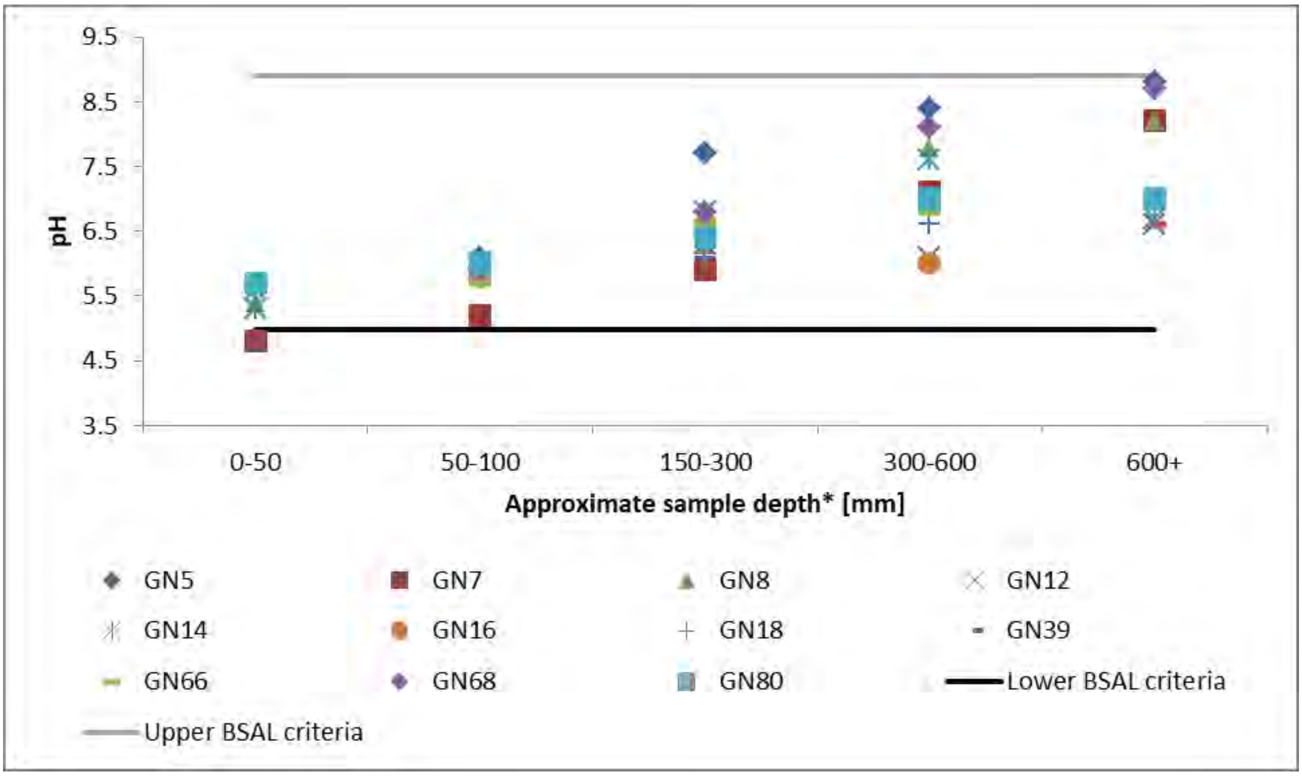
<table>
<tr><th>GN12</th><th>Datum: GDA 94 Zone 56
Easting: 318308.87
Northing: 6411895.18
Recorded: 17th August 2017</th></tr>
<tr><td>Landscape Element: Hillslope
Slope: 2%
Soil Surface Condition: Firm
Vegetation: Derived native grassland, box ironbark
Estimated effective rooting depth: 600 mm
Ground cover: 100%
Run on: Moderate</td><td>Run-off: Moderate
Profile drainage: Imperfectly drained
Profile permeability: Slowly permeable
Evidence of erosion: Sheet erosion
Lithology: Sandstone
Hydraulic conductivity: Not measured
Australian Soil Classification (ASC): Brown Sodosol</td></tr>
<tr><td colspan="2">Profile Characteristics</td></tr>
<tr><td>A1 0-20 mm</td><td>10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.6.
Weak pedality, rough-ped fabric, granular structure, 2-5 mm.
Sharp boundary.</td></tr>
<tr><td>A2 20-100 mm</td><td>10YR 6/2 (moderately moist), 10YR 7/2 (dry) Clay Loam. pH 6.0.
Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm.
Few (10-20%), 6-20 mm sub-rounded ironstone pebbles.
Abrupt boundary.</td></tr>
<tr><td>B21 100-600 mm</td><td>10YR 5/4 (moderately moist) Medium Clay. pH 6.2.
Moderate pedality, rough-ped fabric, angular blocky structure, 20-50 mm.
Few (2-10%), fine, distinct, orange mottles.
Gradual boundary</td></tr>
<tr><td>B22 600-700 mm</td><td>10YR 5/6 (moderately moist) Sandy Light Clay. pH 6.6.
Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm.
Many (20-50%), fine, distinct, orange mottles.
Gradual boundary</td></tr>
<tr><td>B23 700-800 mm</td><td>10YR 4/6 (moderately moist) Light Clay. pH 7.0[1].
Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm.
Gradual boundary</td></tr>
<tr><td>C1 800^{+} mm</td><td>10YR 5/6 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[1].
Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm.
Limit of observation.</td></tr>
</table>

[1] Field pH, maximum laboratory sampling depth 600-700 mm

Plate 4.6 Soil profile GN12

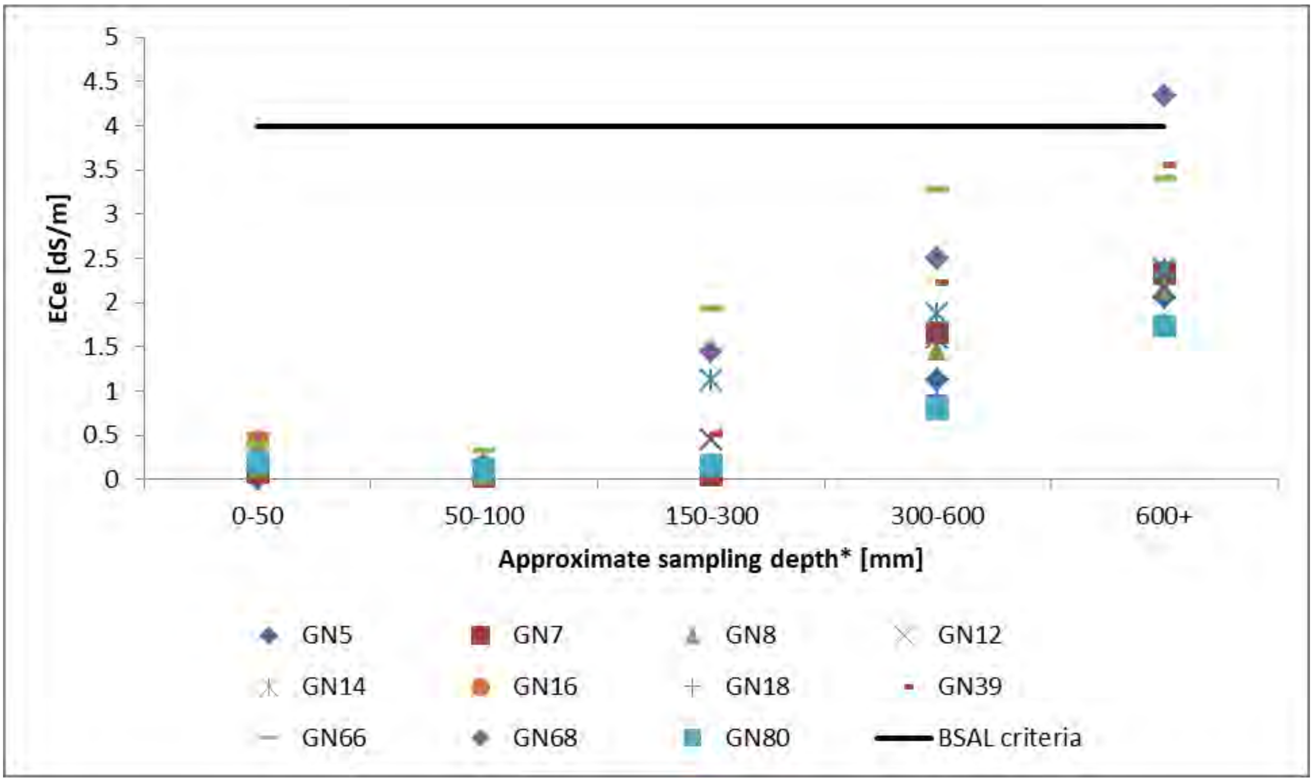
Plate 4.7 GN12, located on a lower, south facing slope

The laboratory pH for all analysed Sodosol soil samples ranged from strongly acid (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 (**Figure 4.1**). The saturated paste electrical conductivity (ECe) varied between 0.05 dS/m and 4.33 dS/m (**Figure 4.2**), thus ranging from non-saline (<2 dS/m) to moderately saline. The ESP ranged from non-sodic (ESP 0.9) to highly sodic and hypernatric (ESP 35.2). With the exception of GN80, the soils displayed an increase of sodicity in the B2 horizon with depth (**Figure 4.3**). The 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 ESP values (**Figures 4.3** and **4.4**).



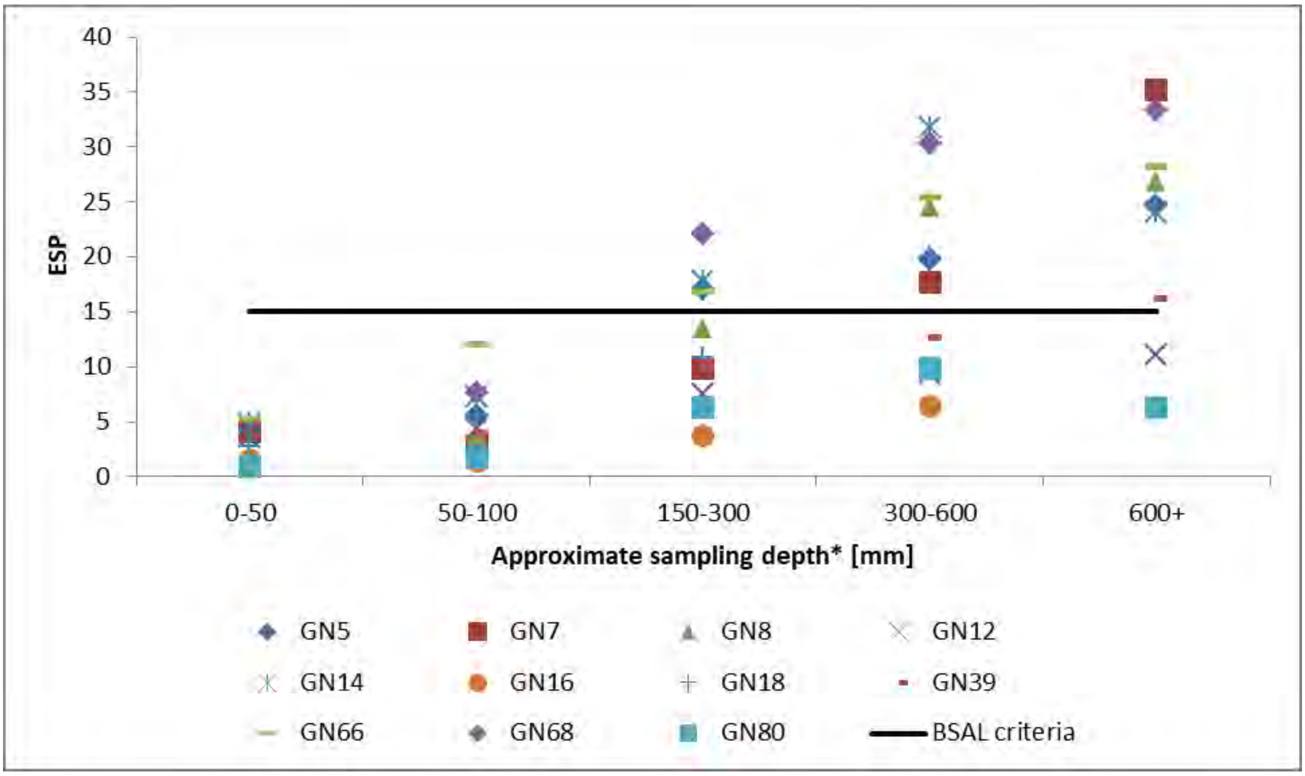
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.1 pH for sampled Sodosols



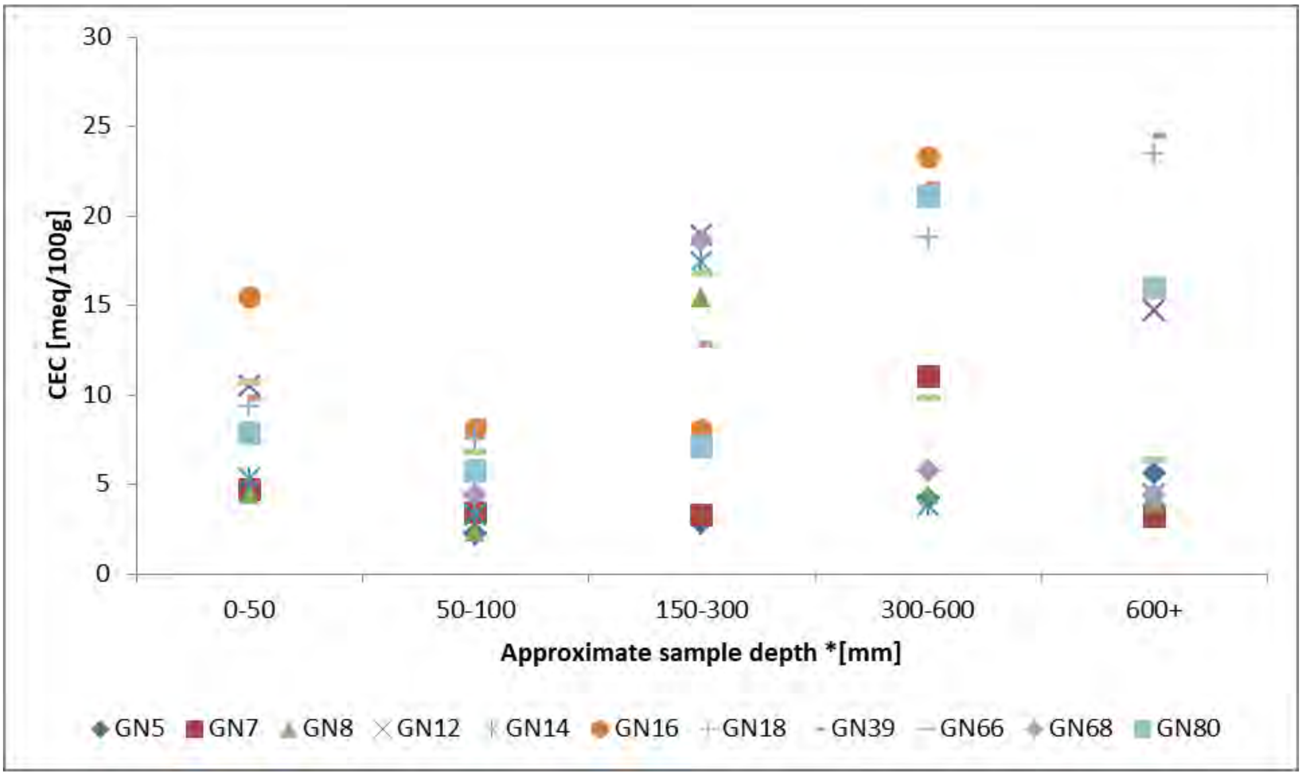
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.2 Saturated paste Electrical Conductivity (ECe) for sampled Sodosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.3 Exchangeable sodium percentage (ESP) for sampled Sodosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.4 Cation exchange capacity (CEC) for sampled Sodosols

4.1.2 Tenosol

Tenosols in the Verification Area occur as Brown-Orthic and are associated with the floodplains of Yorks and Bowmans Creeks (**Plates 4.7** and **4.8**). Due to the lower flow capacity of Yorks Creek, its floodplain and associated Tenosols have a relatively narrow distribution and is absent in some reaches of the creek in the Verification Area.

Plate 4.8 GN3, lower terrace, looking east towards upper terrace

Plate 4.9 GN20, upper terrace, looking west towards Bowmans Creek

During the initial survey campaign, GN3 was the only detailed site classed as a Tenosol with several check sites (GN20, GN21, GN21, GN33, GN37) identifying this ASC Order. In the follow up survey, sites GN70 to GN75 were selected with the aim to detect further Tenosols and thus to collect more information linked to this ASC Order. However, only GN72, GN73 and GN75 were identified as Tenosols. The total area of this ASC Order is 42.3 ha or 7% of the Verification Area.

GN3 and GN72 are located on a lower terrace, with a band of large pebbles occurring at 650 mm and 800 mm, respectively. The textures of the sites on the lower terrace were Sandy Clay Loams, Sandy Loams and Sand. On the upper terrace (GN20, GN21, GN21, GN33, GN37, GN73, GN75) Sandy to Silty Clay Loams were the dominant soil textures. Soil structures 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 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 on the upper floodplain terrace may be well suited for agriculture, but likely require fertiliser input.

Tenosols associated with Yorks Creek, are narrow and have a high flood risk as well.

Table 4.2 shows the profile description of GN75, with **Plate 4.10** and **4.11** presenting the soil profile and associated landscape.

Table 4.2 Soil Profile Description – GN75

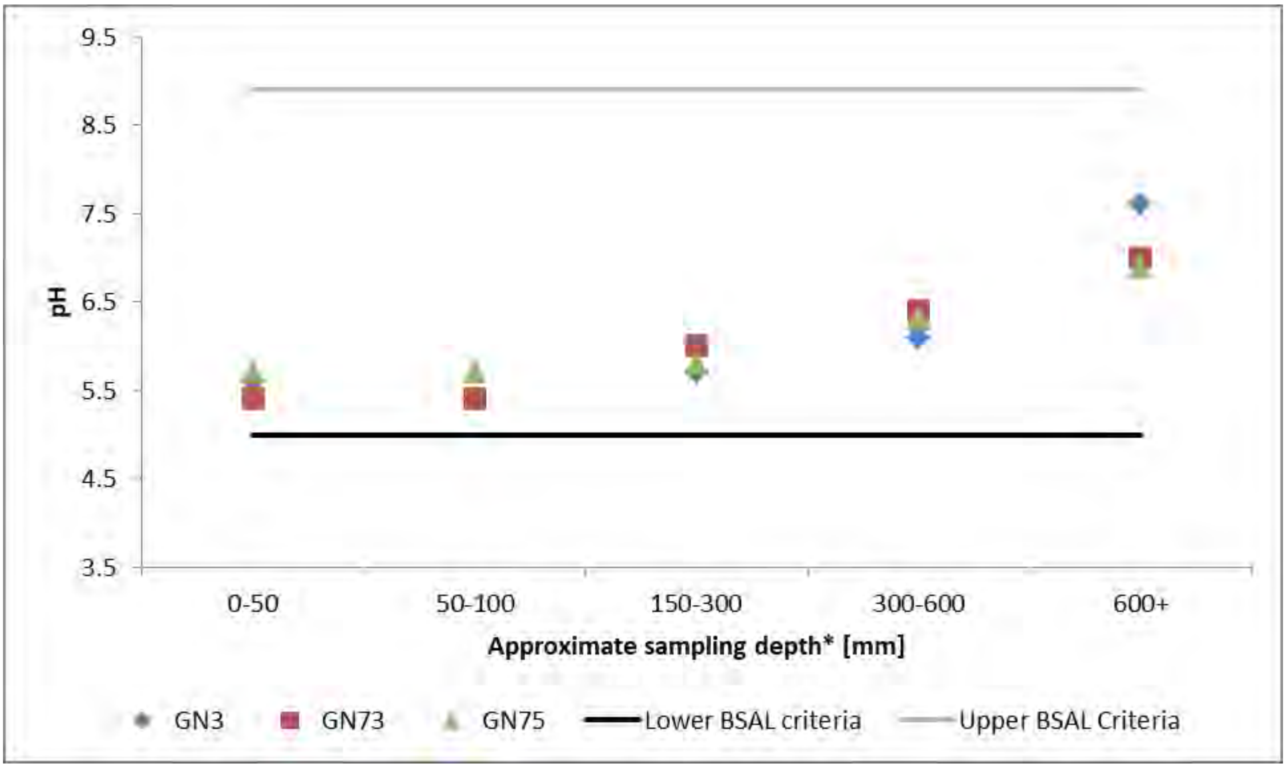
GN75	Datum: GDA 94 Zone 56 Easting: 316554.43 Northing: 6413391.67 Recorded: 21st December 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 900 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, granular structure, 10-20 breaking to 2-5 mm. Clear boundary.
B21 100-350 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 5.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 350-600 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.3. Weak pedality, rough-ped fabric, sub-angular blocky, 2-5 mm. Clear boundary.
2D 850^{+} mm	10YR 2.5/3 (moderately moist) Light Clay Coarse Sandy. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Limit of observation.

Plate 4.10 Soil profile description GN75

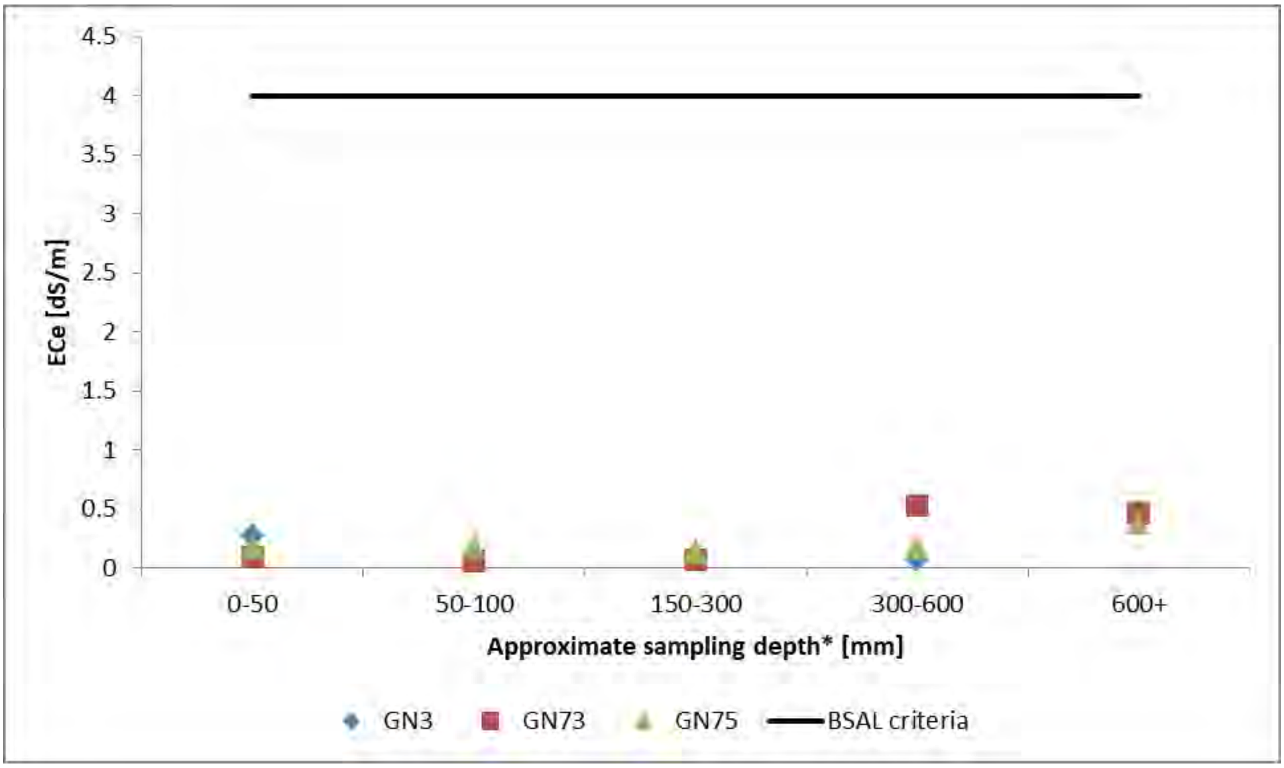
Plate 4.11 GN75, looking north

The A horizon pH of sampled Tenosols ranged from pH 5.4 (strongly acid) to 5.7 (moderately acid). In the B horizon, recorded pH varied from pH 5.4 to 7.6 (slightly alkaline). For all profiles the pH increased with depth (**Figure 4.5**). The Tenosols in the Verification Area are non-saline; GN3 and GN75 are also non-sodic throughout the profile (**Figures 4.6** and **4.7**, respectively). The sodicity of GN73 however, increases with depth and below 300 mm the profile is sodic (**Figure 4.7**). The measured CEC for all three profiles was low to moderate in the upper 300 mm. Thereafter, the CEC of GN75 remained moderate, GN3 decreased to low, whereas GN73 had a high CEC (>15) (**Figure 4.8**). The high CEC of GN73 is most likely due to a high amount of sodium in the profiles, which is reflected in the sites elevated ESP (**Figure 4.7**).



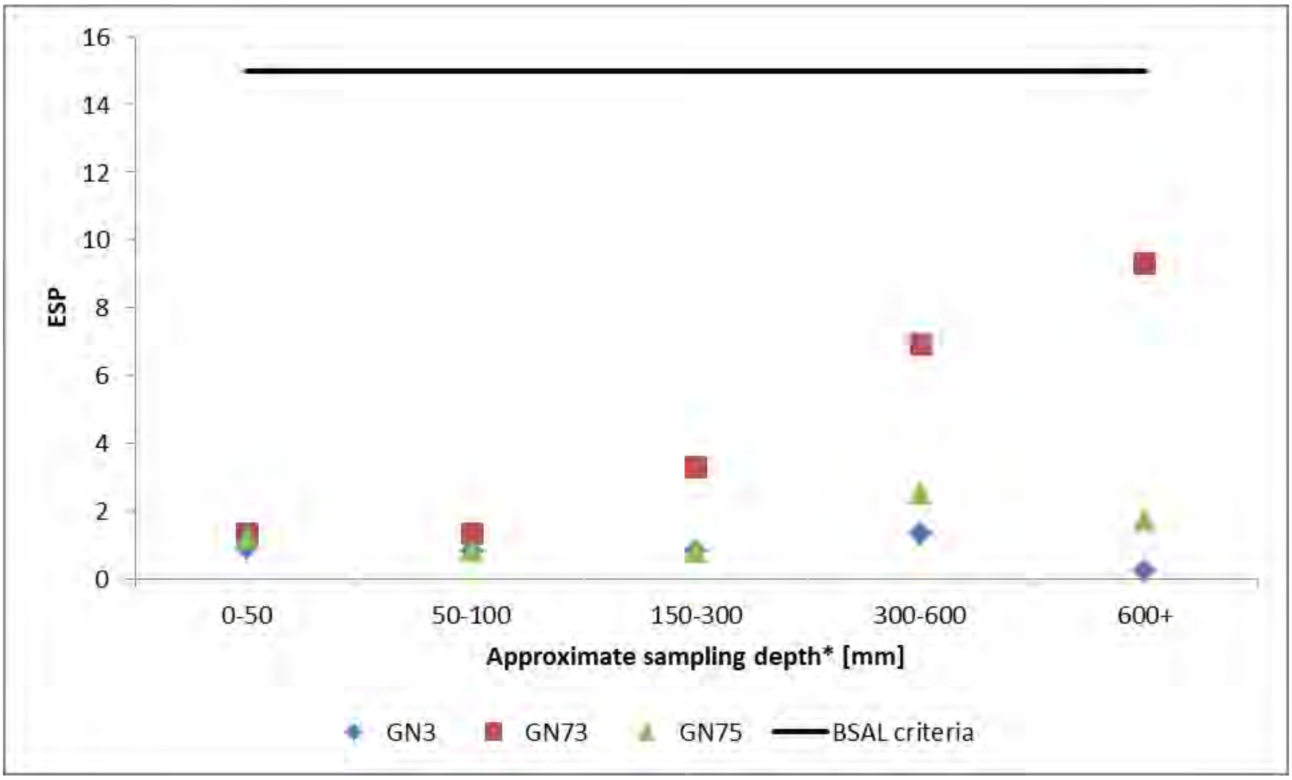
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.5 pH for sampled Tenosols



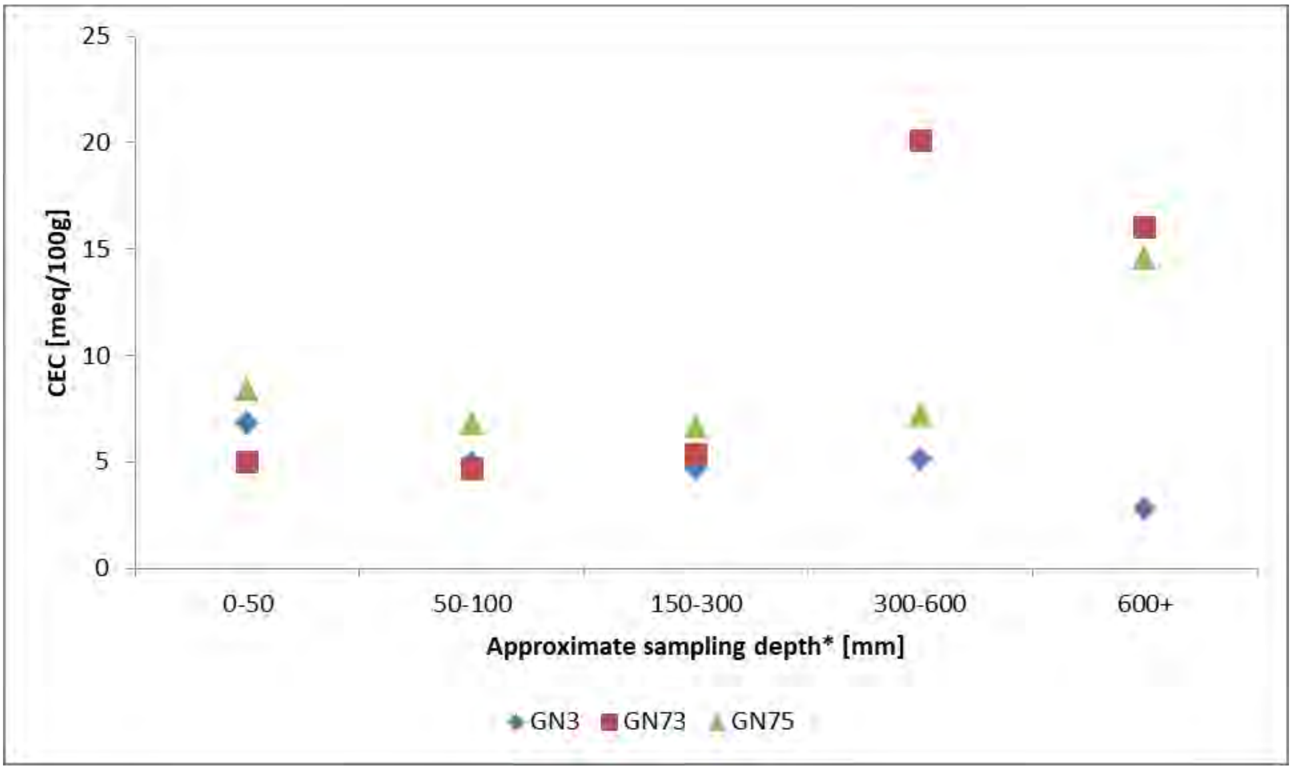
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.6 Saturated paste Electrical Conductivity (ECe) for sampled Tenosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.7 Exchangeable sodium percentage (ESP) for sampled Tenosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.8 Cation exchange capacity (CEC) for sampled Tenosols

4.1.3 Rudosol

Clastic Rudosols occur on hill crests where weathering of parent material is insufficient to form a more mature soil profile (GN32 as shown in **Plate 4.12**). Stratic Rudosols are found where repeated fluvial depositions have occurred without further soil profile development (GN4, GN10, GN11) (**Plate 4.13**). The Clastic Rudosol is derived from the underlying Sandstone, whereas the Stratic Rudosol was formed by *ex-situ* material deposition. Rudosols covered 6.5 ha, or 1.1%, of the Verification Area.

The lack of soil formation is a limitation for agricultural use, especially for Clastic Rudosols.

Plate 4.12 GN32, hillcrest, looking north

Plate 4.13 GN11, area under influence of local spring

The Clastic Rudosol (GN32) had a Sandy Clay Loam with a weak granular to strong sub-angular blocky structure and few coarse fragments throughout the profile. 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. GN4 showed generally a coarser texture and had few coarse fragments through the profile. GN10 and GN11 had a predominantly Clay Loam texture without coarse fragments. **Table 4.3** presents the soil description of GN11, with the soil profile being shown in **Plate 4.14** and the landscape context in **Plate 4.13.**

Table 4.3 Soil Profile Description – GN11

GN11	Datum: GDA 94 Zone 56 Easting: 317945.92 Northing: 6412465.9 Recorded: 18th August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland, red gum regeneration Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics	
A1 0-100 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Abrupt boundary.
B21 100-250 mm	10YR 4/3 (moderately moist) Fine Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Abrupt boundary.
B22 250-350 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B23 350-500 mm	10YR 5/3 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B24 500^+ mm	10YR 3/2 (moderately moist) Silty Clay. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Limit of observation.

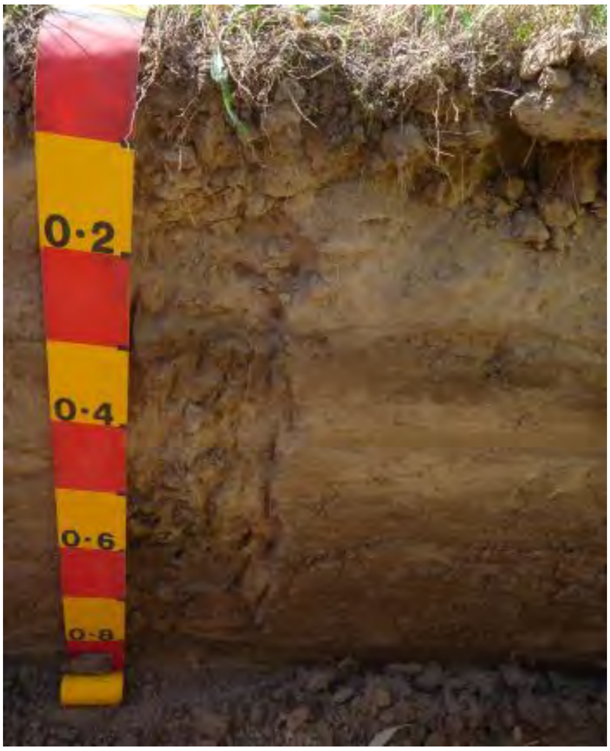
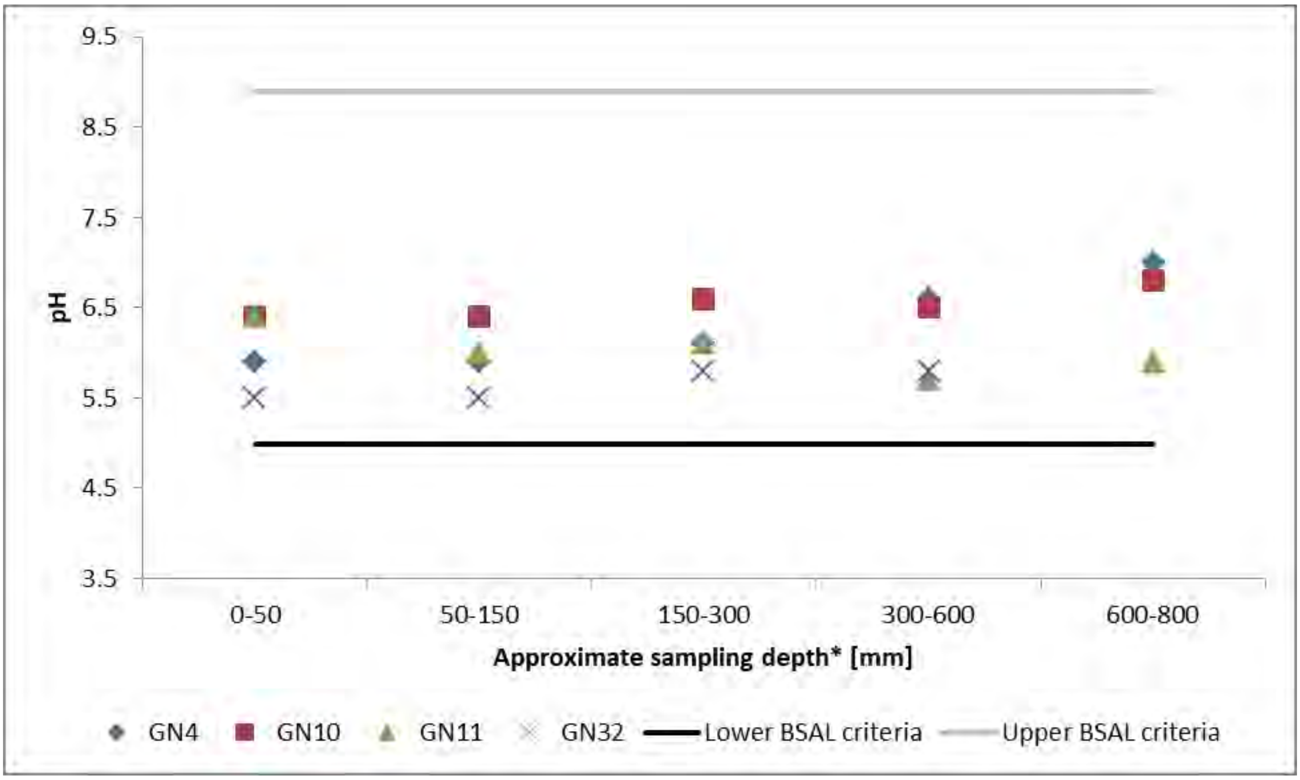


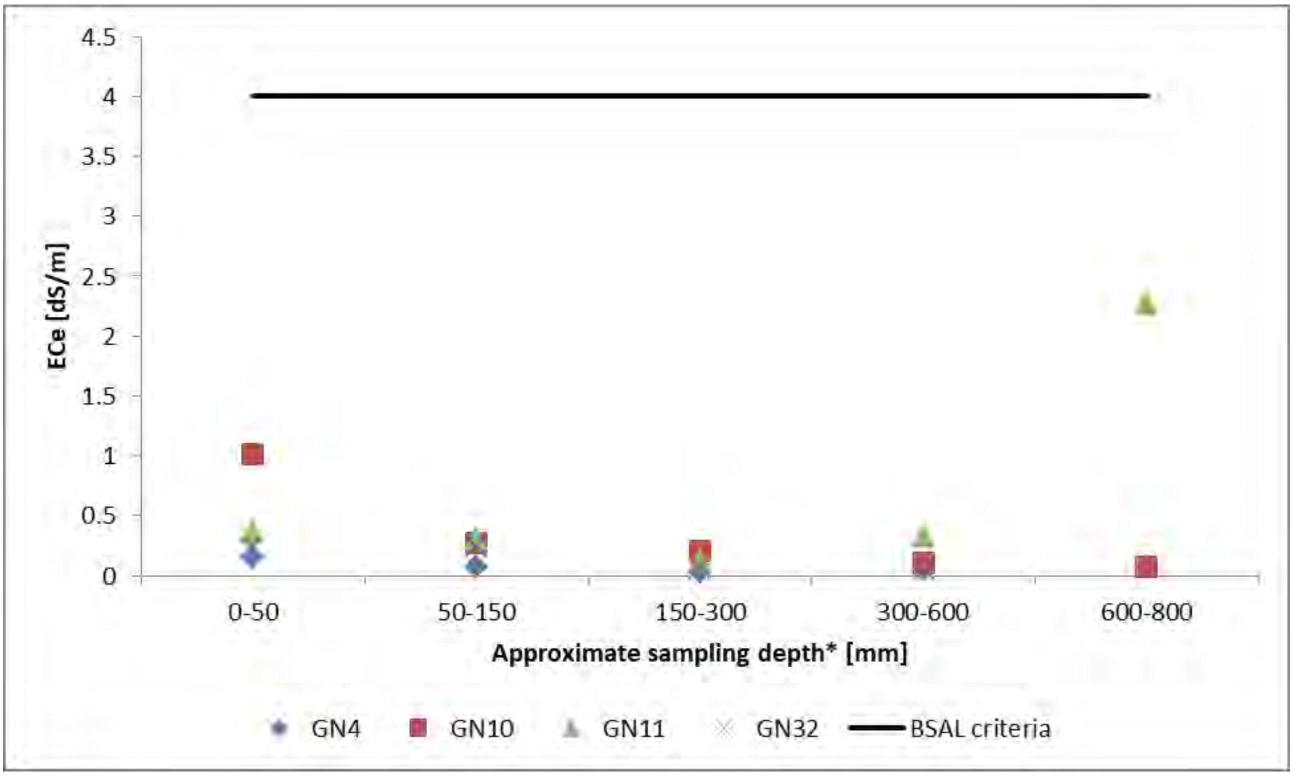
Plate 4.14 Soil profile GN11

The pH of all analysed soil samples was moderately acid to slightly acid. A horizon pH ranged from 5.5 to 6.4 and recorded B horizon pH varied from 5.8 to 6.8 (**Figure 4.9**). All samples are classed as non-saline (**Figure 4.10**). GN4 and GN32 are non-sodic, whereas the topsoil of GN10 (0-50 mm) and 250-500 mm depth of GN11 exceed an ESP of 6 and are therefore considered sodic (**Figure 4.11**). CEC is low to moderate, with the GN11 topsoil showing a high CEC (>15) (**Figure 4.12**).



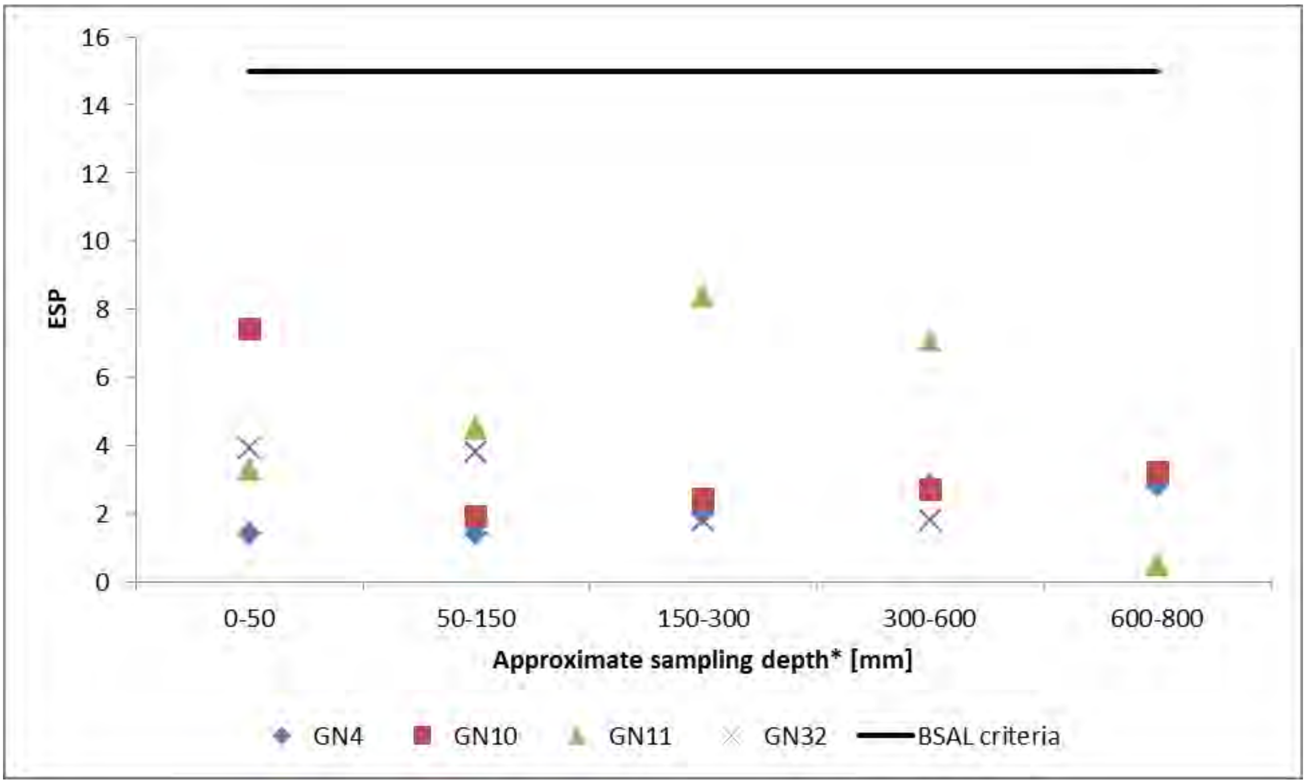
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.9 pH for sampled Rudosols



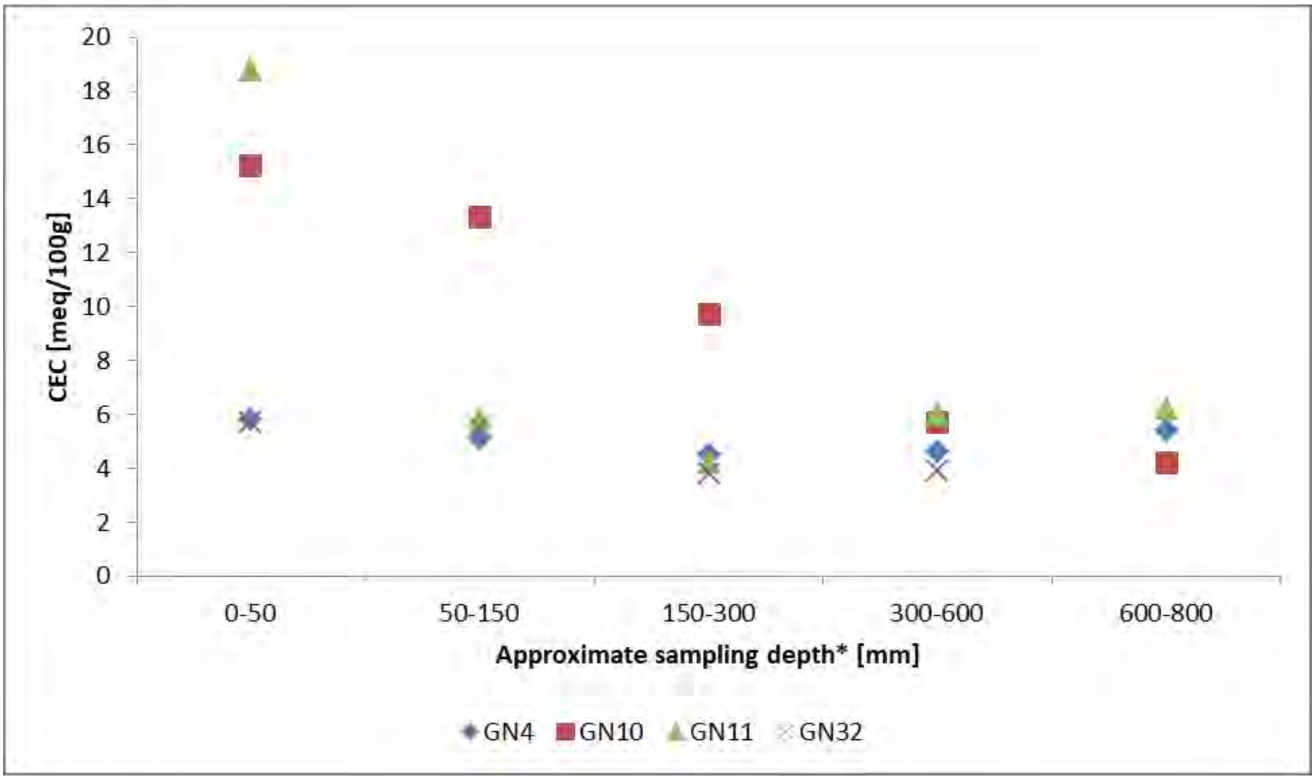
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.10 Saturated paste Electrical Conductivity (ECe) for sampled Rudosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.11 Exchangeable sodium percentage (ESP) for sampled Rudosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.12 Cation exchange capacity (CEC) for sampled Rudosols

4.1.4 Kandosol

Brown Kandosols occur isolated on hillslopes (GN15) (**Plate 4.14**), footslopes (GN34) (**Plate 4.15**) and on a lower alluvial terrace (GN13). The occurrence of Kandosols may be a result of the weathering of isolated, coarser grained sandstones or sandstone conglomerates. GN15 is located in a drainage depression, and as a result accumulation of *ex-situ* derived material may have contributed to all three sites. Kandosols are found on 5.6 ha, or 0.9%, of the Verification Area.

Plate 4.15 GN15, midslope, looking east

Plate 4.16 GN34, footslope, looking north

All sites have a Clay Loam texture grading into Light Clay with apedal massive to moderate sub-angular blocky structures. Common to many mottles were evident in the B horizon of all profiles. GN15 showed few to common rounded pebbles throughout the profile.

The water logging, evident through mottling, is a limitation to agriculture for all sites. In addition, the presence of coarse fragments and a shallow rooting depth for GN15 further impedes land use in this location.

Table 4.4 shows the detailed description of GN15, the soil profile is displayed in **Plate 4.17** and landscape context is provided in **Plate 4.15**.

Table 4.4 Soil Profile Description – GN15

GN15	Datum: GDA 94 Zone 56 Easting: 318473.97 Northing: 6411428.96 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol
Profile Characteristics	
A1 0-100 mm	10YR 5/3 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Clear boundary.
B21 100-250	10YR 4/3 (moderately moist) Sandy Clay Loam. pH 5.8. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, rounded conglomerate pebbles. Gradual boundary.
B22 250-600 mm	10YR 5/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.3. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, rounded conglomerate large pebbles. Gradual boundary
BC 600^{+} mm	10YR 5/3 (moderately moist) Light Clay. pH 6.5[2]. Apedal massive structure, sandy fabric. Many (20-50%), very coarse, distinct brown mottles. Many (20-50%) 6-20 mm, rounded conglomerate pebbles. Limit of observation.

[2] Field pH, maximum soil sampling depth 600-650 mm

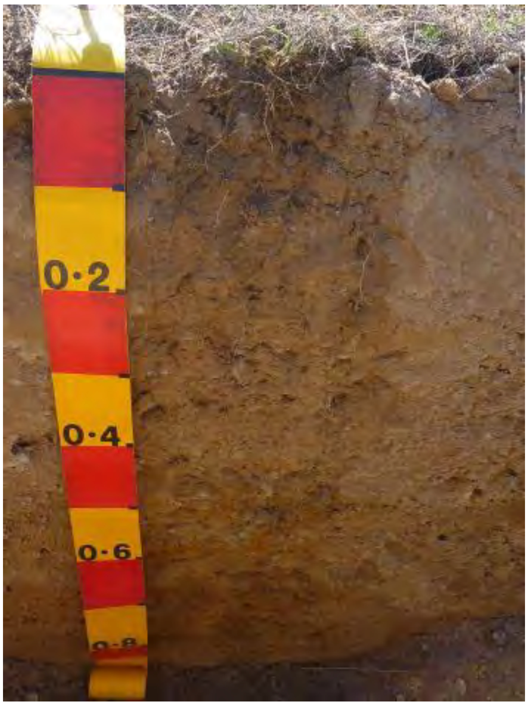
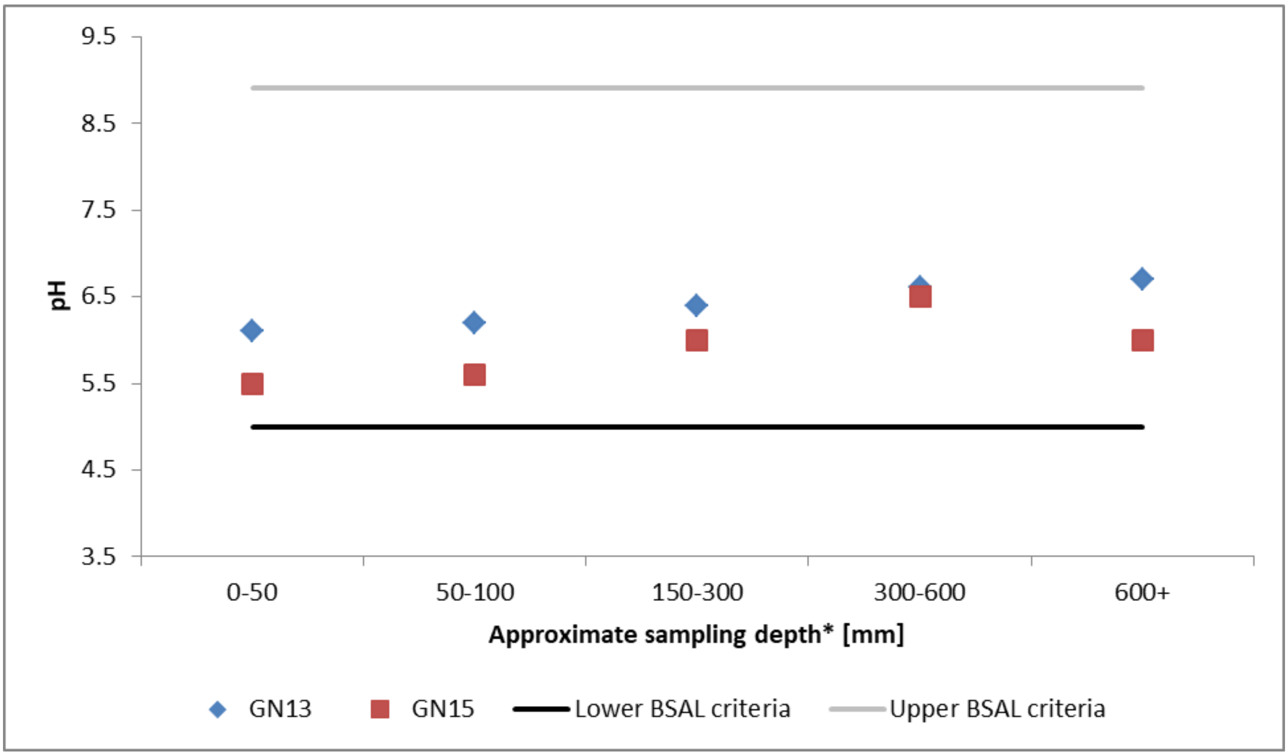


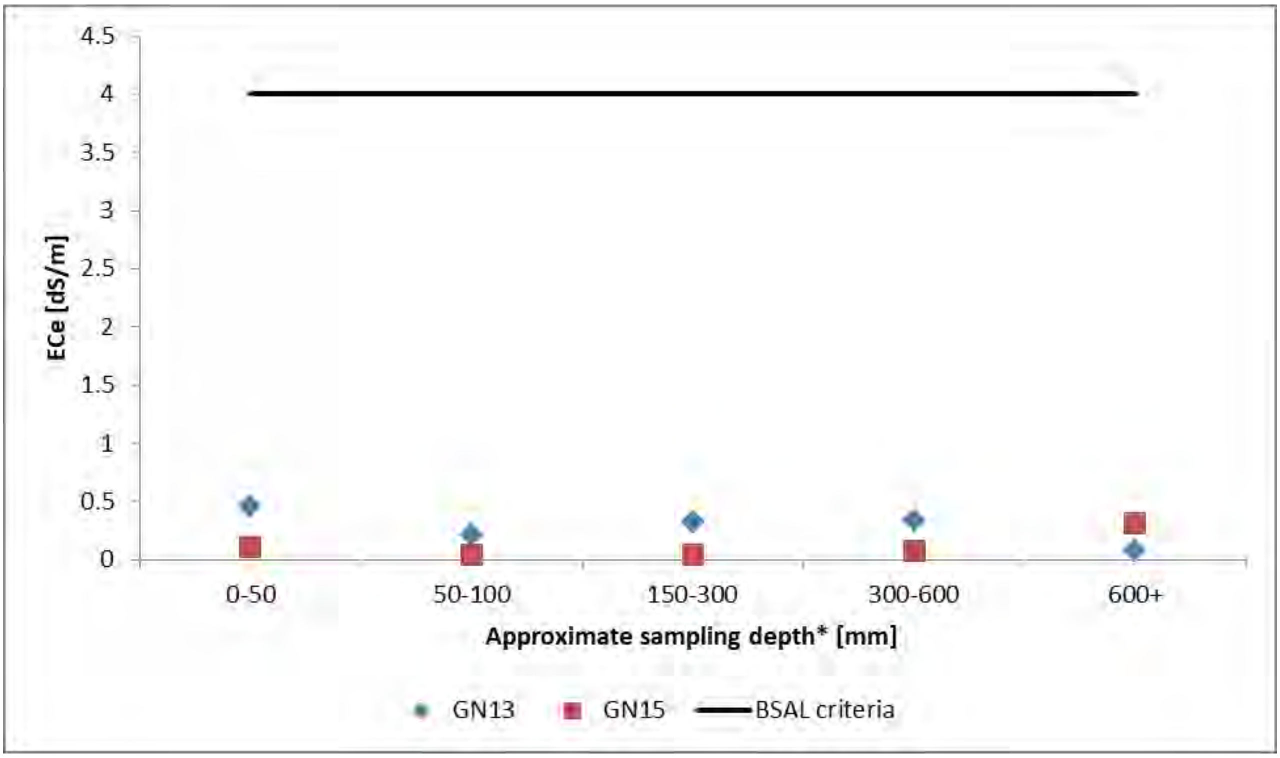
Plate 4.17 Profile description GN15

The pH of the Kandosols is moderately acid to slightly acid, both in the A and B horizons of the analysed sites (**Figure 4.13**). Both profiles are non-saline (**Figure 4.14**) and GN13 is non sodic, while GN15 is sodic below 250 mm and highly sodic below 600 mm (**Figure 4.15**), which may be a result of the influence of the underlying sandstone. GN13 has a moderate CEC throughout the profile, while GN15 has a very low CEC in the upper 600 mm and a moderate CEC below this (**Figure 4.16**). However, this will be due to a high Sodium percentage as shown by the ESP (**Figure 4.15**).



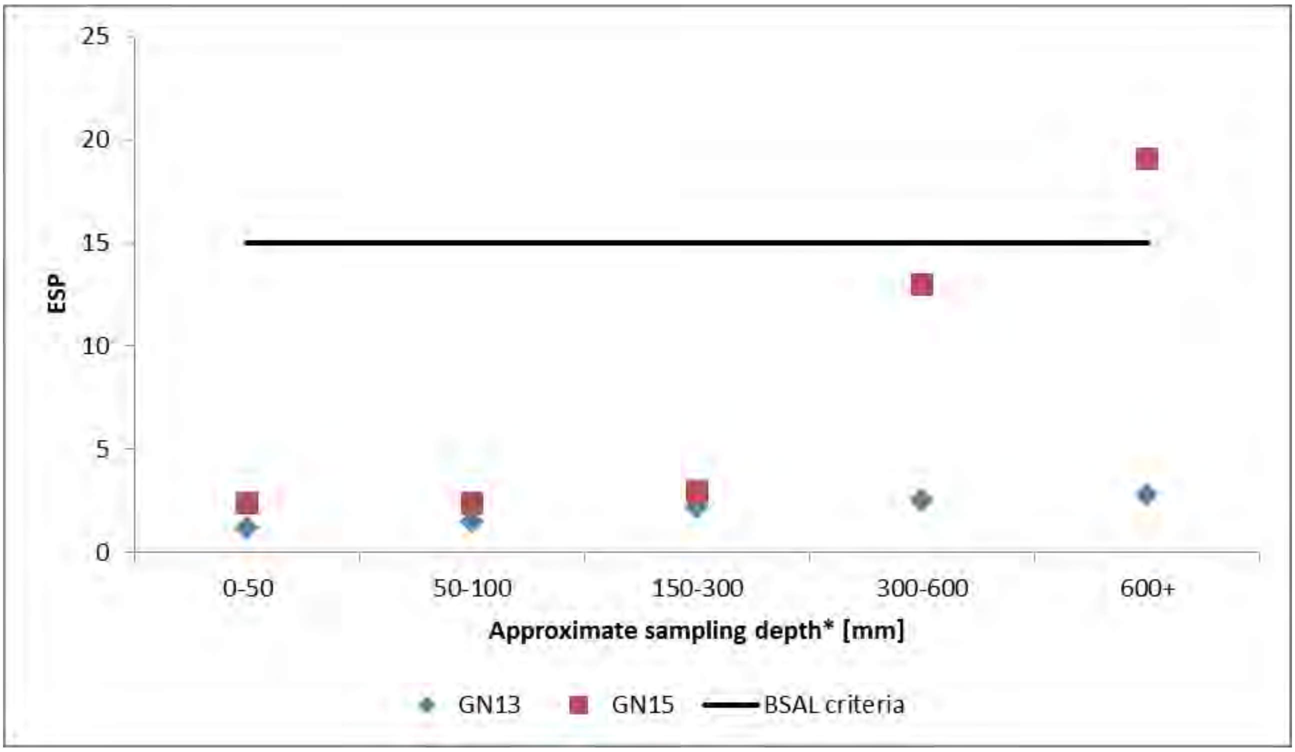
*Reflects **approximate sampling depths, variable for each survey site.**

Figure 4.13 pH for sampled Kandosols



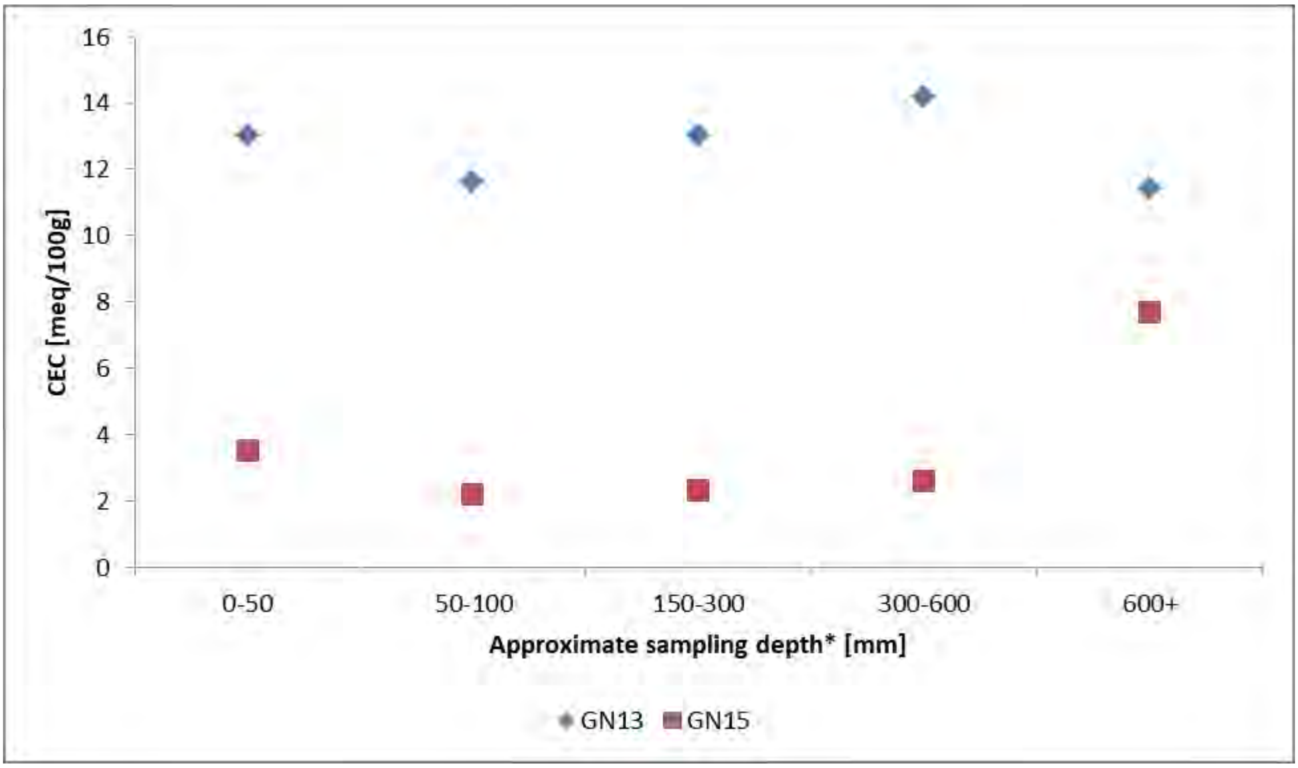
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.14 Saturated paste electrical conductivity (ECe) for sampled Kandosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.15 Exchangeable sodium percentage for sampled Kandosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.16 Cation exchange capacity (CEC) for sampled Kandosols

4.1.5 Chromosol

Brown or Black Chromosols occur on the upper terrace of the creek floodplains (GN6, GN8, GN69, GN71, GN77, GN79) and in one occasion (GN35) on the midslope of the rolling hills (**Plates 4.18** and **4.19**). The Chromosols in the floodplain are derived from *ex situ* material. GN35 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 25.2 ha, or 4.2%, of the Verification Area.

Plate 4.18 GN 71, upper terrace, looking south

Plate 4.19 GN35, midslope, looking north

The A horizon texture of the floodplain Chromosols ranged 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 GN9, mottling occurred the GN6 B21 and the lower B horizon of some of the other profiles. Few manganiferous soft segregations were recorded in the lower depth of GN77 (+650 mm) and GN79 (+800 mm).

Chromosols on the Bowmans Creek floodplain may be well suited for agricultural use, however the Chromosol mapped near Yorks Creek (GN6) has imperfect drainage and rooting restrictions due to high sodicity (see below).

Table 4.5 presents the soil profile description of GN71 with its profile and landscape context being shown in **Plate 4.20** and **4.21** respectively.

Table 4.5 Soil Profile Description – GN71

GN71	**Datum: GDA 94 Zone 56** **Easting: 316552.76** **Northing: 6412017.90** **Recorded: 11th October 2017**
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Moderately well drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol
Profile Characteristics	
A11 0-120 mm	7.5YR 4/3 (moderately moist) Silty Clay Loam. pH 6.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 120-350 mm	7.5YR 4/3(moderately moist), sporadically bleached Silty Clay Loam. pH 5.6. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 350-650 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Gradual boundary.
B22 650-800 mm	7.5YR 4/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, coarse macropores. Gradual boundary.
B23 800^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay. pH 7.0[3]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Limit of observation.

[3] Field pH, maximum sampling depth 650-800 mm

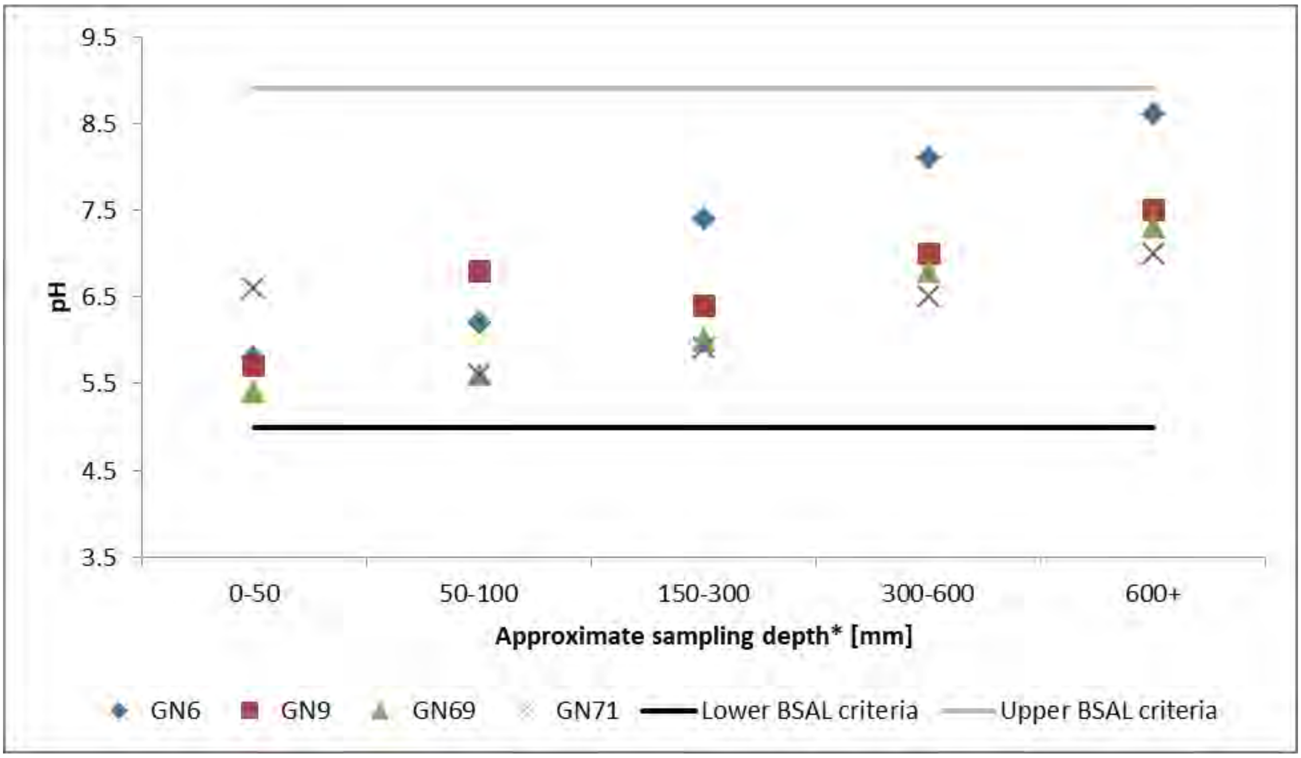
Plate 4.20 Profile description GN71

Plate 4.21 GN71, upper floodplain terrace of Bowmans Creek, looking south

Laboratory analysis of the Chromosol samples showed that A horizon pH ranged from strongly acid (pH 5.54, GN69) to slightly alkaline (pH 7.4, GN6). B horizon pH lay between pH 6.4 (slightly acid) and pH 8.6 (strongly alkaline) (**Figure 4.17**).

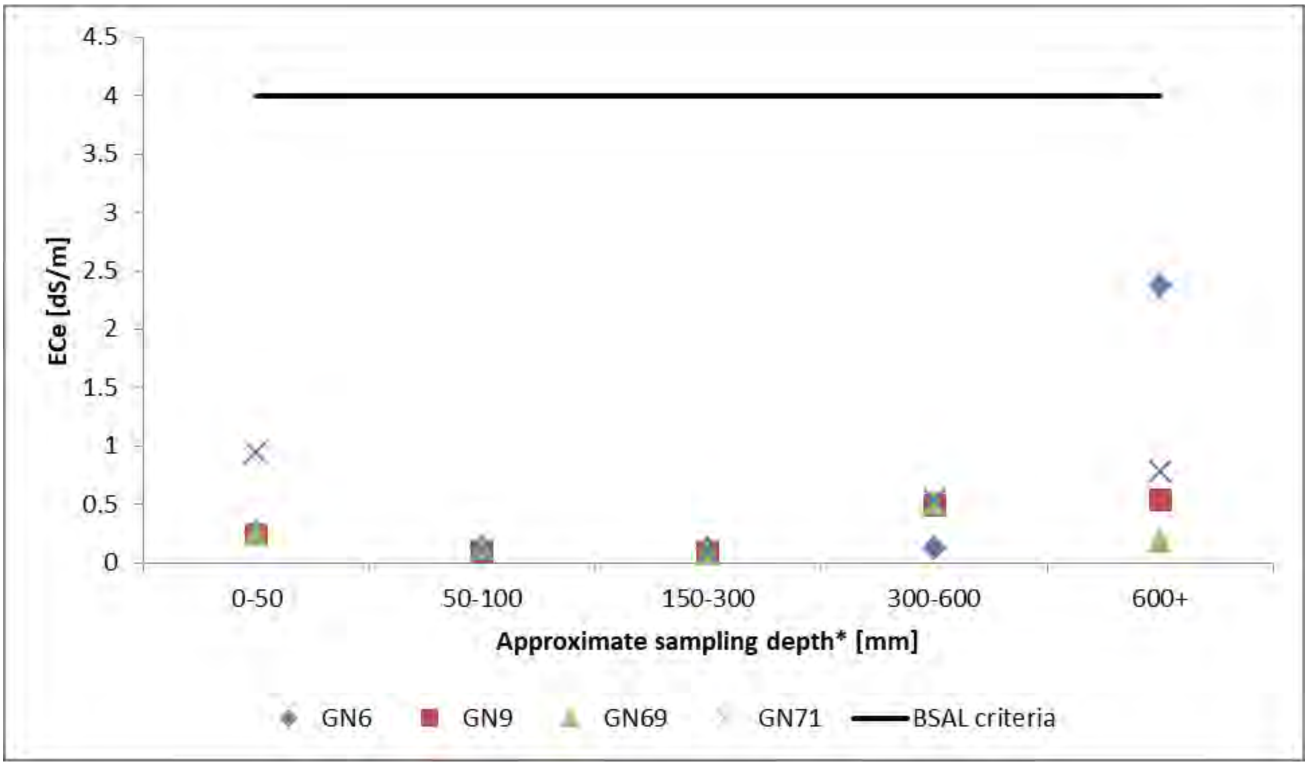
The analysed Chromosol samples were non-saline and non-sodic, with the exception of GN6, which was slightly saline and strongly sodic (ESP 35.5) below 500 mm (**Figures 4.18** and **4.19**). This indicates that the underlying geology strongly influenced the soil formation for GN6 below 500 mm.

The CEC of the A horizons was moderate for all sites, with the exception of the A2 horizon of GN6, which had a low CEC. This may be a result of a slight bleach in this horizon which indicates lateral leaching of nutrients. GN9, GN69 and GN71 had a high CEC rating for the upper B horizon, which may be a result of increased clay contents. The CEC rating of GN6 remained low. The CEC in the lower B decreased to a moderate to low value, with the exception of GN71 (high CEC rating) (**Figure 4.20**).



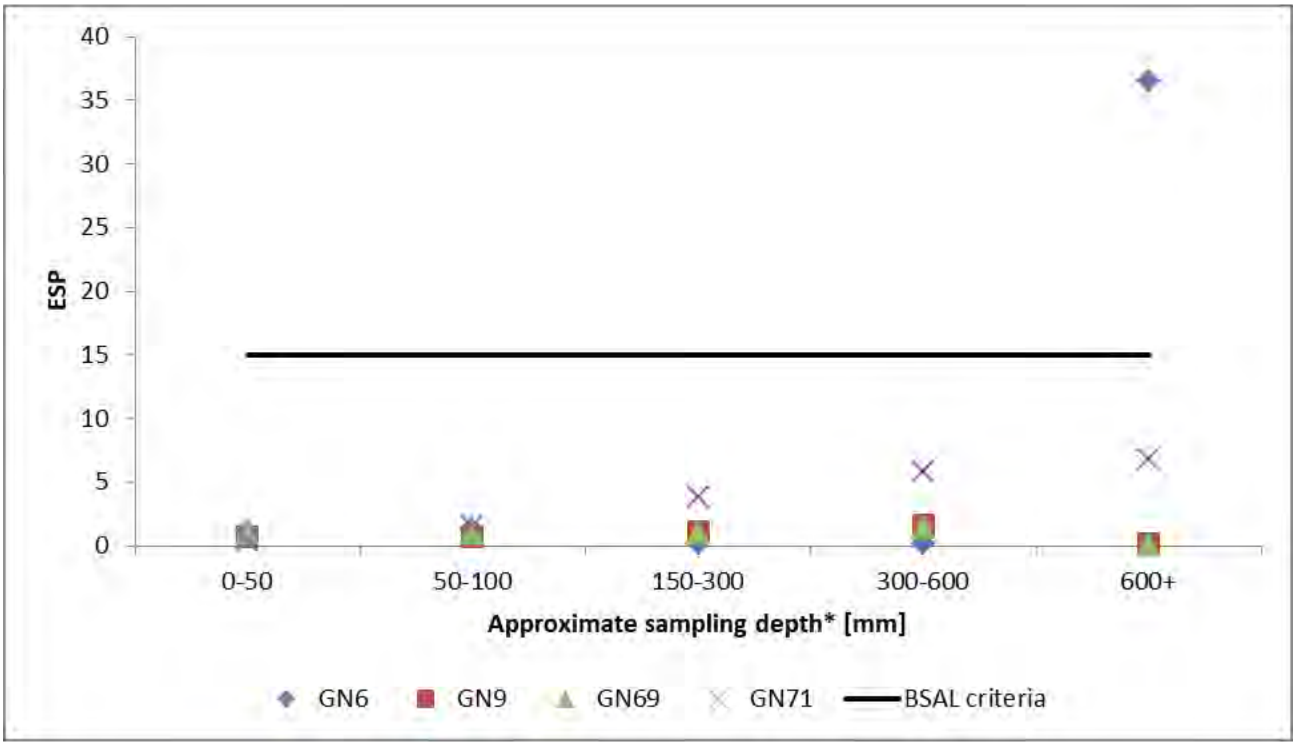
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.17 pH for sampled Chromosols



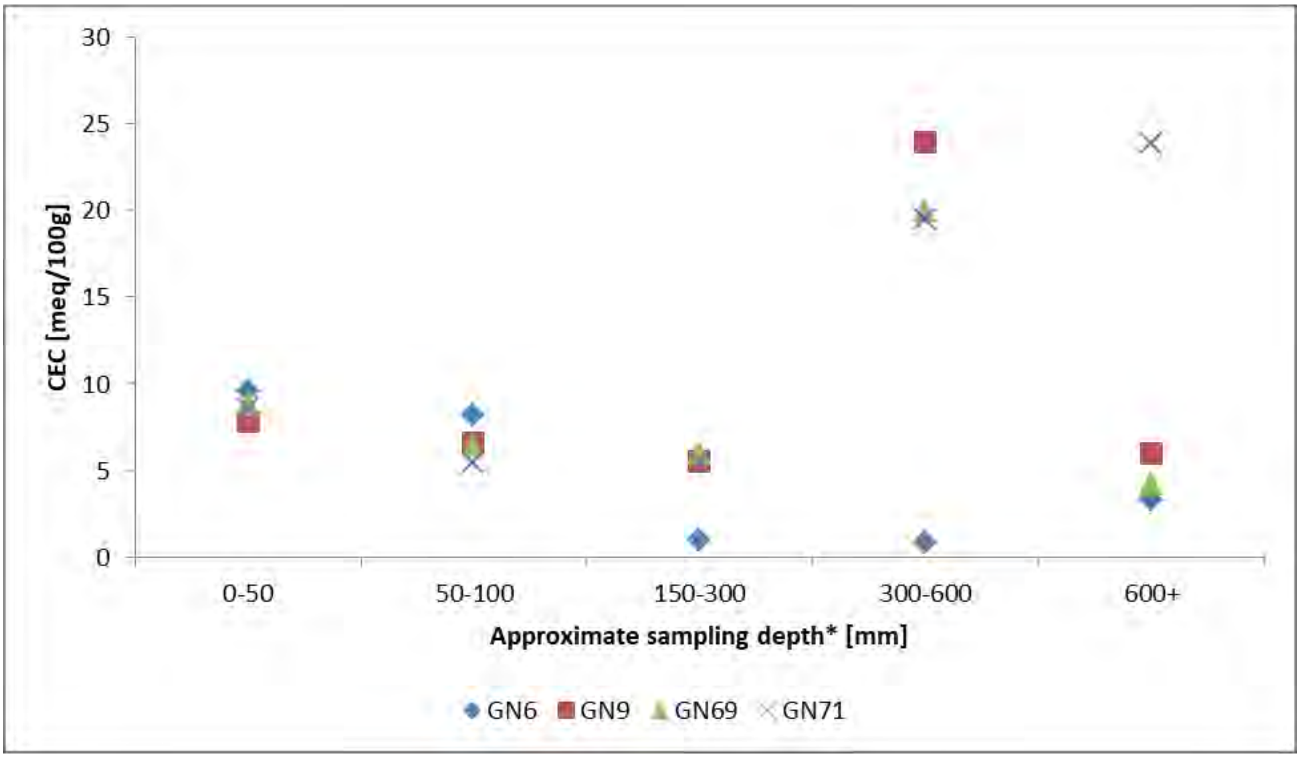
*Reflects approximate sampling depths, variable for each survey site.

Figure 4.18 Saturated paste electrical conductivity (ECe) for sampled Chromosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.19 Exchangeable sodium percentage for sampled Chromosols



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.20 Cation exchange capacity (CEC) for sampled Chromosols

4.1.6 Dermosol

Red and Black Dermosols were found in isolation in floodplain areas (GN26, GN67) and to a limited extent on a mid to lower slope site (GN17) (**Plates 4.22** and **4.23** respectively). This ASC Order is only encountered in approximately 1% of the Verification Area. As a result of this limited extent, only two detailed sites (GN17, GN67) and one check site (GN26) intercepted Dermosols. Dermosols are present on 8.4 ha, or 1.4%, of the Verification 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.

Plate 4.22 GN 26, floodplain, looking west towards Yorks Creek

Plate 4.23 GN17, midslope, looking north

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 of both profiles in the floodplain (GN26, GN67), but cracks did not connect to the surface.

For Dermosols, imperfect drainage is a limitation to agriculture. For GN17, coarse fragments and bedrock at 700 mm further impede land use. As discussed below, both analysed profiles were highly sodic below 600 mm, and thus restrict rooting depth.

Exemplary, GN67 profile description is presented in **Table 4.6** and its profile and landscape context is shown in **Plates 4.24** and **4.25** respectively.

Table 4.6 Soil Profile Description – GN67

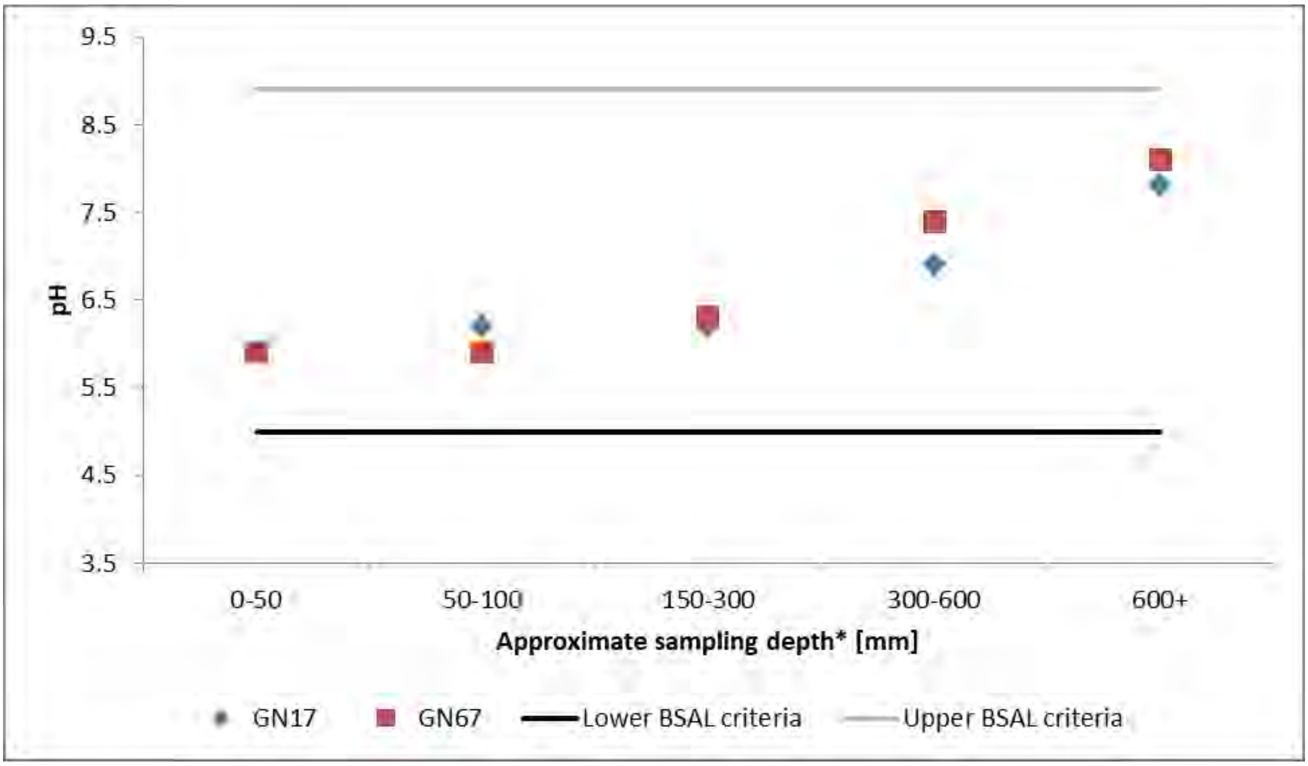
GN67	Datum: GDA 94 Zone 56 Easting: 317507.04 Northing: 6411450.76 Recorded: 12th October 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 950 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Dermosol

Profile Characteristics	
A1 0-100 mm	7.5YR 4/2 (moderately moist) Light Clay. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Common, medium macropores. Gradual boundary.
B21 100-300 mm	10YR 3/1 (moderately moist) Medium Clay. pH 5.9. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Common, medium macropores. Gradual boundary.
B22 300-600 mm	10YR 3/2 (moderately moist) Medium Heavy Clay. pH 7.4. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (<10%), distinct slickensides. Few, medium macropores. Diffuse boundary.
B24 600^{+} mm	10YR 3/3 (moderately moist) Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), fine, faint, orange mottles. Limit of observation.

Plate 4.24 Soil Profile GN67

Plate 4.25 GN67, floodplain terrace of Yorks Creek, looking north

Analysed soil samples showed a moderately acid soil pH in the A and upper B horizon, which increased to moderately alkaline with depth (**Figure 4.21**). GN17 was non saline throughout the profile, while GN67 was slightly saline below 600 mm (**Figure 4.22**). Both sites had non sodic A horizons, but became sodic in the B horizon, with a maximum ESP of 24.4 and 19 below 600 mm, for GN17 and GN69, respectively (**Figure 4.23**). GN67 has a low CEC rating throughout the profile, while the CEC of GN17 was moderate to high, decreasing to low below 600 mm (**Figure 4.24**).



*Reflects approximate sampling depths, variable for each survey site.

Figure 4.21 pH for sampled Dermosols

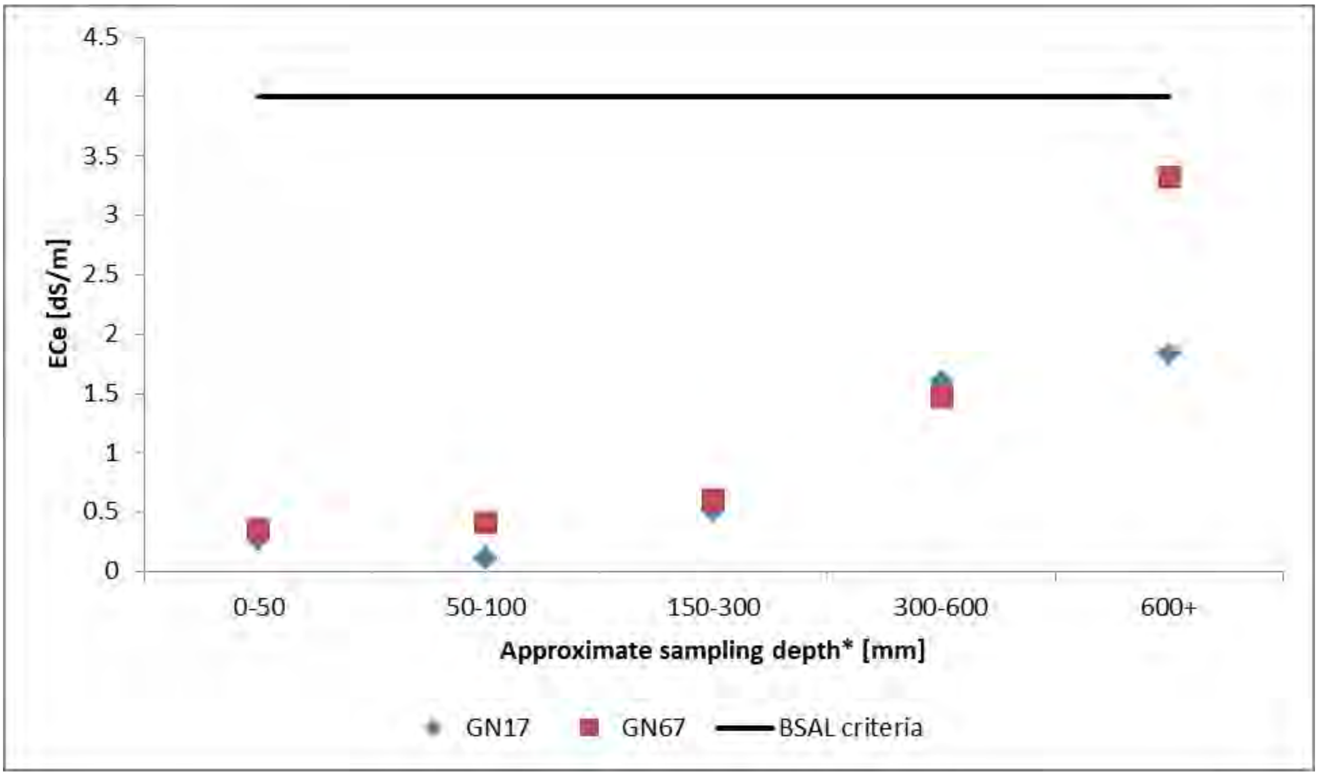


Figure 4.22 Saturated paste electrical conductivity (ECe) for sampled Dermosols

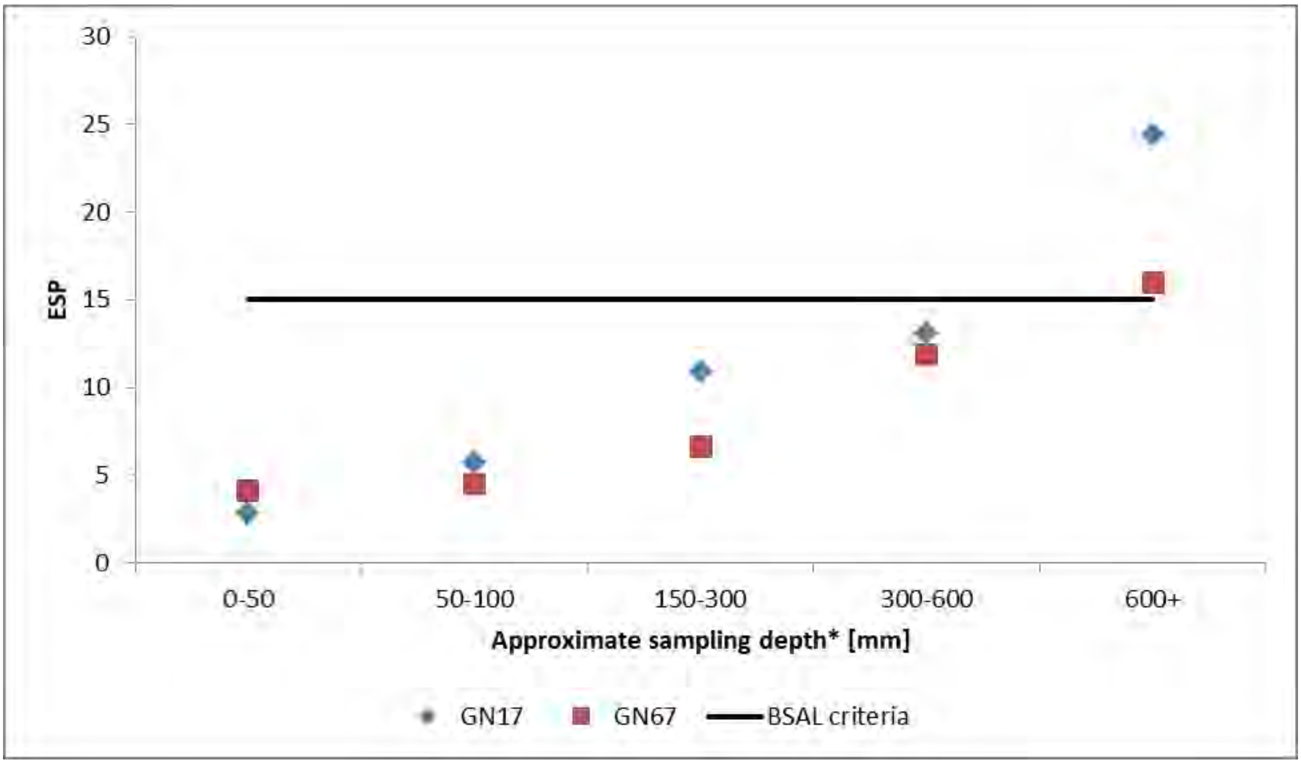


Figure 4.23 **Exchangeable sodium percentage for sampled Dermosols**

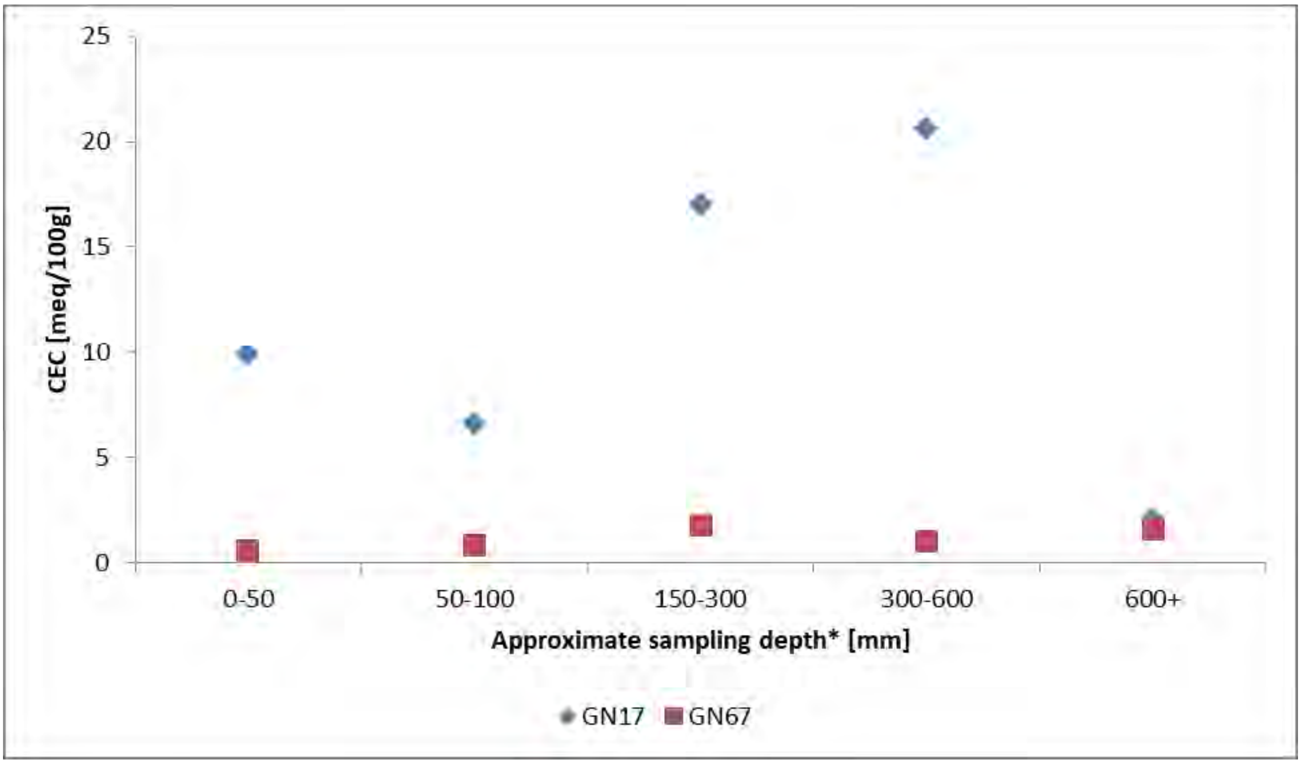


Figure 4.24 **Cation exchange capacity (CEC) for sampled Dermosols**

4.2 Soil Classification and mapping

In accordance with the Interim Protocol, all detailed sites were described to family level following *The Australian Soil Classification* (Isbell, 1996) as presented in **Table 4.7**. **Table 4.8** shows the ASC Order and suborder for the check sites. The distribution of the identified soils in the Verification Area is shown in **Figure 4.25**.

Sodosol is the dominant soil order in the Verification Area, taking up almost 84% of the area. Tenosols cover approximately 7% of the area, while Chromosols can be found in approximately 4% of the Verification Area. Dermosols and Rudosols cover just over 1% of the Verification Area (1.4% and 1.1%, respectively), while Kandosols are present on 0.9% of the area (**Table 4.9**).

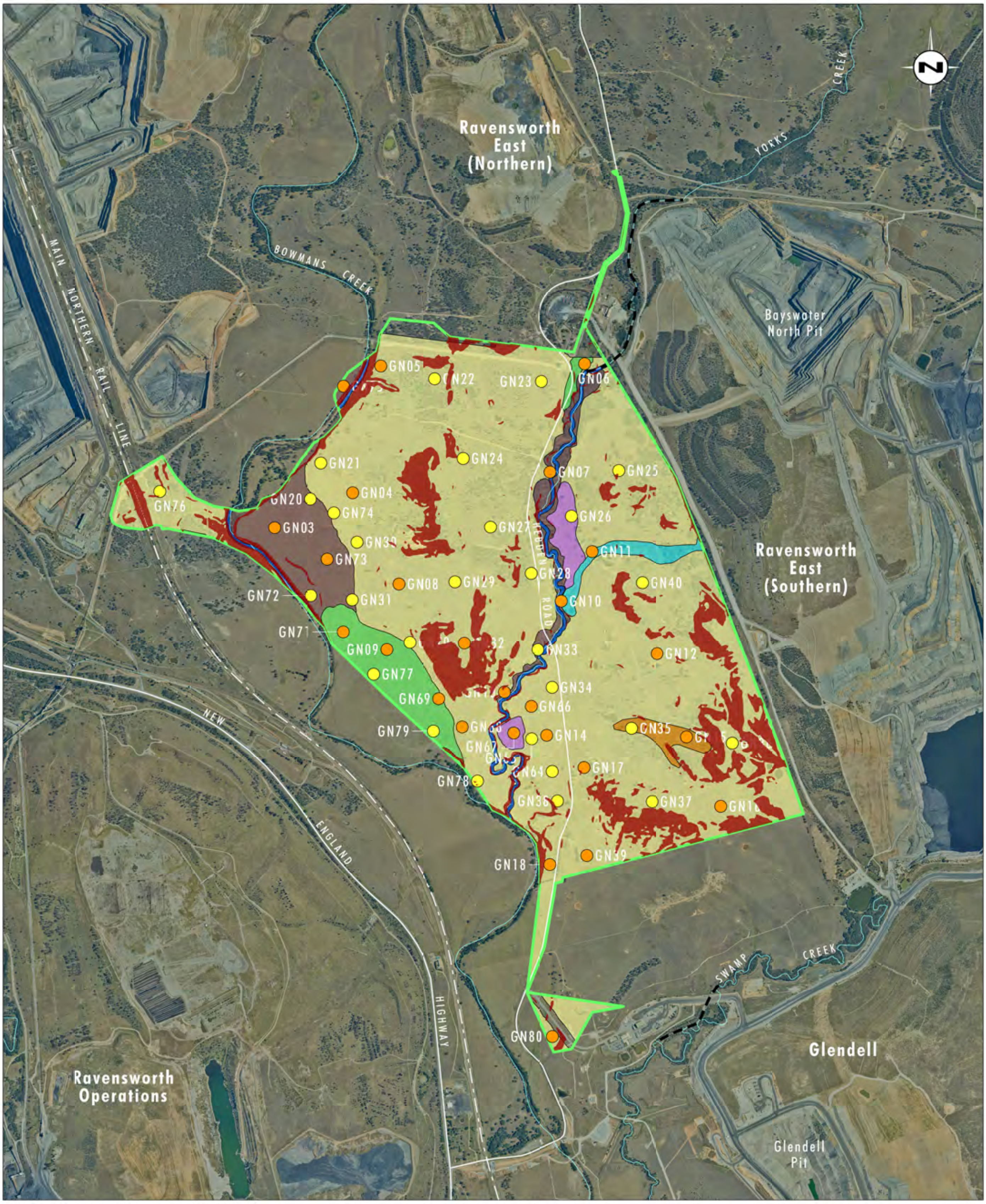


Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)

0 0.5 1.0 1.5km
1:30 000

Legend

- Verification Area
- Slope >10%
- Brown/Red/Yellow/Grey/Black Sodosol
- Brown-Orthic Tenosol
- Clastic/Stratic Rudosol
- Brown Kandosol
- Brown/Black Chromosol
- Red/Black Dermosol
- Creek Line
- Soil Sampling Sites – Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 4.25

Distribution of Soil Units Across the Verification Area

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20180511 10.15

Table 4.7 Soil classification for detailed sites

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN3	Tenosol	Brown-Orthic	Regolithic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Loamy B horizon maximum texture: Clayey Soil depth: Very deep
GN4	Rudosol	Stratic			Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Loamy Soil depth: Shallow
GN5	Sodosol	Brown	Mesonatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN6	Chromosol	Brown	Mesotrophic	Bleached-Sodic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Very Deep
GN7	Sodosol	Brown	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Very Deep
GN8	Sodosol	Brown	Subnatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN9	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep/Very Deep

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN10	Rudosol	Stratic			Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Loamy Soil depth: Shallow
GN11	Rudosol	Stratic			Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy Soil depth: Shallow
GN12	Sodosol	Brown	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN13	Kandosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN14	Sodosol	Brown	Mesonatric	Mesotrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non-gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN15	Kandosol	Brown	Mesotrophic	Sodic	A horizon thickness: Moderate Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN16	Sodosol	Red	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Moderate
GN17	Dermosol	Red	Eutrophic	Sodic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN18	Sodosol	Brown	Mesonatric	Eutrophic	A horizon thickness: Thick Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate/Deep
GN32	Rudosol	Clastic	Lithosolic	Basic	Gravel of the surface and A1 horizon: Slightly gravelly A1 horizon texture: Clay Loamy Soil depth: Shallow
GN39	Sodosol	Brown	Subnatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Moderate
GN66	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep
GN67	Dermosol	Black	Mesotrophic	Vertic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clayey B horizon maximum texture: Clayey Soil depth: Deep
GN68	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep
GN69	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep

Site ID	ASC Order	ASC suborder	Great Group	Sub-Group	Family
GN71	Chromosol	Brown	Eutrophic	Haplic	A horizon thickness: Thick Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep
GN73	Tenosol	Brown-Orthic	Regolothic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clay Loamy Soil depth: Deep
GN75	Tenosol	Brown-Orthic	Regolithic	Basic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Silty B horizon maximum texture: Clayey Soil depth: Deep
GN80	Sodosol	Black	Mesonatric	Eutrophic	A horizon thickness: Medium Gravel of the surface and A1 horizon: Non gravelly A1 horizon texture: Clay Loamy B horizon maximum texture: Clayey Soil depth: Deep

Table 4.8 Soil classification for check sites

Site ID	ASC Order	ASC suborder
GN20	Tenosol	Brown-Orthic
GN21	Tenosol	Brown-Orthic
GN22	Sodosol	Yellow
GN23	Sodosol	Yellow
GN24	Sodosol	Brown
GN25	Sodosol	Grey
GN26	Dermosol	Black
GN27	Sodosol	Brown
GN28	Sodosol	Brown
GN29	Sodosol	Brown
GN30	Sodosol	Brown
GN31	Tenosol	Brown-Orthic
GN33	Tenosol	Brown-Orthic
GN34	Kandosol	Brown
GN35	Chromosol	Brown
GN36	Sodosol	Grey
GN37	Tenosol	Brown-Orthic
GN38	Sodosol	Brown
GN40	Sodosol	Brown
GN64	Sodosol	Black
GN65	Sodosol	Black
GN70	Sodosol	Brown
GN72	Tenosol	Brown-Orthic
GN74	Sodosol	Brown
GN76	Sodosol	Brown
GN77	Chromosol	Black
GN78	Sodosol	Brown
GN79	Chromosol	Black

Table 4.9 Area of each ASC Order in the Verification Area

ASC Order	Area (ha)	Area (%)
Sodosol	508.1	83.9
Tenosol	42.3	7.0
Chromosol	25.2	4.2
Dermosol	8.4	1.4
Rudosol	6.5	1.1
Kandosol	5.6	0.9

5.0 Assessment against BSAL criteria

The following section contains an assessment of each of the detailed sites against the 12 BSAL criteria shown in **Figure 2.2.**

5.1 Criteria 1-9: Landscape and soil physical properties

Criteria 1 Is slope less than or equal to 10%?

Several areas of the Verification Area exceed the 10% slope threshold. These areas are shown in **Figure 3.1**, comprising 83.3 ha, and were excluded from further detailed assessment. Slope analysis is based on LiDAR data and continuous triangulation.

Criteria 2 Is there less than 30% rock outcrop?

Yes. Rock outcrop in the Verification Area does not exceed 30% at any point.

Criteria 3 Does less than or equal to 20% of the area have unattached rock fragments that are more than 60 mm in diameter?

Yes. Surface occurrence of coarse fragments across the Verification Area does not exceed 20% at any point.

Criteria 4 Does less than or equal to 50% of the area have gilgai greater than 500 mm deep?

Yes. No gilgai are present in the Verification Area.

Criteria 5a Is the slope less than 5%?

Yes. Areas of less than 5% slope (primarily on alluvial plains and some hillslopes) within the Verification Area are shown in **Figure 5.1**. Proceed to Criteria 6.

Criteria 5b Is the slope greater than 5% and less than or equal to 10%.

Yes. Areas of slope greater than 5% and less than or equal to 10% occur within the Verification Area. Proceed to Criteria 7.

Criteria 6 Are there nil rock outcrops on slopes of less than 5%?

Yes. This criterion does not apply for sites with slopes > 5% and less than or equal to 10%.

Criteria 7a On slopes < 5%, does the soil have moderate fertility?

Criteria 7b On slopes > 5% and less than or equal to 10%, does the soil have moderately high or high fertility?

Appendix 2 of the Interim Protocol provides a ranking of relative soil fertility based on ASC Order, ASC Suborder and ASC Great Group. The fertility of all detailed sites has been assessed based on this and is presented in **Table 5.1**. Sites that do not meet the required fertility criteria are highlighted in red.

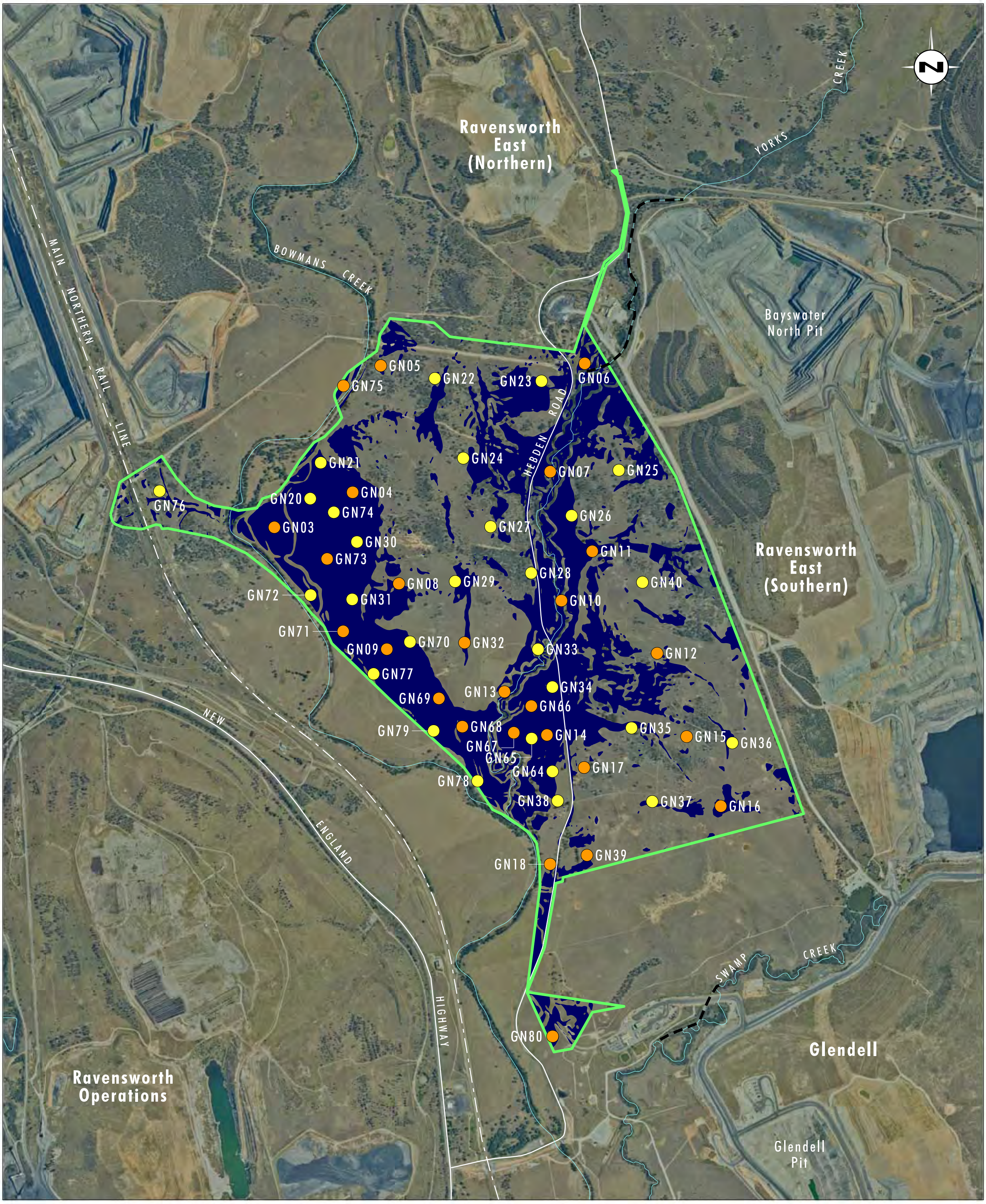

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017)

0 0.5 1.0 1.5km
1:30 000

Legend

- Verification Area
- Slope <= 5%
- Soil Sampling Sites – Check Sites
- Soil Sampling Sites - Detailed Sites
- Existing Creek Diversion

FIGURE 5.1

Area of Slope Less Than or Equal to 5%

File Name (A4): R04/4166_024.dgn
20180511 10.14

Table 5.1 Assessment of soil fertility

Site ID	ASC Order	ASC suborder	Great Group	Slope (%)	Fertility rating
GN3	Tenosol	Brown-Orthic	Regolithic	< 5	Moderately low
GN4	Rudosol	Stratic		< 5	Moderately low
GN5	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN6	Chromosol	Brown	Mesotrophic	< 5	Moderately high
GN7	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN8	Sodosol	Brown	Subnatric	< 5	Moderately low
GN9	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN10	Rudosol	Stratic		< 5	Moderately low
GN11	Rudosol	Stratic		< 5	Moderately low
GN12	Sodosol	Brown	Subnatric	< 5	Moderately low
GN13	Kandosol	Brown	Eutrophic	< 5	Moderately low
GN14	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN15	Kandosol	Brown	Mesotrophic	> 5 and <10	Moderately low
GN16	Sodosol	Red	Subnatric	< 5	Moderately low
GN17	Dermosol	Red	Eutrophic	> 5 and <10	Moderately high
GN18	Sodosol	Brown	Mesonatric	< 5	Moderately low
GN32	Rudosol	Clastic	Lithosolic	< 5	Moderately low
GN39	Sodosol	Brown	Subnatric	> 5 and < 10	Moderately low
GN66	Sodosol	Black	Mesonatric	< 5	Moderately low
GN67	Dermosol	Black	Vertic	< 5	Moderately high
GN68	Sodosol	Black	Mesonatric	< 5	Moderately low
GN69	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN71	Chromosol	Brown	Eutrophic	< 5	Moderately high
GN73	Tenosol	Brown-Orthic	Regolothic	< 5	Moderately high
GN75	Tenosol	Brown-Orthic	Regolithic	< 5	Moderately high
GN80	Sodosol	Black	Mesonatric	< 5	Moderately low

Criteria 8 Is effective rooting depth to a physical barrier greater than or equal to 750 mm?

The Interim Protocol states that "*In the context of BSAL, effective rooting depth to a physical barrier is the depth of soil material from the surface to bedrock, weathered rock, hard pans or continuous gravel layers. These physical barriers may restrict penetration by plant roots and effectively mark the bottom of the soil profile*." The assessment of effective rooting depth for the Verification Area is based on the criteria specified in Table 4 of the Interim Protocol. The results of the assessment are provided in **Table 5.2.**

Table 5.2 Assessment of effective rooting depth to physical barrier

Site ID	Observed rooting depth (mm)	Physical barrier present (>100 mm layer containing >20% coarse fragments and/or segregations >60 mm	Depth (mm)	Effective Rooting depth to physical barrier ≥ 750 mm?
GN3	700	Yes - 20-50% large pebbles	650	No
GN4	900	No		Yes
GN5	180	No		Yes
GN6	550	No		Yes
GN7	600	No		Yes
GN8	600	Yes – 20-50% large pebbles	600	No
GN9	900	No		Yes
GN10	900	No		Yes
GN11	800	No		Yes
GN12	600	No		Yes
GN13	800	No		Yes
GN14	650	No		Yes
GN15	650	Yes – 20-50% large pebbles	600	No
GN16	580	Yes –Mudstone Bedrock	580	No
GN17	600	Yes –Mudstone Bedrock	700	No
GN18	800	Yes – 20-50% medium pebbles	450	No
GN32	350-600	Yes – Conglomerate bedrock	350-600	No
GN39	680	No		Yes
GN66	800	No		Yes
GN67	950	No		Yes
GN68	1000	No		Yes
GN69	1200	No		Yes
GN71	1000	No		Yes
GN73	1000	No		Yes
GN75	900	No		Yes
GN80	700	No		Yes

Criteria 9 Is soil drainage better than poor?

The assessment of drainage is based on the criteria specified in Table 2 of the Interim Protocol, which is based on soil colour and also the presence of distinct or prominent mottles > 10% in occurrence. The results of the assessment are provided in **Table 5.3.**

Table 5.3 Assessment of soil drainage

Site ID	Colour Gley, Grey or Bleached?	Mottles > 10% present, either distinct or prominent?	Soil drained better than poor?
GN3	No	No	Yes
GN4	No	No	Yes
GN5	Yes - Bleached	No	No
GN6	No	Yes	No
GN7	Yes – Bleached	Yes	No
GN8	No	No	Yes
GN9	No	No	Yes
GN10	No	No	Yes
GN11	No	No	Yes
GN12	Yes – Bleached	Yes	No
GN13	No	Yes	No
GN14	Yes – Bleached	Yes	No
GN15	No	Yes	No
GN16	Yes – Bleached	No	No
GN17	No	No	Yes
GN18	No	No	Yes
GN32	No	No	Yes
GN39	Yes – Bleached	No	No
GN66	No	No	Yes
GN67	No	No	Yes
GN68	Yes – Grey	No	No
GN69	No	No	Yes
GN71	No	No	Yes
GN73	No	No	Yes
GN75	No	No	Yes
GN80	Yes – Bleached	No	No

5.1.1 Soil and landscape BSAL verification criteria – Summary

Several of the assessed sites fail the soil physical and landscape verification criteria (Criteria 1-9) on at least one criterion. A summary is provided below in **Table 5.4.**

Table 5.4 Soil physical and landscape verification criteria results

Site ID	Criteria passed	Criteria failed
GN3	1,2,3,4,5,6,9	7, 8
GN4	1,2,3,4,5,8,9	7
GN5	1,2,3,4,5,6,8	7, 9
GN6	1,2,3,4,5,6,7,8	9
GN7	1,2,3,4,5,6,8	7, 9
GN8	1,2,3,4,5,6,9	7, 8
GN9	1,2,3,4,5,6,7,8,9	
GN10	1,2,3,4,5,6,8,9	7
GN11	1,2,3,4,5,6,8,9	7
GN12	1,2,3,4,5,6,8	7, 9
GN13	1,2,3,4,5,6,8	7, 9
GN14	1,2,3,4,5,6,8	7, 9
GN15	1,2,3,4,5,6	7, 8, 9
GN16	1,2,3,4,5,6	7,8,9
GN17	1,2,3,4,5,7,9	6, 8
GN18	1,2,3,4,5,6,9	7, 8
GN32	1,2,3,4,5,6,9	7, 8
GN39	1,2,3,4,5,8	7, 9
GN66	1,2,3,4,5,6,8,9	7
GN67	1,2,3,4,5,6,7,8,9	
GN68	1,2,3,4,5,6,8	7, 9
GN69	1,2,3,4,5,6,7,8,9	
GN71	1,2,3,4,5,6,7,8,9	
GN73	1,2,3,4,5,6,7,8,9	
GN75	1,2,3,4,5,6,7,8,9	
GN80	1,2,3,4,5,6,8	7, 9

5.2 Assessment against BSAL criteria 10-12 – Soil chemical properties

Assessment of the Verification Area has been made against the soil chemistry criteria, which are as follows:

Criteria 10 **Does the pH range from 5.0 – 8.9 if measured in water (or 4.5 to 8.1 if measured in calcium chloride), within the uppermost 600 mm of the profile?**

Criteria 11 **Is salinity (ECe) ≤4 ds/m or are chlorides < 800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile?**

Criteria 12 **Is effective rooting depth to a chemical barrier ≥750 mm?**

Criteria for assessing effective rooting depth to a chemical barrier have been taken from Table 4 of the Interim Protocol. These are as follows:

- pH 5.0-8.9, if measured in water
- ECe < 4 dS/m
- ESP < 15%
- Ca:Mg ratio > 0.1

The summary of the results of all detailed soils is presented in **Table 5.5**, the detailed assessment of each sample against Criteria 10 and 11 are presented in **Appendix A**. Laboratory test results taken from the detailed soil test pits are included in **Appendix B.**

Table 5.5 Summary of assessment of Criteria 10-12

Site ID	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN3	Yes	Yes	Yes
GN4	Yes	Yes	Yes
GN5	Yes	Yes	No
GN6	Yes	Yes	No
GN7	No	Yes	No
GN8	Yes	Yes	No
GN9	Yes	Yes	Yes
GN10	Yes	Yes	Yes
GN11	Yes	Yes	Yes
GN12	Yes	Yes	Yes
GN13	Yes	Yes	Yes
GN14	Yes	Yes	No
GN15	Yes	Yes	No
GN16	Yes	Yes	Yes
GN17	Yes	Yes	No
GN18	Yes	Yes	No
GN32	Yes	Yes	Yes
GN39	Yes	Yes	No

Site ID	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN66	Yes	Yes	No
GN67	Yes	Yes	No
GN68	Yes	No	No
GN69	Yes	Yes	Yes
GN71	Yes	Yes	Yes
GN73	Yes	Yes	Yes
GN75	Yes	Yes	Yes
GN80	Yes	Yes	Yes

5.2.1 Soil chemistry verification criteria – Summary

Several of the assessed sites fail the soil chemistry verification criteria (Criteria 10-12).

5.3 Mapping of BSAL

GN9, GN69 and GN71 (all Chromosols) as well as, GN73 and GN75 (both Tenosols) meet all 12 BSAL criteria and thus are considered BSAL.

All sites are located in Bowmans Creek upper floodplain terrace. The total area of BSAL within the Verification Area is 40.4 ha, or 7% of the area under assessment. The majority of this is situated to the east of Bowmans Creek, with a small parcel, associated with GN75, sited to the north of the creek. This smaller BSAL area occupies only 1 ha within the Verification Area, and thus does not comply with the minimum size criterion of 20 ha. However, it is expected that BSAL continues in the area adjacent to GN75 (**Figure 5.2**). Contiguous BSAL in the area outside of the Verification Area has been estimated based on the original Upper Hunter SRLUP mapping and slope analysis. As the total area of contiguous areas of estimated BSAL adjacent to the 1 ha area around GN74 within the Verification Area exceeds 20 ha, this area has also been assessed as being BSAL.

Table 5.6 BSAL results

Site ID	BSAL criteria passed	BSAL criteria failed
GN3	1,2,3,4,5,6,9,10,11,12	7,8
GN4	1,2,3,4,5,8,9,10,11,12	7
GN5	1,2,3,4,5,6,8,10,11	7,9,12
GN6	1,2,3,4,5,6,8,10,11	7,9,12
GN7	1,2,3,4,5,6,7,8,10,11	9,12
GN8	1,2,3,4,5,6,9,10,11	7,8,12
GN9	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN10	1,2,3,4,5,6,8,9,10,11,12	7
GN11	1,2,3,4,5,6,8,9,10,11,12	7
GN12	1,2,3,4,5,6,8,10,11,12	7,9
GN13	1,2,3,4,5,6,8,10,11,12	7,9
GN14	1,2,3,4,5,6,8,10,11	7,9,12
GN15	1,2,3,4,5,6,10,11	7,8,9,12
GN16	1,2,3,4,5,6,10,11,12	7,8,9

Site ID	BSAL criteria passed	BSAL criteria failed
GN17	1,2,3,4,5,7,9,10,11	6,8,12
GN18	1,2,3,4,5,6,9,10,11	7,8,12
GN32	1,2,3,4,5,6,9,10,11,12	7,8
GN39	1,2,3,4,5,8,10,11	7,9,12
GN66	1,2,3,4,5,6,8,9,10,11	7,12
GN67	1,2,3,4,5,6,7,8,9,10,11	12
GN68	1,2,3,4,5,6,8,10	7,9,11,12
GN69	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN71	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN73	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN75	**1,2,3,4,5,6,7,8,9,10,11,12**	
GN80	1,2,3,4,5,6,8,10,11,12	7,9

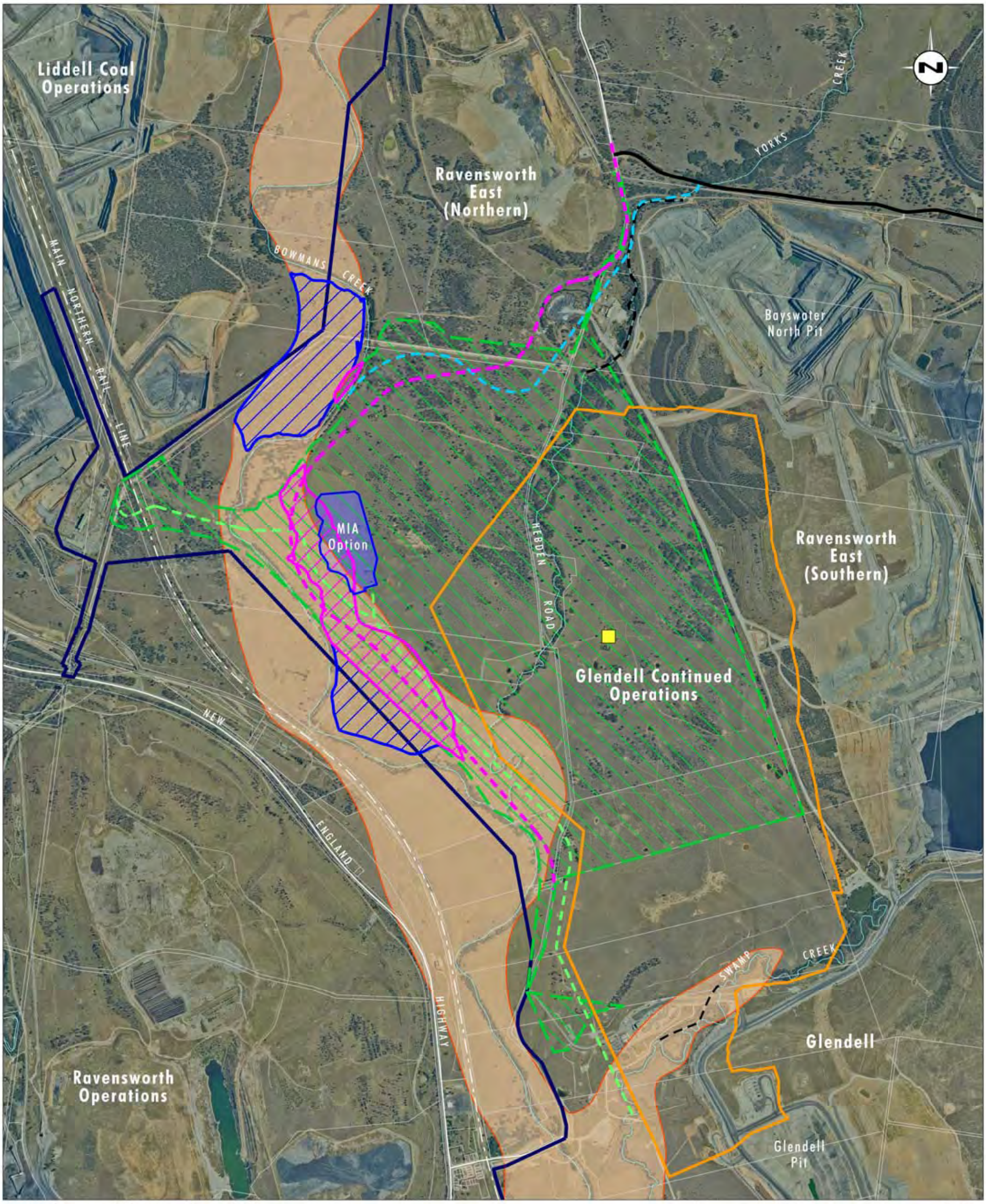

Image Source: Glencore (Jan 2018)
Data Source: Glencore (2017), NSW Department of Planning and Infrastructure (2013)
Note: Ravensworth Homestead to be relocated

Legend

- Project Area
- Proposed Glendell Pit Extension
- Ravensworth Homestead
- New MIA Option
- Mount Owen Access Road
- Verification Area
- Mapped BSAL Upper Hunter SRLUP
- Verified BSAL within Verification Area
- Contiguous BSAL
- Existing Creek Diversion
- Proposed Heavy Vehicle Access Road
- Proposed Hebden Road Realignment
- Proposed Yorks Creek Diversion

FIGURE 5.2

BSAL in Verification Area

File Name (A4): R04/4166_068.dgn
20180511 10.19

6.0 Conclusion

The results of the BSAL verification, using both the Upper Hunter SRLUP assessment methodology and the Interim Protocol, illustrate that there are two parcels of BSAL within the Verification Area. These areas are mapped in **Figure 5.2**. All other areas in the Verification Area fail at least one of the BSAL assessment criteria.

All relevant soil morphological and laboratory data have been uploaded into the NSW Soil and Land Information System database and the approved laboratory data template, as per the Site Verification Certificate guidelines.

7.0 References

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APPENDIX A

Soil Survey Descriptions

Appendix A

Detailed sites

Please note for all detailed sites: Laboratory pH was measured in a 1:5 soil water solution. Where more than one sample has been analysed within a horizon, the results have been averaged.

GN3	Datum: GDA 94 Zone 56 Easting: 316167.86 Northing: 6412599.88 Recorded: 22nd August 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A11 0-100 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A12 100-200 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.4. Apedal massive structure, sandy fabric. Sharp boundary.
B21 200-650 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Loam. pH 6.1 Apedal massive structure, sandy fabric. Abrupt boundary.
2B2 650+ mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay. pH 7.6 Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%) 20-60 mm sub-rounded conglomerate large pebbles. Limit of observation.

GN3 soil profile

GN 3, lower Bowmans Creek floodplain, looking west towards Bowmans Creek

GN4	Datum: GDA 94 Zone 56 Easting: 316605.64 Northing: 6412795.75 Recorded: 22nd August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 850+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Rapidly drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics

A1 0-150 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 5.9. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 6-20 mm sub-angular conglomerate pebbles Abrupt boundary.
2A1 150-300 mm	7.5YR 4/4 (moderately moist) Loamy Coarse Sand. pH 6.1. Apedal massive structure, sandy fabric. Few (2-10%) 6-20 mm angular medium pebbles Gradual boundary.
2B2 150-850 mm	7.5YR 4/6 (moderately moist) Loamy Coarse Sand. pH 6.6. Apedal massive structure, sandy fabric. Few (2-10%) 6-20 mm angular medium pebbles Gradual boundary.
D 850^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[1] Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%) 2-6 mm, maganiferous, soft segregations. Limit of observation.

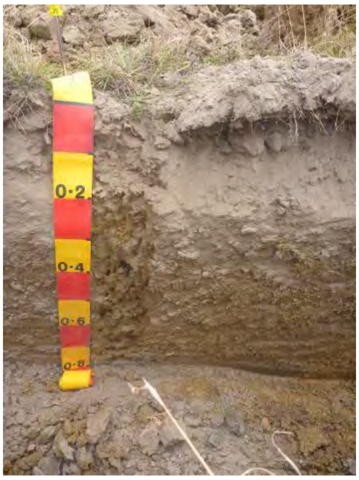
GN4 soil profile


GN4, upper floodplain terrace, looking west towards Bowmans Creek

[1] Field pH as maximum sampled depth is 600-800 mm

GN5	**Datum: GDA 94 Zone 56** **Easting: 316762.92** **Northing: 6413504.17** **Recorded: 21st August 2017**
Landscape Element: Hillslope Slope: 5% Soil Surface Condition: Hard setting Vegetation: Bulloak regeneration, derived native grassland Estimated effective rooting depth: 180 mm Ground cover: 80% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-10mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 5.5[2]. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp, broken boundary.
A2 10-180 mm	7.5YR 4/2 (moderately moist), 7.5YR 7/1 (dry) Sandy Loam. pH 6.1. Apedal massive structure, sandy fabric. Many (20-50%) 6-20 mm sub-rounded conglomerate medium pebbles. Abrupt boundary.
B21 180-600 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Medium Clay. pH 8.1 Moderate pedality, rough-ped fabric, sub-angular structure, 5-10 mm. Few (2-10%) medium, faint orange mottles. Few (2-10%) 6-20 mm sub-rounded medium pebbles. Abrupt boundary.
B22 600^{+} mm	7.5YR 5/4 (moderately moist) Coarse Sandy Medium Clay (light). pH 8.8 Moderate pedality, rough-ped fabric, sub-angular structure, 10-20 mm. Few (2-10%) medium, faint orange mottles Few (2-10%) 20-60 mm sub-rounded large pebbles. Limit of observation.



GN5 soil profile

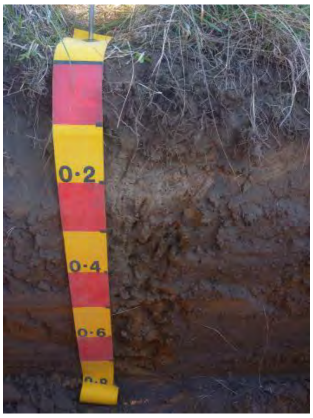

GN5, looking south

[2] Field pH. This horizon was not sampled as insufficient material was available for sampling without sample contamination with A2 horizon.

GN6	Datum: GDA 94 Zone 56 Easting: 317903.81 Northing: 6413516.94 Recorded: 23rd August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Swamp oak, derived native grassland Estimated effective rooting depth: 550 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

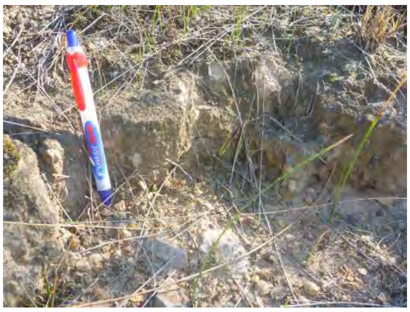
Profile Characteristics

A1 0-150 mm	10YR 2/1 (moderately moist) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 150-250 mm	10YR 3/4 (moderately moist), 10YR 6/4 (dry) Sandy Clay Loam. pH 7.4. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Clear boundary.
B21 250-550 mm	10YR 4/4 (moderately moist) Medium Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, distinct, orange mottles Gradual boundary
B22 550^{+} mm	10YR 4/6 (moderately moist) Coarse Sandy Light Clay. pH 8.6. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%), medium, prominent, brown mottles. Very few (<2%) 6-20 mm, rounded, conglomerate pebbles. Limit of observation.



GN6, soil profile


GN6, looking south



Commencing erosion (left), eroded out coarse fragments (right) to the east GN6 close to Yorks Creek

GN7	Datum: GDA 94 Zone 56 Easting: 317710.71 Northing: 6412911.23 Recorded: 24th August 2017
Landscape Element: Footslope Slope: 1% Soil Surface Condition: Firm Vegetation: Swamp oak, Bulloak, derived, native grassland Estimated effective rooting depth: 280 mm Ground cover: 80% Run on: High	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-120 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 5.0. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 120-280 mm	7.5YR 6/3 (moderately moist), 7.5YR 7/2 (dry) Sandy Loam. pH 5.9. Apedal massive structure, sandy fabric. Sharp boundary.
B21 280-500 mm	7.5YR 4/4 (moderately moist) Light Medium Clay. pH 7.1 Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles Clear boundary
B22 500-800 mm	7.5YR 5/6 (moderately moist) Coarse Sandy Light Clay. pH 8.2. Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Few (2-10%), medium, distinct, orange mottles Gradual boundary
B23 800+ mm	7.5YR 5/4 (moderately moist) Coarse Sandy Light Clay. pH 8.5[3]. Moderate pedality, rough-ped fabric, columnar breaking to angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, orange mottles Limit of observation.

GN7, soil profile


GN7, looking south

[3] Field pH as maximum sampling depth 500-800 mm

GN8	**Datum: GDA 94 Zone 56** **Easting: 316864.54** **Northing: 6412284.91** **Recorded: 22nd August 2017**
Landscape Element: Hillslope Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: High	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-80 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 5.4. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 80-200 mm	7.5YR 4/4 (moderately moist), 7.5YR 6/4 (dry) Coarse Sandy Clay Loam. pH 5.8. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Common (10-20%), 2-6 mm, sub-angular conglomerate pebbles. Abrupt boundary.
B21 200-600 mm	7.5YR 3/4 (moderately moist) Light Medium Clay. pH 7.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), medium, faint, orange mottles. Clear boundary
BC 600^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 8.2. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%), medium, faint, orange mottles. Many (20-50%), 20-60 mm, rounded large pebbles. Common (10-20%), 20-60 mm, ferruginous, weak fragments. Limit of observation.

GN8, soil profile


GN8, looking east (uphill)

GN9	Datum: GDA 94 Zone 56 Easting: 316796.97 Northing: 6411918.12 Recorded: 22nd August 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 700+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics

A1 0-100 mm	7.5YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.3. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-400 mm	7.5YR 4/4 (moderately moist) Sandy Loam. pH 6.4. Apedal massive structure, sandy fabric. Very few (<2%), 2-6 mm, rounded conglomerate pebbles. Abrupt boundary.
B22 400-700 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Light Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Clear boundary
B23 700^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Limit of observation.

GN9, soil profile


GN8, upper terrace of Bowmans Creek floodplain, looking east towards rollomg hills

GN10	Datum: GDA 94 Zone 56 Easting: 317773.7 Northing: 6412189.84 Recorded: 23rd August 2017
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm Vegetation: Swamp oak Estimated effective rooting depth: 900+ mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics

A1 0-50 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 6.4. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
B21 50-180 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Apedal massive structure, sandy fabric. Gradual boundary.
B22 180-300 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam (heavy). pH 6.6. Apedal massive structure, sandy fabric. Gradual boundary
B23 300^{+} mm	At 300 mm: 7.5YR 3/4 (moderately moist) Loamy Sand. pH 6.5. Apedal massive structure, sandy fabric. At 600 mm: 7.5YR 4/4 (moderately moist) Loamy Sand. pH 6.8. Apedal massive structure, sandy fabric. Limit of observation.

GN10, soil profile

GN10 on Yorks Creek floodplain, looking south

GN11	Datum: GDA 94 Zone 56 Easting: 317945.92 Northing: 6412465.9 Recorded: 18th August 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland, red gum regeneration Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Stratic Rudosol

Profile Characteristics

A1 0-100 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.4. Moderate rough-ped fabric, granular structure, 5-10 mm. Abrupt boundary.
B21 100-250 mm	10YR 4/3 (moderately moist) Fine Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Abrupt boundary.
B22 250-350 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B23 350-500 mm	10YR 5/3 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary
B24 500^{+} mm	10YR 3/2 (moderately moist) Silty Clay. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Limit of observation.

GN11, soil profile

GN11, looking west towards Bowmans Creek

GN12	Datum: GDA 94 Zone 56 Easting: 318308.87 Northing: 6411895.18 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland, box ironbark Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-20 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 20-100 mm	10YR 6/2 (moderately moist), 10YR 7/2 (dry) Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (10-20%), 6-20 mm sub-rounded ironstone pebbles. Abrupt boundary.
B21 100-600 mm	10YR 5/4 (moderately moist) Medium Clay. pH 6.2. Moderate pedality, rough-ped fabric, angular blocky structure, 20-50 mm. Few (2-10%), fine, distinct, orange mottles. Gradual boundary
B22 600-700 mm	10YR 5/6 (moderately moist) Sandy Light Clay. pH 6.6. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, orange mottles. Gradual boundary
B23 700-800 mm	10YR 4/6 (moderately moist) Light Clay. pH 7.0[4]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Gradual boundary
C1 800^{+} mm	10YR 5/6 (moderately moist) Coarse Sandy Clay Loam. pH 7.0[5]. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Limit of observation.

GN12, soil profile


GN12, looking north

[4] Field pH, maximum laboratory sampling depth 600-700 mm

GN13	Datum: GDA 94 Zone 56 Easting: 317454.85 Northing: 6411679.84 Recorded: 21st August 2017
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: High	Run-off: Low Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol

Profile Characteristics

A11 0-100 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.1. Strong pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-400 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 6.2. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, orange mottles. Gradual boundary
B21 400-500 mm	10YR 3/4 (moderately moist) Light Clay Fine Sandy. pH 6.6. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, brown mottles. Abrupt boundary
B23 500^{+} mm	10YR 2/1 (moderately moist) Silty Clay Loam. pH 6.7. Moderate pedality, rough-ped fabric, angular blocky structure, 10-50 mm. Limit of observation.

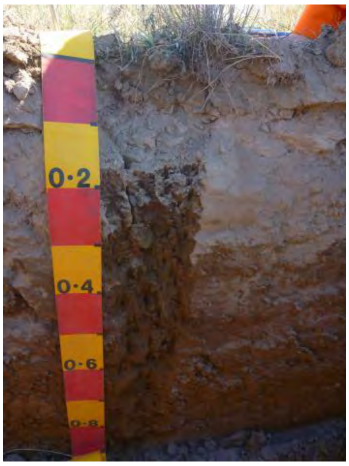
GN13, soil profile


GN13, Yorks Creek floodplain, looking south

GN14	Datum: GDA 94 Zone 56 Easting: 317692.56 Northing: 6411438.11 Recorded: 23rd August 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-50 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 5.3. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 50-150	7.5YR 6/1 (moderately moist), 7.5YR 7/1 (dry) Coarse Sandy Clay Loam. pH 5.9. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B21 150-400 mm	7.5YR 3/4 (moderately moist) Light Medium Clay. pH 6.8. Strong pedality, rough-ped fabric, columnar breaking to sub-angular blocky, 20-50 mm. Common, fine, macropores. Clear boundary
B22 400-600 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Clay. pH 7.6. Strong pedality, rough-ped fabric, sub-angular blocky structure, 10-20 mm. Gradual boundary
B23 600^{+} mm	7.5YR 4/6 (moderately moist) Coarse Sandy Light Clay. pH 6.7. Strong pedality, rough-ped fabric sub-angular blocky structure, 10-20 mm. Common (10-20%), medium, distinct, brown mottles. Limit of observation.



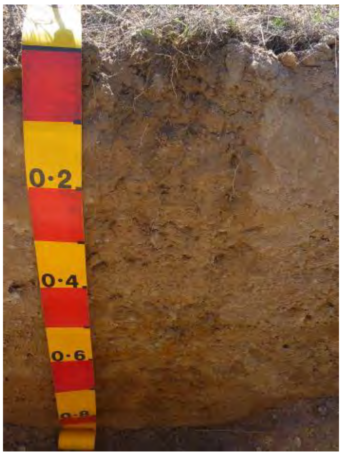
GN14, soil profile

GN14, looking west towards York Creek

GN15	Datum: GDA 94 Zone 56 Easting: 318473.97 Northing: 6411428.96 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 650 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Kandosol

Profile Characteristics

A1 0-100 mm	10YR 5/3 (moderately moist) Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Clear boundary.
B21 100-250	10YR 4/3 (moderately moist) Sandy Clay Loam. pH 5.8. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, rounded conglomerate pebbles. Gradual boundary.
B22 250-600 mm	10YR 5/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.3. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, rounded conglomerate large pebbles. Gradual boundary
BC 600+ mm	10YR 5/3 (moderately moist) Light Clay. pH 6.5[5]. Apedal massive structure, sandy fabric. Many (20-50%), very coarse, distinct brown mottles. Many (20-50%) 6-20 mm, rounded conglomerate pebbles. Limit of observation.



GN15, soil profile

GN15, looking east

[5] Field pH, maximum soil sampling depth 600-650 mm

GN16	Datum: GDA 94 Zone 56 Easting: 318664.87 Northing: 6411039.89 Recorded: 17th August 2017
Landscape Element: Hillcrest Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 580 mm Ground cover: 100% Run on: Low	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: Sheet erosion Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Red Sodosol

Profile Characteristics

A1 0-30 mm	10YR 4/4 (moderately moist) Sandy Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Clear boundary.
A2 30-250 mm	7.5YR 5/2 (moderately moist), 7.5YR 7/2 (dry) Sandy Clay Loam. pH 5.8. Weak pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Abrupt boundary.
B21 250-480 mm	5YR 4/6 (moderately moist) Medium Heavy Clay. pH 6.6. Moderate pedality, smooth-ped fabric, columnar (150-200 mm) breaking to sub-angular blocky structure, 5-10 mm. Diffuse boundary.
B22 480-580 mm	7.5YR 4/6 (moderately moist) Light Medium Clay. pH 6.0. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm Diffuse boundary
Cv 580^{+} mm	Soft Mudstone breaking into 10-50 mm, angular-blocky fragments. Limit of observation.

GN16, soil profile

GN16, looking north

GN17	Datum: GDA 94 Zone 56 Easting: 317900.59 Northing: 6411256.12 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 600 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Red Dermosol

Profile Characteristics

A1 0-150 mm	7.5YR 3/4 (moderately moist) Silty Light Clay. pH 6.1. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, rounded conglomerate pebbles. Diffuse boundary.
B21 150-450	5YR 4/6 (moderately moist) Medium Heavy Clay. pH 6.2. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) fine, faint, yellow mottles. Clear boundary.
B22 450-600 mm	10YR 4/6 (moderately moist) Medium Clay. pH 6.9. Strong pedality rough-ped fabric, angular blocky structure, 10-20 mm. Many (20-50%) fine, faint, orange mottles. Clear boundary
B23 600-700 mm	2.5YR 4/4 (moderately moist) Light Clay. pH 7.8. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Many (20-50%) 2-6 mm, angular, mudstone small pebbles. Sharp boundary
Cv 700^{+} mm	Soft Mudstone breaking into 10-50 mm, angular-blocky fragments. Limit of observation.

GN17, soil profile


GN17, looking west towards Hebden Road

GN18	Datum: GDA 94 Zone 56 Easting: 317710.16 Northing: 6410715.06 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 2% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 800 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A11 0-100 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Very few (<2%) 2-6 mm, sub-rounded pebbles. Abrupt boundary.
A12 100-300 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Clear boundary.
B21 300-450 mm	7.5YR 2.5/3 (moderately moist) Medium Heavy Clay (Heavy). pH 6.6. Moderate pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Very few (<2%) fine, faint, orange mottles. Abrupt boundary
B22 450-750 mm	7.5YR 4/6 (moderately moist) Medium Heavy Clay (Heavy). pH 7.0. Strong pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%) 6-20 mm, angular medium pebbles. Gradual boundary
B23 750^{+} mm	7.5YR 5/8 (moderately moist) Medium Heavy Clay (Heavy). pH 7.0[6]. Strong pedality, smooth-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%) 2-60 mm, angular small pebbles. Limit of observation.

GN18, soil profile

GN18, looking north

[6] Field pH, maximum sampling depth 450-750 mm.

GN32	Datum: GDA 94 Zone 56 Easting: 317231.37 Northing: 6411954.52 Recorded: 21st August 2017
Landscape Element: Hillcrest Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 350/600 mm Ground cover: 100% Run on: Low	Run-off: Moderate Profile drainage: Well drained Profile permeability: Highly permeable Evidence of erosion: No Lithology: Conglomerate Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Clastic Rudosol

Profile Characteristics

A1 0-100 mm	10YR 3/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Few (2-10%) 2-6 mm, sub-rounded, small pebbles. Abrupt boundary.
B21 100-350/600 mm	10YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.8. Strong pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%) 6-20 mm, sub-rounded, medium pebbles. Clear, wavy boundary.
BC 350/600^{+} mm	Weathered conglomerate Limit of observation.

GN32, soil profile

GN32, looking west

Sandstone outcrop downhill of GN32

GN39	Datum: GDA 94 Zone 56 Easting: 317916.48 Northing: 6410765.52 Recorded: 23rd August 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 680 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Sandstone/Mudstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 5.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 100-150 mm	7.5YR 3/3 (moderately moist), 7.5YR 7/1 (dry) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 150-300 mm	7.5YR 2.5/2 (moderately moist) Medium Heavy Clay (Light). pH 6.5. Moderate pedality rough-ped fabric, angular blocky structure, 10-20 mm. Common (10-20%), fine, faint, red mottles. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Clear boundary.
B22 300-680 mm	7.5YR 4/4 (moderately moist) Medium Heavy Clay. pH 6.9. Strong pedality, smooth-ped fabric, angular blocky structure, 20-40mm. Common (10-20%), medium, distinct, brown biological mixing. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Common, medium, macropores. Abrupt boundary
B23 680^{+} mm	10YR 4/6 (moderately moist) Medium Heavy Clay (Heavy). pH 6.6. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) 2-6 mm, sub-rounded, small pebbles. Very few (<2%) medium, manganiferous, soft segregations. Common, medium, macropores Limit of observation.

GN39, soil profile

GN39, looking south

GN39	Datum: GDA 94 Zone 56 Easting: 317916.48 Northing: 6410765.52 Recorded: 23rd August 2017

Surface rock near GN39 site

GN66	Datum: GDA 94 Zone 56 Easting: 317605.07 Northing: 6411599.96 Recorded: 12th October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 580 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics

A1 0-20 mm	10YR 3/3 (moderately moist) Clay Loam. pH 5.7. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Broken boundary.
A2 20-150 mm	10YR 4/2 (moderately moist), 10YR 6/2 (dry) Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary.
B21 150-400 mm	10YR 3/1 (moderately moist) Medium Clay. pH 6.6. Strong pedality, rough-ped fabric, prismatic structure, 10-20 mm. Common, fine macropores. Gradual boundary.
B22 400-580 mm	10YR 3/2 (moderately moist) Medium Clay. pH 6.8. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%) 6-20 mm, sub-angular, medium pebbles. Common, fine macropores. Gradual boundary.
B23 580-800 mm	10YR 3/3 (moderately moist) Medium Clay. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Gradual boundary.
B24 800^{+} mm	10YR 3/3 (moderately moist) Light Clay. pH 7.0[7]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%) 2-6 mm, sub-angular, medium pebbles. Limit of observation.

GN66, soil profile


GN66, looking north

[7] Field pH, maximum sampling depth 580-800 mm

GN67	Datum: GDA 94 Zone 56 Easting: 317507.04 Northing: 6411450.76 Recorded: 12th October 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 950 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Dermosol

Profile Characteristics

A1 0-100 mm	7.5YR 4/2 (moderately moist) Light Clay. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 5-10 mm. Common, medium macropores. Gradual boundary.
B21 100-300 mm	10YR 3/1 (moderately moist) Medium Clay. pH 5.9. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Common, medium macropores. Gradual boundary.
B22 300-600 mm	10YR 3/2 (moderately moist) Medium Heavy Clay. pH 7.4. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Few (<10%), distinct slickensides. Few, medium macropores. Diffuse boundary.
B24 600^{+} mm	10YR 3/3 (moderately moist) Heavy Clay. pH 8.1. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%), fine, faint, orange mottles. Limit of observation.

GN67, soil profile


GN67, looking north

Slickenside in GN67 soil profile

GN68	Datum: GDA 94 Zone 56 Easting: 317219.21 Northing: 6411484.79 Recorded: 12th October 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth:8 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: Sheet erosion Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics

A1 0-10 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.0[8]. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Broken boundary.
A2 10-180 mm	10YR 4/2 (moderately moist), 10YR 6/2 (dry) Silty Clay Loam. pH 5.9 Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 180-400 mm	10YR 3/2 (moderately moist) Medium Clay. pH 6.8. Strong pedality, rough-ped fabric, prismatic structure, 5-10 mm. Few (2-10%), fine, faint, orange mottles. Gradual boundary.
B22 400-700 mm	10YR 3/4 (moderately moist) Light Clay. pH 8.1. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), fine, faint, orange mottles. Few (2-10%), fine, manganiferous weak nodules and soft segregations. Diffuse boundary.
B24 700^{+} mm	10YR 3/6 (moderately moist) Light Clay. pH 8.7. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Common (10-20%), medium –coarse manganiferous weak nodules and soft segregations. Limit of observation.

GN68, soil profile

GN68, looking north

[8] Field pH, A1 horizon too thin and broken to sample for laboratory analysis without contamination with A2

GN69	Datum: GDA 94 Zone 56 Easting: 317088.29 Northing: 6411642.67 Recorded: 12th October 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1200 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics

A1 0-100 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 5.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 100-400 mm	7.5YR 3/2 (moderately moist), 7.5YR 5/2 (dry) Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B21 400-630 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Medium Heavy Clay. pH 6.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), medium, manganiferous soft segregations. Clear boundary.
2D1 630-850 mm	7.5YR 3/4 (moderately moist) Sand. pH 7.3. Apedal massive structure, sandy fabric. Abrupt boundary.
3D 850-950 mm	7.5YR 4/4 (moderately moist), Coarse Sandy Clay Loam. pH 7.0[9]. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary
4D 950+ mm	7.5YR 2.5/2 (moderately moist) Light Clay (light). pH 7.0[10]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Few (2-10%), fine, distinct, orange mottles. Very few (<2%), %), fine, manganiferous soft segregations. Limit of observation.

GN69, soil profile


GN69, looking west towards Bowmans Creek

[9] Field pH, maximum sampling depth 630-850 mm
[10] Field pH, maximum sampling depth 630-850 mm

GN71	Datum: GDA 94 Zone 56 Easting: 316552.76 Northing: 6412017.90 Recorded: 11th October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Moderately well drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics

A11 0-120 mm	7.5YR 4/3 (moderately moist) Silty Clay Loam. pH 6.6. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 120-350 mm	7.5YR 4/3(moderately moist), sporadically bleached Silty Clay Loam. pH 5.6. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Sharp boundary.
B21 350-650 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 6.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Gradual boundary.
B22 650-800 mm	7.5YR 4/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, coarse macropores. Gradual boundary.
B23 800^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay. pH 7.0[11]. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Limit of observation.

GN71, soil profile


GN71, looking north

[11] Field pH, maximum sampling depth 650-800 mm

GN73	**Datum: GDA 94 Zone 56** **Easting: 316462.82** **Northing: 6412423.32** **Recorded: 11th October 2017**
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 1000 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	7.5YR 6/3 (moderately moist) Silty Clay Loam. pH 5.4. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
B21 100-280 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 5.4. Apedal massive structure, sandy fabric. Gradual boundary.
B22 280-480 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Apedal massive structure, sandy fabric. Very few (<2%) 6-20 mm, sub-angular, medium pebbles. Sharp boundary.
2D1 480-750 mm	10YR3/6 (moderately moist) Sandy Light Clay. pH 6.4. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 5-10 mm. Clear boundary.
2D2 750^{+} mm	10YR 3/4 (moderately moist) Sandy Light Clay. pH 7.0. Moderate pedality, roough-ped fabric, sub-angular blocky structure, 2-5 mm. Very few (<2%) 2-6 mm, angular, small pebbles. Limit of observation.

GN73, soil profile

GN73, Bowmans Creek upper floodplain, looking west towards creek

GN75	Datum: GDA 94 Zone 56 Easting: 316554.43 Northing: 6413391.67 Recorded: 21st December 2017
Landscape Element: Backplain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 900 mm Ground cover: 100% Run on: Moderate	Run-off: Low Profile drainage: Moderately well drained Profile permeability: Moderately permeable Evidence of erosion: No Lithology: Alluvium Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics

A1 0-100 mm	10YR 4/3 (moderately moist) Silty Clay Loam. pH 5.7. Moderate pedality, rough-ped fabric, granular structure, 10-20 breaking to 2-5 mm. Clear boundary.
B21 100-350 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 5.8. Moderate pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 350-600 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.3. Weak pedality, rough-ped fabric, sub-angular blocky, 2-5 mm. Clear boundary.
2D 850^{+} mm	10YR 2.5/3 (moderately moist) Light Clay Coarse Sandy. pH 6.9. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Limit of observation.

GN75, soil profile


GN75, Bowmans Creek floodplain, looking north

GN80	Datum: GDA 94 Zone 56 Easting: 317724.15 Northing: 6409752.10 Recorded: 22nd December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm Vegetation: Derived native grassland Estimated effective rooting depth: 700 mm Ground cover: 100% Run on: Moderate	Run-off: Moderate Profile drainage: Imperfectly drained Profile permeability: Slowly permeable Evidence of erosion: No Lithology: Sandstone Hydraulic conductivity: Not measured Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics

A1 0-180 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 5.9. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A2 180-300 mm	7.5YR 5/4 (moderately moist), 7.5YR 7/3 (dry) Silty Clay Loam. pH 6.4. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Abrupt boundary.
B21 300-600 mm	7.5YR 2.5/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, smooth-ped fabric, angular blocky structure, 10-20 mm. Gradual boundary.
B22 600-750 mm	7.5YR 3/4 (moderately moist) Light Clay. pH 7.0. Strong pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Common (2-10%) medium, faint, brown mottles. Gradual boundary.
B23 750^{+} mm	7.5YR 2.5/2 (moderately moist) Light Clay light. pH 7.0[12]. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), fine, faint, orange mottles. Limit of observation.

GN80, soil profile

GN80, looking south

[12] Field pH, maximum sampling depth 600-750 mm

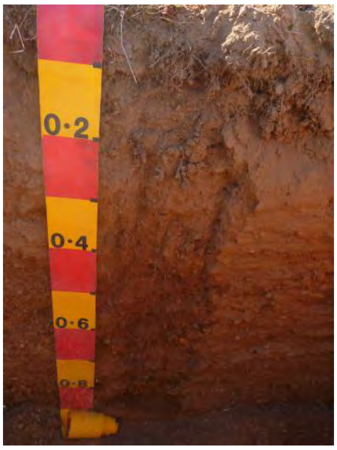
Check sites

GN20	Datum: GDA 94 Zone 56 Easting: 316368.38 Northing: 6412760.55 Recorded: 22nd August 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-80 mm	7.5YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.5. Clear boundary.
B21 80-180 mm	7.5YR 3/4 (moderately moist) Sandy Clay Loam. pH 6.0. Sharp boundary
B22 180-400 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Clear boundary
D 400^{+} mm	Clay with visible sand Limit of observation.

GN20, soil profile


GN20, looking west towards Bowmans Creek

GN21	Datum: GDA 94 Zone 56 Easting: 316427.17 Northing: 6412961.44 Recorded: 22nd August 2017
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown-Orthic Tenosol
Profile Characteristics	
A1 0-100 mm	7.5YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Abrupt boundary.
B21 100-400 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Clear boundary
B22 400-700 mm	7.5YR 4/6 (moderately moist) Light Clay Coarse Sandy. pH 7.0. Abundant (50-90%) 20-60 mm, sub-rounded, large pebbles. Clear boundary
B23 700-800 mm	Increase in clay content
Cv 800^{+} mm	Highly weathered sandstone Limit of observation.



GN21, soil profile

GN21, looking south

GN22	Datum: GDA 94 Zone 56 Easting: 317065.64 Northing: 6413432.98 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 5% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Yellow Sodosol

Profile Characteristics

A1 0-30 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.0. Sharp boundary.
A2 30-200 mm	7.5YR 5/4 (moderately moist), 7.5YR 7/2 (dry) Loam Fine Sandy. pH 6.0. Very few (<2%) 2-6 mm, sub-rounded, medium pebbles. Clear boundary
B21 200-400 mm	7.5YR 6/6 (moderately moist) Light Clay Fine Sandy. pH 6.5. Many (20-50%), medium, faint, orange and grey mottles. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Clear boundary Limit of description.

GN22, soil profile

GN22, looking south

GN23	Datum: GDA 94 Zone 56 Easting: 317661.77 Northing: 6413418.15 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Yellow Sodosol

Profile Characteristics

A1 0-100 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 5.0. Sharp boundary.
A2 100-200 mm	7.5YR 5/4 (moderately moist), 7.5YR 7/2 (dry) Loam Fine Sandy. pH 6.0. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Clear boundary
B21 200-450 mm	7.5YR 6/6 (moderately moist) Light Clay Fine Sandy. pH 6.5. Many (20-50%), medium, faint, orange mottles. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Limit of observation.
BC 650^{+} mm	

GN23, soil profile


GN23, looking east

GN24	Datum: GDA 94 Zone 56 Easting: 317224.72 Northing: 6412986.74 Recorded: 21st August 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC):Brown Sodosol

Profile Characteristics

A1 0-20 mm	7.5YR 3/2 (moderately moist) Loamy Sand. pH 5.5. Sharp, broken boundary.
A2 20-180 mm	7.5YR 3/3 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary
B21 180-400 mm	7.5YR 5/4 (moderately moist) Medium Clay (light). pH 6.5. Many (20-50%), coarse, distinct, orange mottles. Very few (<2%) 2-6 mm, sub-rounded, medium pebbles. Limit of observation.
B22 400^{+} mm	

GN24, soil profile


GN24, looking west

GN25	Datum: GDA 94 Zone 56 Easting: 318094.44 Northing: 6412919.49 Recorded: 18th August 2017
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Grey Sodosol

Profile Characteristics

A1 0-50 mm	10YR 3/2 (moderately moist) Coarse Sandy Clay Loam. pH 5.5. Sharp boundary.
A2 50-300 mm	10YR 5/3 (moderately moist), 10YR 7/2 (dry) Coarse Sandy Clay Loam. pH 5.5. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Sharp boundary
B21 300^{+} mm	7.5YR 4/2 (moderately moist) Sandy Light Clay. pH 6.0. Few (2-10%), small, distinct, orange mottles. Many (20-50%) 6-20 mm, sub-rounded, medium pebbles. Limit of observation.

GN25, soil profile


GN25, looking north

GN26	**Datum: GDA 94 Zone 56** **Easting: 317830.54** **Northing: 6412665.08** **Recorded: 18th August 2017**
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Dermosol
Profile Characteristics	
A1 0-100 mm	7.5YR 2.5/1 (moderately moist) Silty Light Clay. pH 6.0. Clear boundary.
B21 50-300 mm	7.5YR 2.5/1 (moderately moist) Medium Clay. pH 6.5. Common, medium macropores in moist profile. Gradual boundary Limit of observation.
B22 200^{+} mm	

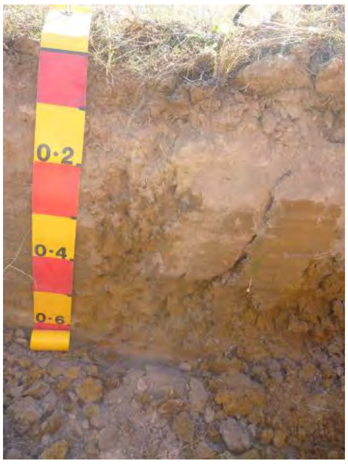
GN26, soil profile

GN26, looking south

GN27	Datum: GDA 94 Zone 56 Easting: 317377.36 Northing: 6412603.47 Recorded: 22nd August 2017
Landscape Element: Hillslope Slope: 7% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-50 mm	7.5YR 3/2 (moderately moist) Sandy Clay Loam. pH 5.5. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Abrupt boundary.
A2 50-200 mm	7.5YR 4/2 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Very few (<2%) 2-6 mm, sub-rounded, small pebbles. Abrupt boundary
B21 200-500 mm	7.5YR 4/4 (moderately moist) Medium Clay (light). pH 7.0. Clear boundary Limit of observation.



GN27, soil profile


GN27, looking north

GN28	Datum: GDA 94 Zone 56 Easting: 317604.55 Northing: 6412344.35 Recorded: 22nd August 2017
Landscape Element: Footslope Slope: 5% Soil Surface Condition: Hard setting	Vegetation: Derived native grassland, bulloak regeneration Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics	
A1 0-20 mm	7.5YR 4/2 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Sharp, broken boundary.
A2 20-210 mm	7.5YR 6/3 (moderately moist), 7.5YR 7/1 (dry) Coarse Sandy Clay Loam. pH 6.5. Few (2-10%) 2-6 mm, sub-angular, small pebbles. Abrupt boundary
B21 210^{+} mm	7.5YR 4/6 (moderately moist) Light Medium Clay. pH 7.0. Few (2-10%) 2-6 mm, sub-angular, small pebbles Few (2-10%) 6-20 mm, ferruginous concretions. Limit of observation.

GN28, soil profile

GN28, looking east towards Hebden Road and Yorks Creek in the far background

GN29	**Datum: GDA 94 Zone 56** **Easting: 317179.09** **Northing: 6412297.07** **Recorded: 22nd August 2017**
Landscape Element: Hillcrest Slope: 2% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-100 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 6.5. Sharp boundary.
A2 100-200 mm	7.5YR 4/4 (moderately moist), 7.5YR 5/4 (dry) Silty Clay Loam. pH 6.0. Few (2-10%) 6-20 mm, sub-rounded, medium pebbles. Abrupt boundary
B21 200-350 mm	7.5YR 5/8 (moderately moist) Medium Clay. pH 6.5. Few (2-10%) 2-6 mm, angular, small pebbles Gradual boundary.

GN29, soil profile


GN29, looking west


GN29, surface rock (left) and sandstone outcrop (right)

GN30	Datum: GDA 94 Zone 56 Easting: 316629.8 Northing: 6412518.39 Recorded: 22nd August 2017
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

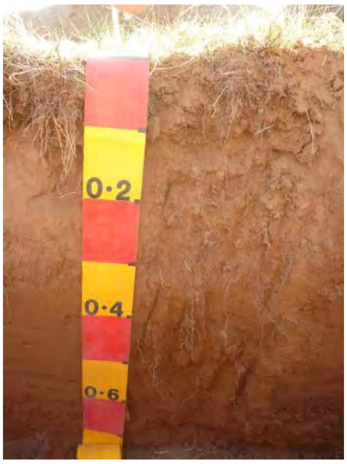
A1 0-150 mm	7.5YR 4/4 (moderately moist) Silty Clay Loam. pH 6.5. Abrupt boundary.
A2 150-350 mm	7.5YR 4/4 (moderately moist), 7.5YR 6/3 (dry) Coarse Sandy Clay Loam. pH 6.5. Abrupt boundary
B21 350-600 mm	7.5YR 4/4 (moderately moist) Medium Heavy Clay. pH 7.0. Clear boundary.

GN30, soil profile

GN30, looking east

GN31	Datum: GDA 94 Zone 56 Easting: 316603.2 Northing: 6412196.78 Recorded: 22nd August 2017
Landscape Element: Plain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics	
A1 0-100 mm	7.5YR 3/3 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Abrupt boundary.
B21 100-330 mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.5. Gradual boundary
B22 330^{+} mm	7.5YR 4/4 (moderately moist) Coarse Sandy Clay Loam. pH 7.0. Common (10-20%) 6-20, rounded medium pebbles. Limit of observation.



GN31, soil profile


GN31, Bowmans Creek upper floodplain terrace, looking north

GN33	Datum: GDA 94 Zone 56 Easting: 317642.52 Northing: 6411917.62 Recorded: 24th August 2017
Landscape Element: Backplain Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics

A1 0-200 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.0. Clear boundary.
B21 200-500 mm	10YR 4/4 (moderately moist) Silty Clay Loam. pH 6.0. Gradual boundary
B22 500^{+} mm	10YR 3/3 (moderately moist) Sandy Clay Loam. pH 6.5. Limit of observation.

GN33, soil profile


GN33, looking west

GN34	Datum: GDA 94 Zone 56 Easting: 317722.9 Northing: 6411706.27 Recorded: 22nd August 2017
Landscape Element: Footslope Slope: 0% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvial/Sandstone Australian Soil Classification (ASC): Brown Kandosol

Profile Characteristics

A1 0-150 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 6.0. Clear boundary.
B21 150-450 mm	7.5YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Common, medium macropores. Gradual boundary
B22 450^{+} mm	7.5YR 3/4 (moderately moist) Coarse Sandy Light Medium Clay. pH 7.0. Common, medium, faint orange mottles. Limit of observation.

GN34, soil profile


GN34, looking west

GN35	Datum: GDA 94 Zone 56 Easting: 318165.62 Northing: 6411477.37 Recorded: 17th August 2017
Landscape Element: Footslope Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone/Mudstone Australian Soil Classification (ASC): Brown Chromosol

Profile Characteristics	
A1 0-50 mm	10YR 4/4 (moderately moist) Silty Clay Loam. pH 6.0. Abrupt boundary.
A2 50-200 mm	10YR 5/3 (moderately moist), 10YR 7/1 (dry) Fine Sandy Loam. pH 6.5. Few (10-20%), 6-20 mm sub-rounded ironstone pebbles. Clear boundary
B21 200-400 mm	10YR 5/2 (moderately moist) Sandy Light Clay. pH 7.0. Few (2-10%)6-20 mm, sub-rounded, medium ironstone pebbles Few, fine, faint, brown mottles. Limit of observation.

GN35, soil profile


GN35, looking north

GN36	Datum: GDA 94 Zone 56 Easting: 318729.19 Northing: 6411394.13 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 4% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone/Mudstone Australian Soil Classification (ASC): Grey Sodosol

Profile Characteristics

A1 0-80 mm	7.5YR 5/3 (moderately moist) Silty Clay Loam. pH 6.0. Abrupt boundary.
A2 80-400 mm	10YR 6/2 (moderately moist), 10YR 7/1 (dry) Fine Sandy Loam. pH 6.5. Very few (<2%), 20-60 mm sub-angular ironstone pebbles. Clear boundary
B22 400^{+} mm	10YR 4/2 (moderately moist) Heavy Clay. pH 7.0. Common, fine, distinct, brown mottles. Limit of observation.

GN36, soil profile

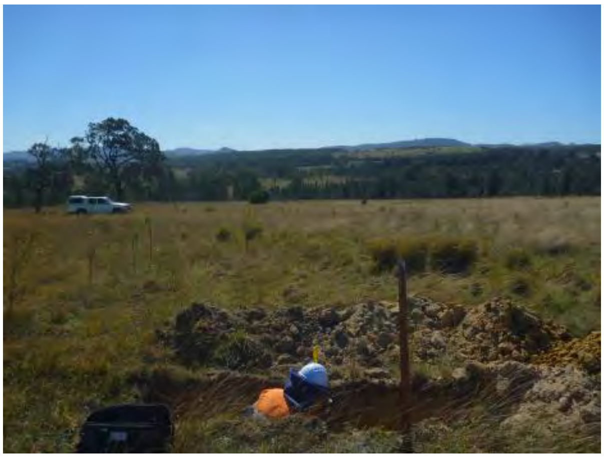

GN36, looking south

GN37	Datum: GDA 94 Zone 56 Easting: 318281.53 Northing: 6411065.84 Recorded: 17th August 2017
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics

A1 0-50 mm	7.5YR 4/2 (moderately moist) Loamy Sand. pH 6.5. Abrupt boundary.
B21 50-300 mm	7.5YR 6/3 (moderately moist) Loamy Sand. pH 6.5. Few (2-10%), 20-60 mm sub-rounded ironstone pebbles. Gradual boundary
B22 300-420 mm	10YR 5/4 (moderately moist) Coarse Sandy Loam. pH 6.5. Gradual boundary
BC 420^{+} mm	10YR 5/6 (moderately moist) Sandy Light Clay. pH 7.0. Few, coarse, distinct, brown mottles. Limit of observation.

GN37, soil profile


GN37, looking north

GN38	Datum: GDA 94 Zone 56 Easting: 317752.38 Northing: 6411069.77 Recorded: 24th August 2017
Landscape Element: Hillslope Slope: 7% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A11 0-150 mm	7.5YR 3/2 (moderately moist) Sandy Clay Loam. pH 5.5. Abrupt boundary.
A12 150-300 mm	10YR 2/2 (moderately moist) Sandy Clay Loam. pH 5.5. Few (2-10%), 20-60 mm sub-rounded ironstone pebbles. Gradual boundary
A2 300-480 mm	7.5YR 5/2 (moderately moist), 7.5YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Very few (<2%) 6-20 mm sub-rounded, medium pebbles. Gradual boundary
B21 480^{+} mm	Greyish, brown Coarse Sandy Light Clay with many faint orange mottles. pH 7.5. Limit of observation.

GN38, soil profile


GN38, looking north

GN40	Datum: GDA 94 Zone 56 Easting: 318226.57 Northing: 6412292.52 Recorded: 18th August 2017
Landscape Element: Hillslope Slope: 4% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-200 mm	10YR 2/2 (moderately moist) Sandy Clay Loam. pH 5.5. Sharp boundary.
A2 200-350 mm	10YR 4/3 (moderately moist), 10YR 6/2 (dry) Coarse Sandy Clay Loam. pH 6.0. Many (20-50%) 6-20 mm, sub-angular, medium pebbles.. Gradual boundary
B21 300-500 mm	7.5YR 4/2 (moderately moist) Coarse Sandy Medium Clay. pH 6.0. Many (20-50%) small, distinct, brown mottles. Sharp boundary

GN40, soil profile


GN40, looking west

GN64	Datum: GDA 94 Zone 56 Easting: 317723.12 Northing: 6411234.17 Recorded: 12th October 2017
Landscape Element: Hillslope Slope: 3% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics

A1 0-20 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
A2 20-250 mm	7.5YR 3/2 (moderately moist), sporadically bleached Silty Clay Loam. pH 6.5. Strong pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common, medium macropores. Sharp boundary.
B21 250-550 mm	10YR 3/1 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, columnar structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles. Many, fine macropores. Gradual boundary.
B22 550^{+} mm	10YR 4/6 (moderately moist) Medium Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%), fine, distinct, grey mottles Common (10-20%) 6-20 mm sub-angular medium pebbles. Limit of observation.

GN64, soil profile


GN64, looking south

GN65	Datum: GDA 94 Zone 56 Easting: 317606.96 Northing: 6411418.31 Recorded: 12nd October 2017
Landscape Element: Plain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Black Sodosol

Profile Characteristics

A1 0-30 mm	7.5YR 3/2 (moderately moist) Silty Clay Loam. pH 6.5. Broken boundary.
A2 30-200 mm	10YR 5/2 (moderately moist), 10YR 6/1 (dry) Sandy Clay Loam. pH 6.5. Common (10-20%) 6-20 mm, sub-angular, medium pebbles. Sharp boundary.
B21 200-400^{+} mm	10YR 3/2 (moderately moist) Sandy Light Medium Clay. pH 7.0. Common (10-20%), fine, faint orange mottles. Many (20-50%) 6-20 mm, angular, medium pebbles. Limit of observation.

GN65, soil profile


GN65, looking east

GN70	Datum: GDA 94 Zone 56 Easting: 316926.38 Northing: 6411958.75 Recorded: 12th October 2017
Landscape Element: Footslope Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol
Profile Characteristics	
A1 0-50 mm	10YR 3/2 (moderately moist) Silty Clay Loam. pH 6.5. Apedal massive structure, sandy fabric. Sharp boundary.
A2 50-220 mm	10YR 5/2 (moderately moist), 10YR 7/1 (dry) Silty Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Abrupt boundary.
B1 220-300 mm	10YR 4/2 (moderately moist) Light Clay (heavy). pH 7.0. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, manganiferous weak nodules and soft segregations. Gradual boundary.
B21 300-500 mm	10YR 4/3 (moderately moist) Medium Heavy Clay. pH 7.0. Strong pedality, smooth-ped fabric, prismatic breaking to angular blocky structure, 20-50 mm. Many (20-50%), medium, distinct, orange mottles. Few (2-10%), fine, manganiferous soft segregations. Common, coarse macropores. Gradual boundary.
B22 500-850 mm	10YR 4/2 (moderately moist), Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Many (20-50%), medium, distinct, orange mottles. Very few (<2%) 6-20 mm, sub-rounded, medium pebbles. Common, coarse macropores. Abrupt boundary
2D 850^{+} mm	10YR 4/6 (moderately moist) Coarse Sand. pH 7.0. Apedal massive structure, sandy fabric. Common (10-20%), medium, distinct, grey mottles. Common (10-20%) 60-20 mm, sub-rounded, large pebbles. Many (20-50%), coarse, manganiferous soft segregations. Limit of observation.

GN70	Datum: GDA 94 Zone 56 Easting: 316926.38 Northing: 6411958.75 Recorded: 12th October 2017

GN70, soil profile

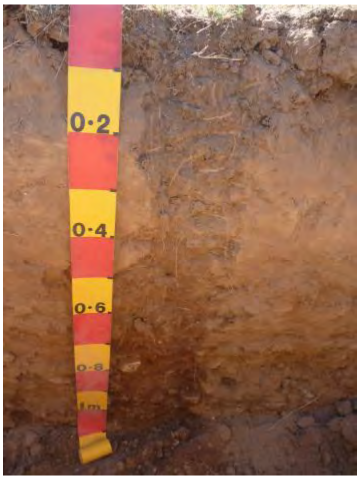

GN70, looking south


GN70, manganiferous, weak nodule

GN72	Datum: GDA 94 Zone 56 Easting: 316370.86 Northing: 6412220.61 Recorded: 11th October 2017
Landscape Element: Backplain Slope: 1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown-Orthic Tenosol

Profile Characteristics

A1 0-100 mm	7.5YR 3/3 (moderately moist) Silty Clay Loam. pH 7.0. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abrupt boundary.
B21 100-300 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Gradual boundary.
B22 300-550 mm	7.5YR 3/4 (moderately moist) Coarse Sandy Loam. pH 6.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Clear boundary.
2D1 550-800 mm	10YR3/6 (moderately moist) Clayey Sand. pH 7.0. Weak pedality, rough-ped fabric, sub-angular blocky structure, 2-5 mm. Few (2-10%) 20-60 mm, sub-rounded, large pebbles. Sharp boundary.
2D2 800^{+} mm	10YR 3/6(moderately moist) Clayey Sand. pH 7.0. Apedal massive structure, sandy fabric. Very abundant (>90%) 10-60 mm to 200-600 mm, rounded large pebbles to stones. Limit of observation.



GN72, soil profile


GN72, looking south

GN74	Datum: GDA 94 Zone 56 Easting: 316500.40 Northing: 6412683.76 Recorded: 11th October 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A11 0-100 mm	7.5YR 4/3 (moderately moist) Coarse Sandy Loam. pH 7.0. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Sharp boundary.
A12 100-500 mm	At 150 mm: 7.5YR 4/3 (moderately moist) Coarse Sandy Loam. pH 6.0. Apedal massive structure, sandy fabric. Common (10-20%) 6-20 mm, sub-rounded, medium pebbles. At 450 mm: 7.5YR 4/4 (moderately moist) Coarse Sandy Loam. pH 6.5. Apedal massive structure, sandy fabric. Many (20-50%) 20-60 mm, sub-rounded, large pebbles. Sharp, wavy boundary.
B21 500-850 mm	At 600 mm: 7.5YR 4/6 (moderately moist) Sandy Light Clay. pH 6.5. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 200-500 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. At 800 mm: 7.5YR 4/6 (moderately moist) Sandy Light Clay. pH 6.5. Strong pedality, rough-ped fabric, angular blocky, 20-50 mm. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Very few (<2%), fine, manganiferous soft segregations. Sharp boundary.
2D 850^{+} mm	10YR 3/6 (moderately moist) Coarse Sand. pH 7.0. Apedal massive structure, sandy fabric. Very abundant (>90%)10-60 mm to 200-600 mm, rounded large pebbles to stones. Limit of observation.

GN74	Datum: GDA 94 Zone 56 Easting: 316500.40 Northing: 6412683.76 Recorded: 11th October 2017

GN74, soil profile

GN74, looking west

GN74, columns in trench

GN76	Datum: GDA 94 Zone 56 Easting: 315525.65 Northing: 6412802.88 Recorded: 21st December 2017
Landscape Element: Hillslope Slope: 6% Soil Surface Condition: Firm	Vegetation: Derived native grassland and Bulloak Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A2[13] 0-100 mm	7.5YR 8/2 (dry), 10YR 6/3 (moderately moist) Sandy Loam. pH 6.5. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Abundant (50-90%) 20-60 mm, rounded large pebbles. Sharp boundary.
B21 100-320 mm	10YR 5/3 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, smooth-ped fabric, prismatic breaking to angular blocky structure, 10-20 mm. Many (20-50%), medium, distinct, orange mottles. Many (20-50%) 20-60 mm to 6-20 mm, rounded large to medium pebbles. Common, fine macropores. Gradual boundary.
B22 320-500 mm	10YR 5/6 (moderately moist) Medium Heavy Clay. pH 7.5. Strong pedality, smooth-ped fabric, angular blocky, 10-20 mm. Many (20-50%), coarse, distinct, grey mottles. Very few (<2%) 2-6 mm, sub-angular, small pebbles. Gradual boundary.
B23 500-700 mm	10YR 6/1 (moderately moist) Medium Heavy Clay. pH 7.0. Moderate pedality, smooth-ped fabric, sub-angular blocky structure, 10-20 mm. Many (20-50%), very coarse, distinct, orange mottles. Very few (<2%) manganiferous, fine, soft segregations. Gradual boundary.
B24 700^{+} mm	10YR 7/1 (moderately moist) Medium Clay . pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 10-20 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, fine, soft segregations. Limit of observation.

[13] A1 completely eroded

GN76	Datum: GDA 94 Zone 56 Easting: 315525.65 Northing: 6412802.88 Recorded: 21st December 2017

GN76, soil profile

GN76, looking south

Erosion downhill from GN76

GN77	Datum: GDA 94 Zone 56 Easting: 316722.83 Northing: 6411779.98 Recorded: 21st December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Chromosol

Profile Characteristics

A11 0-150 mm	7.5YR 2.5/3 (moderately moist) Clay Loam. pH 6.5. Weak pedality, rough-ped fabric, granular structure, 2-5 mm. Sharp boundary.
A12 150-400 mm	7.5YR 3/4 (moderately moist) Clay Loam. pH 6.0. Weak pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Sharp boundary.
B21 450-650 mm	5YR 2.5/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 20-50 mm. Common, fine macropores. Clear boundary.
B22 650-850 mm	7.5YR 3/4 (moderately moist) Medium Clay. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Few (2-10%) manganiferous, fine, soft segregations. Gradual boundary.
B23 850^{+} mm	7.5YR 3/3 (moderately moist) Light Clay Coarse Sandy. pH 7.0. Moderate pedality, rough-ped fabric, angular blocky structure, 5-10 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, medium, soft segregations. Limit of observation.

GN77, soil profile


GN77, looking west towards a lower terrace and Bowmans Creek

GN78	Datum: GDA 94 Zone 56 Easting: 317304.52 Northing: 6411180.66 Recorded: 22nd December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Sandstone Australian Soil Classification (ASC): Brown Sodosol

Profile Characteristics

A1 0-10 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Broken boundary.
A2 310-200 mm	10YR 7/2 (moderately moist), 7.5YR 8/1 (dry) Silty Clay Loam. pH 6.5. Sharp boundary.
B21 200^{+} mm	10YR 4/3 (moderately moist) Medium Clay. pH 6.0. Limit of observation.

GN78, soil profile


Looking north

GN79	Datum: GDA 94 Zone 56 Easting: 317058.60 Northing: 6411461.51 Recorded: 21st December 2017
Landscape Element: Plain Slope: <1% Soil Surface Condition: Firm	Vegetation: Derived native grassland Lithology: Alluvium Australian Soil Classification (ASC): Black Chromosol

Profile Characteristics	
A11 0-100 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.5. Moderate pedality, rough-ped fabric, granular structure, 2-5 mm. Gradual boundary.
A12 100-300 mm	10YR 3/4 (moderately moist) Silty Clay Loam. pH 6.0. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Sharp boundary.
B21 300-550 mm	10YR 2/2 (moderately moist) Medium Clay. pH 7.0. Strong pedality, rough-ped fabric, prismatic breaking to angular blocky, 10-20 mm. Gradual boundary.
B22 550-800 mm	10YR 3/4 (moderately moist) Medium Clay. pH 7.5. Moderate pedality, roough-ped fabric, angular blocky structure, 10-20 mm. Few (2-10%) fine, faint, orange mottles. Common, fine macropores Gradual boundary.
B23 800^{+} mm	7.5YR 3/3 (moderately moist) Light Clay. pH 7.5. Moderate pedality, rough-ped fabric, angular blocky structure, 2-5 mm. Common (10-20%), medium, distinct, orange mottles. Few (2-10%), manganiferous, medium, soft segregations. Limit of observation.

GN79, soil profile

GN79, looking east

APPENDIX B

Detailed Assessment of Sample against Criteria 10 & 11

Site ID	Sample depth [mm]	pH Threshold values In water 5.0-8.9	ECe (dS/m) <4 dS/m	ESP (%) <15	Ca:Mg ratio >0.1	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN3	0-50	5.6	0.269	0.9	2.4	Yes	Yes	Yes
	100-200	5.4	0.086	0.8	3	Yes	Yes	
	200-300	5.7	0.076	0.8	3.7	Yes	Yes	
	300-600	6.1	0.074	1.3	4.1	Yes	Yes	
	650+	7.6	0.476	<0.2	3.8	Yes	Yes	
GN4	0-50	5.9	0.149	1.4	2.5	Yes	Yes	Yes
	50-150	5.9	0.072	1.4	2.8	Yes	Yes	
	150-300	6.1	0.027	2	3	Yes	Yes	
	300-600	6.6	0.052	2.8	2.8	Yes	Yes	
	600-800	7	0.069	2.8	7.5	Yes	Yes	
GN5	0-50	*Not sampled, insufficient topsoil due to sheet erosion*				NA	NA	No
	50-150	6.1	0.055	5.6	1	Yes	Yes	
	180-300	7.7	0.125	17.1	< 0.2*	Yes	Yes	
	300-600	8.4	1.13	19.8	< 0.2*	Yes	Yes	
	600-800	8.8	2.05	24.6	< 0.2*	Yes	Yes	
GN6	0-50	5.8	0.264	1.1	2.9	Yes	Yes	No
	50-150	6.2	0.14	1.3	2.8	Yes	Yes	
	150-250	7.4	0.123	<0.2	1.1	Yes	Yes	
	300-550	8.1	0.131	<0.2		Yes	Yes	
	550+	8.6	2.37	36.5	< 0.2*	Yes	Yes	
GN7	0-50	4.8	0.086	4.1	1.5	No	Yes	No
	50-120	5.2	0.032	2.7	2	Yes	Yes	
	120-280	5.9	0.057	9.8	1.2	Yes	Yes	

Site ID	Sample depth [mm]	pH Threshold values In water 5.0-8.9	ECe (dS/m) <4 dS/m	ESP (%) <15	Ca:Mg ratio >0.1	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
	300-500	7.1	1.66	17.7	0.3	Yes	Yes	
	500-800	8.2	2.34	35.2	0.2	Yes	Yes	
GN8	0-50	5.4	0.125	1.9	1.2	Yes	Yes	No
	50-150	5.8	0.049	3.9	0.8	Yes	Yes	
	200-300	6.3	0.152	13.5	0.1	Yes	Yes	
	300-600	7.8	1.46	24.5	< 0.2*	Yes	Yes	
	600+	8.2	2.16	26.8	< 0.2*	Yes	Yes	
GN9	0-50	5.7	0.24	0.7	2.9	Yes	Yes	Yes
	50-100	6.8	0.095	0.7	3.5	Yes	Yes	
	150-300	6.4	0.089	1.1	6.8	Yes	Yes	
	400-600	7	0.493	1.6	5	Yes	Yes	
	700+	7.5	0.538	<0.2	6.3	Yes	Yes	
GN10	0-50	6.4	1.01	7.4	1.2	Yes	Yes	Yes
	50-150	6.4	0.267	1.9	1.2	Yes	Yes	
	180-300	6.6	0.207	2.4	1.2	Yes	Yes	
	300-600	6.5	0.108	2.7	1.4	Yes	Yes	
	600+	6.8	0.068	3.2	1.7	Yes	Yes	
GN11	0-50	6.4	0.356	3.3	0.7	Yes	Yes	Yes
	100-150	6	0.3	4.5	0.4	Yes	Yes	
	250-300	6.1	0.125	8.4	0.3	Yes	Yes	
	350-500	5.7	0.331	7.1	1.6	Yes	Yes	
	500+	5.9	2.27	0.5	0.1	Yes	Yes	

Site ID	Sample depth [mm]	pH Threshold values In water 5.0-8.9	ECe (dS/m) <4 dS/m	ESP (%) <15	Ca:Mg ratio >0.1	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN12	0-20	5.6	0.411	3.6	0.8	Yes	Yes	Yes
	20-100	6	0.114	4.3	0.7	Yes	Yes	
	100-300	6.3	0.456	7.5	0.3	Yes	Yes	
	300-600	6.1	1.6	9.4	0.2	Yes	Yes	
	600-700	6.6	2.16	11.1	0.2	Yes	Yes	
GN13	0-50	6.1	0.463	1.2	1.3	Yes	Yes	Yes
	100-150	6.2	0.208	1.5	1.2	Yes	Yes	
	150-300	6.4	0.322	2.2	1.2	Yes	Yes	
	400-500	6.6	0.337	2.5	1.3	Yes	Yes	
	500-800	6.7	0.08	2.8	1.4	Yes	Yes	
GN14	0-50	5.3	0.292	4.8	1.2	Yes	Yes	No
	50-150	5.9	0.098	7.3	0.5	Yes	Yes	
	150-300	6.8	1.13	17.8	< 0.1	Yes	Yes	
	400-600	7.6	1.87	31.8	< 0.2*	Yes	Yes	
	600+	6.7	2.38	24.1	< 0.1	Yes	Yes	
GN15	0-50	5.5	0.111	2.4	1.2	Yes	Yes	No
	100-150	5.6	0.044	2.4	1	Yes	Yes	
	150-250	6	0.038	3	0.8	Yes	Yes	
	250-600	6.5	0.076	13	0.2	Yes	Yes	
	600+	6	0.309	19.1	< 0.1	Yes	Yes	
GN16	0-30	5.7	0.433	1.5	1.5	Yes	Yes	Yes
	50-150	5.8	0.138	1.4	1.6	Yes	Yes	
	150-300	6.6	0.181	3.7	1	Yes	Yes	
	300-600	6	0.81	6.4	0.4	Yes	Yes	

Site ID	Sample depth [mm]	pH Threshold values In water 5.0-8.9	ECe (dS/m) <4 dS/m	ESP (%) <15	Ca:Mg ratio >0.1	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN17	0-50	5.9	0.274	2.8	0.8	Yes	Yes	No
	50-150	6.2	0.12	5.7	0.6	Yes	Yes	
	150-300	6.2	0.513	10.9	0.4	Yes	Yes	
	450-600	6.9	1.6	13.1	0.3	Yes	Yes	
	600-700	7.8	1.84	24.4	0.3	Yes	Yes	
GN18	0-50	5.7	0.38	2.8	0.9	Yes	Yes	No
	100-150	5.9	0.16	5.4	0.8	Yes	Yes	
	150-300	6.1	0.159	10.8	0.6	Yes	Yes	
	300-450	6.6	0.941	20	0.2	Yes	Yes	
	450-750	7	1.75	24.5	0.1	Yes	Yes	
GN32	0-50	5.5	0.229	3.9	2.1	Yes	Yes	Yes
	50-100	5.5	0.238	3.8	2	Yes	Yes	
	100-150	5.8	0.062	1.8	1.8	Yes	Yes	
	150-300	5.8	0.057	1.8	1.9	Yes	Yes	
GN39	0-50	5.6	0.239	1.7	0.9	Yes	Yes	No
	100-150	6	0.328	4	0.6	Yes	Yes	
	150-300	6.5	0.511	10.3	0.2	Yes	Yes	
	400-600	6.9	2.22	12.7	< 0.1	Yes	Yes	
	650+	6.6	3.56	16.2	0.1	Yes	Yes	
GN66	0-20	5.7	0.386	5.3	1.0	Yes	Yes	No
	20-150	5.7	0.332	12.1	0.5	Yes	Yes	
	150-300	6.6	1.94	16.8	0.3	Yes	Yes	
	400-580	6.8	3.28	25.4	0.2	Yes	Yes	
	580-800	6.9	3.4	28.2	0.2	Yes	Yes	

Site ID	Sample depth [mm]	pH Threshold values In water 5.0-8.9	ECe (dS/m) <4 dS/m	ESP (%) <15	Ca:Mg ratio >0.1	Pass Criteria 10	Pass Criteria 11	Pass Criteria 12
GN67	0-50	5.9	0.352	4.1	0.6	Yes	Yes	No
	50-100	5.9	0.408	4.5	0.5	Yes	Yes	
	150-300	6.3	0.61	6.6	0.4	Yes	Yes	
	300-600	7.4	1.47	11.9	0.4	Yes	Yes	
	600-800	8.1	3.32	16	0.3	Yes	Yes	
GN68	0-50	*Not sampled, insufficient topsoil due to sheet erosion*						No
	50-150	5.9	0.164	7.6	1.2	Yes	Yes	
	150-300	6.8	1.45	22.1	0.5	Yes	Yes	
	400-700	8.1	2.5	30.3	0.4	Yes	Yes	
	700-1000	8.7	4.33	33.3	0.3	Yes	No	
GN71	0-50	6.6	0.938	0.4	3.0	Yes	Yes	Yes
	50-120	5.6	0.099	1.5	2.8	Yes	Yes	
	150-300	5.9	0.086	3.8	3.5	Yes	Yes	
	350-600	6.5	0.542	5.8	2.9	Yes	Yes	
	650-800	7	0.777	6.8	3.0	Yes	Yes	
GN73	0-50	5.4	0.096	1.3	3.3	Yes	Yes	Yes
	100-200	5.4	0.056	1.3	4.0	Yes	Yes	
	300-450	6	0.069	3.3	3.0	Yes	Yes	
	500-700	6.4	0.531	6.9	2.1	Yes	Yes	
	700-1000	7	0.462	9.3	2.3	Yes	Yes	

<table>
<tr><th>Site ID</th><th>Sample depth [mm]</th><th>pH Threshold values In water 5.0-8.9</th><th>ECe (dS/m) <4 dS/m</th><th>ESP (%) <15</th><th>Ca:Mg ratio >0.1</th><th>Pass Criteria 10</th><th>Pass Criteria 11</th><th>Pass Criteria 12</th></tr>
<tr><td rowspan="5">GN75</td><td>0-50</td><td>5.7</td><td>0.18</td><td>1.2</td><td>4.0</td><td>Yes</td><td>Yes</td><td rowspan="5">Yes</td></tr>
<tr><td>50-100</td><td>5.7</td><td>0.187</td><td>0.8</td><td>5.7</td><td>Yes</td><td>Yes</td></tr>
<tr><td>100-300</td><td>5.8</td><td>0.141</td><td>0.8</td><td>5.8</td><td>Yes</td><td>Yes</td></tr>
<tr><td>350-600</td><td>6.3</td><td>0.168</td><td>2.5</td><td>3.5</td><td>Yes</td><td>Yes</td></tr>
<tr><td>600-1000</td><td>6.9</td><td>0.379</td><td>1.7</td><td>2.4</td><td>Yes</td><td>Yes</td></tr>
<tr><td rowspan="5">GN80</td><td>0-50</td><td>5.7</td><td>0.211</td><td>0.9</td><td>2.9</td><td>Yes</td><td>Yes</td><td rowspan="5">Yes</td></tr>
<tr><td>50-150</td><td>6</td><td>0.107</td><td>1.8</td><td>2.9</td><td>Yes</td><td>Yes</td></tr>
<tr><td>180-300</td><td>6.4</td><td>0.168</td><td>6.3</td><td>2.3</td><td>Yes</td><td>Yes</td></tr>
<tr><td>300-600</td><td>7</td><td>0.81</td><td>9.8</td><td>2.8</td><td>Yes</td><td>Yes</td></tr>
<tr><td>600-750</td><td>7</td><td>1.74</td><td>6.3</td><td>4.0</td><td>Yes</td><td>Yes</td></tr>
</table>

*detection limit of laboratory, likely to not meet BSAL criteria 12.

APPENDIX C

Laboratory Test Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1717430**	Page	: 1 of 23
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 3986C	Date Samples Received	: 25-Aug-2017 13:10
Order number	: ----	Date Analysis Commenced	: 29-Aug-2017
C-O-C number	: ----	Issue Date	: 11-Sep-2017 18:43
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 87		
No. of samples analysed	: 87		

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED007(Exchangeable Cations): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ED006(Exchangeable Cations on Alkaline Soils): Unable to calculate Calcium/Magnesium Ratio for some samples as the required results for Calcium/Magnesium are below LOR.
- ED008 (Exchangeable Cations with pre-treatment by ICP-AES): Unable to calculate Magnesium/Potassium Ratio results for Some samples as required Exchangeable Potassium results are less than the limit of reporting.
- EA031 (Saturated Paste pH): NATA accreditation does not cover the performance of this service.
- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ED006 (Exchangeable Cations on Alkaline Soils): Sample EB1717430-034 shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H^+ + Al^{3+}).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN3 0-50	GN3 100-200	GN3 200-300	GN3 300-600	GN3 650+
			Client sampling date / time	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30	22-Aug-2017 13:30
Compound	CAS Number	LOR	Unit	EB1717430-001	EB1717430-002	EB1717430-003	EB1717430-004	EB1717430-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	5.4	5.7	6.1	7.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	54	24	15	11	56
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	5.2	5.3	5.7	6.8
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	269	86	76	74	476
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.6	0.3	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.5	0.2	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	----	2.2
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	----	0.6
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	----	<0.2
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	----	<0.2
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	----	2.8
Exchangeable Sodium Percent	----	0.2	%	----	----	----	----	<0.2
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	----	3.8
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.6	2.1	2.6	3.7	----
Exchangeable Magnesium	----	0.1	meq/100g	1.5	0.7	0.7	0.9	----
Exchangeable Potassium	----	0.1	meq/100g	1.6	1.5	1.1	0.5	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	6.8	4.9	4.7	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	5.1	----
Exchangeable Sodium Percent	----	0.1	%	0.9	0.8	0.8	1.3	----
Calcium/Magnesium Ratio	----	0.1	-	2.4	3.0	3.7	4.1	----
Magnesium/Potassium Ratio	----	0.1	-	1.0	0.4	0.6	1.8	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN4 0-50	GN4 50-150	GN4 150-300	GN4 300-600	GN4 600-800
			Client sampling date / time	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30	22-Aug-2017 15:30
Compound	CAS Number	LOR	Unit	EB1717430-006	EB1717430-007	EB1717430-008	EB1717430-009	EB1717430-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.9	6.1	6.6	7.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	55	15	10	7	10
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	5.6	5.5	5.9	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	149	72	27	52	69
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.2	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.3	2.8	2.7	3.1	4.5
Exchangeable Magnesium	----	0.1	meq/100g	1.3	1.0	0.9	1.1	0.6
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.1	0.8	0.2	0.1
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.1	0.2
Cation Exchange Capacity	----	0.1	meq/100g	5.8	5.1	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	4.5	4.6	5.4
Exchangeable Sodium Percent	----	0.1	%	1.4	1.4	2.0	2.8	2.8
Calcium/Magnesium Ratio	----	0.1	-	2.5	2.8	3.0	2.8	7.5
Magnesium/Potassium Ratio	----	0.1	-	1.2	0.9	1.2	4.9	5.9

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN5 50-150	GN5 180-300	GN5 300-600	GN5 600-800	GN6 0-50
			Client sampling date / time	21-Aug-2017 12:30	21-Aug-2017 12:30	21-Aug-2017 12:30	21-Aug-2017 12:30	23-Aug-2017 08:30
Compound	CAS Number	LOR	Unit	EB1717430-011	EB1717430-012	EB1717430-013	EB1717430-014	EB1717430-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	7.7	8.4	8.8	5.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	11	106	217	402	25
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.3	6.5	7.2	7.3	5.6
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	55	125	1130	2050	264
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	<0.2	0.3	0.3	----
Exchangeable Magnesium	----	0.2	meq/100g	----	2.3	3.1	3.9	----
Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	0.5	0.8	1.4	----
Cation Exchange Capacity	----	0.2	meq/100g	----	2.8	4.2	5.6	----
Exchangeable Sodium Percent	----	0.2	%	----	17.1	19.8	24.6	----
Calcium/Magnesium Ratio	----	0.2	-	----	<0.2	<0.2	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.9	----	----	----	6.6
Exchangeable Magnesium	----	0.1	meq/100g	0.9	----	----	----	2.3
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	----	0.5
Exchangeable Sodium	----	0.1	meq/100g	0.1	----	----	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	2.2	----	----	----	9.6
Exchangeable Sodium Percent	----	0.1	%	5.6	----	----	----	1.1
Calcium/Magnesium Ratio	----	0.1	-	1.0	----	----	----	2.9
Magnesium/Potassium Ratio	----	0.1	-	4.2	----	----	----	4.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN6 50-150	GN6 150-250	GN6 300-550	GN6 550+	GN7 0-50
			Client sampling date / time	23-Aug-2017 08:30	23-Aug-2017 08:30	23-Aug-2017 08:30	23-Aug-2017 08:30	24-Aug-2017 09:00
Compound	CAS Number	LOR	Unit	EB1717430-016	EB1717430-017	EB1717430-018	EB1717430-019	EB1717430-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	7.4	8.1	8.6	4.8
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	16	205	544	26
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	6.2	5.9	7.3	4.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	140	123	131	2370	86
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	2.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	1.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	0.5	0.8	<0.2	----
Exchangeable Magnesium	----	0.2	meq/100g	----	0.4	<0.2	2.1	----
Exchangeable Potassium	----	0.2	meq/100g	----	<0.2	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	<0.2	<0.2	1.2	----
Cation Exchange Capacity	----	0.2	meq/100g	----	1.0	0.8	3.3	----
Exchangeable Sodium Percent	----	0.2	%	----	<0.2	<0.2	36.5	----
Calcium/Magnesium Ratio	----	0.2	-	----	1.1	----	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.7	----	----	----	1.2
Exchangeable Magnesium	----	0.1	meq/100g	2.0	----	----	----	0.8
Exchangeable Potassium	----	0.1	meq/100g	0.4	----	----	----	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.1	----	----	----	0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	4.7
Cation Exchange Capacity	----	0.1	meq/100g	8.2	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	1.3	----	----	----	4.1
Calcium/Magnesium Ratio	----	0.1	-	2.8	----	----	----	1.5
Magnesium/Potassium Ratio	----	0.1	-	5.1	----	----	----	2.5

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN7 50-120	GN7 120-280	GN7 300-500	GN7 500-800	GN8 0-50
			Client sampling date / time	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	22-Aug-2017 11:00
Compound	CAS Number	LOR	Unit	EB1717430-021	EB1717430-022	EB1717430-023	EB1717430-024	EB1717430-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.2	5.9	7.1	8.2	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	5	11	360	603	19
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	4.8	4.9	5.9	6.7	5.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	32	57	1660	2340	125
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.9	0.4	----	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	0.8	0.3	----	----	0.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	0.4	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	1.6	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	1.1	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	3.2	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	35.2	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.6	1.4	----	----	2.0
Exchangeable Magnesium	----	0.1	meq/100g	0.8	1.2	----	----	1.7
Exchangeable Potassium	----	0.1	meq/100g	0.1	<0.1	----	----	0.5
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.3	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	3.4	3.3	----	----	4.5
Exchangeable Sodium Percent	----	0.1	%	2.7	9.8	----	----	1.9
Calcium/Magnesium Ratio	----	0.1	-	2.0	1.2	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	8.3	----	----	----	3.2
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	2.0	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	6.9	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	<0.1	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.0	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	11.0	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	17.7	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN7 50-120	GN7 120-280	GN7 300-500	GN7 500-800	GN8 0-50
			Client sampling date / time	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	24-Aug-2017 09:00	22-Aug-2017 11:00
Compound	CAS Number	LOR	Unit	EB1717430-021	EB1717430-022	EB1717430-023	EB1717430-024	EB1717430-025
				Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued								
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.3	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN8 50-150	GN8 200-300	GN8 300-600	GN8 600+	GN9 0-50
			Client sampling date / time	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 11:00	22-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-026	EB1717430-027	EB1717430-028	EB1717430-029	EB1717430-030
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**5.8**	**6.3**	**7.8**	**8.2**	**5.7**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**8**	**65**	**421**	**674**	**46**
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	**5.4**	**5.2**	**6.6**	**7.1**	**6.0**
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	**49**	**152**	**1460**	**2160**	**240**
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	**0.4**	----	----	----	**0.2**
Exchangeable Aluminium	----	0.1	meq/100g	**0.3**	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	<0.2	<0.2	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	**3.3**	**2.9**	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	**1.1**	**1.1**	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	**4.4**	**4.0**	----
Exchangeable Sodium Percent	----	0.2	%	----	----	**24.5**	**26.8**	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	<0.2	<0.2	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**0.8**	**1.6**	----	----	**4.3**
Exchangeable Magnesium	----	0.1	meq/100g	**1.0**	**11.6**	----	----	**1.5**
Exchangeable Potassium	----	0.1	meq/100g	**0.2**	**0.2**	----	----	**1.8**
Exchangeable Sodium	----	0.1	meq/100g	<0.1	**2.1**	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	**2.4**	----	----	----	**7.8**
Cation Exchange Capacity	----	0.1	meq/100g	----	**15.5**	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**3.9**	**13.5**	----	----	**0.7**
Calcium/Magnesium Ratio	----	0.1	-	**0.8**	**0.1**	----	----	**2.9**
Magnesium/Potassium Ratio	----	0.1	-	**4.7**	**50.6**	----	----	**0.8**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN9 50-100	GN9 150-300	GN9 400-600	GN9 700+	GN10 0-50
			Client sampling date / time	22-Aug-2017 12:00	22-Aug-2017 12:00	22-Aug-2017 12:00	22-Aug-2017 12:00	23-Aug-2017 11:00
Compound	CAS Number	LOR	Unit	EB1717430-031	EB1717430-032	EB1717430-033	EB1717430-034	EB1717430-035
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.8	6.4	7.0	7.5	6.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	24	12	62	47	469
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.5	5.8	6.3	6.8	6.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	95	89	493	538	1010
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	----	5.1	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	----	0.8	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	----	<0.2	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	----	<0.2	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	----	6.0	----
Exchangeable Sodium Percent	----	0.2	%	----	----	----	<0.2	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	----	6.3	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.8	3.4	18.9	----	----
Exchangeable Magnesium	----	0.1	meq/100g	0.8	0.5	3.8	----	----
Exchangeable Potassium	----	0.1	meq/100g	3.0	1.5	0.8	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.4	----	----
Cation Exchange Capacity	----	0.1	meq/100g	6.6	5.5	23.9	----	----
Exchangeable Sodium Percent	----	0.1	%	0.7	1.1	1.6	----	----
Calcium/Magnesium Ratio	----	0.1	-	3.5	6.8	5.0	----	----
Magnesium/Potassium Ratio	----	0.1	-	0.3	0.4	4.8	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	7.4
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	6.0
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	1.6
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	15.2
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	0.5
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	----	----	----	----	3.7

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN10 50-150	GN10 180-300	GN10 300-600	GN10 600+	GN11 0-50
			Client sampling date / time	23-Aug-2017 11:00	23-Aug-2017 11:00	23-Aug-2017 11:00	23-Aug-2017 11:00	18-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-036	EB1717430-037	EB1717430-038	EB1717430-039	EB1717430-040
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.6	6.5	6.8	6.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	21	16	11	12	78
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.4	6.2	6.4	6.7	6.6
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	267	207	108	68	356
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	6.8	5.0	3.1	2.4	7.0
Exchangeable Magnesium	----	0.1	meq/100g	5.8	4.1	2.2	1.4	10.5
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	0.2	0.3	0.7
Exchangeable Sodium	----	0.1	meq/100g	0.2	0.2	0.2	0.1	0.6
Cation Exchange Capacity	----	0.1	meq/100g	13.3	9.7	5.7	4.2	18.8
Exchangeable Sodium Percent	----	0.1	%	1.9	2.4	2.7	3.2	3.3
Calcium/Magnesium Ratio	----	0.1	-	1.2	1.2	1.4	1.7	0.7
Magnesium/Potassium Ratio	----	0.1	-	14.3	12.1	9.4	5.5	15.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN11 100-150	GN11 250-300	GN11 350-500	GN11 500+	GN12 0-20
			Client sampling date / time	18-Aug-2017 12:00	18-Aug-2017 12:00	18-Aug-2017 12:00	18-Aug-2017 12:00	17-Aug-2017 15:45
Compound	CAS Number	LOR	Unit	EB1717430-041	EB1717430-042	EB1717430-043	EB1717430-044	EB1717430-045
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.0	6.1	5.7	5.9	5.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	41	23	77	530	97
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.5	6.0	5.2	5.2	6.2
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	300	125	331	2270	411
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	0.5	0.2	0.1
Exchangeable Aluminium	----	0.1	meq/100g	----	----	0.4	<0.1	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.6	0.9	2.5	----	4.2
Exchangeable Magnesium	----	0.1	meq/100g	3.7	2.7	1.6	----	4.9
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.2	1.0	----	0.9
Exchangeable Sodium	----	0.1	meq/100g	0.3	0.3	0.4	----	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	6.0	----	10.5
Cation Exchange Capacity	----	0.1	meq/100g	5.8	4.2	----	----	----
Exchangeable Sodium Percent	----	0.1	%	4.5	8.4	7.1	----	3.6
Calcium/Magnesium Ratio	----	0.1	-	0.4	0.3	1.6	----	0.8
Magnesium/Potassium Ratio	----	0.1	-	10.8	13.6	1.5	----	5.5
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	0.5	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	4.0	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.4	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	6.2	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	23.0	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	0.1	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN12 20-100	GN12 100-300	GN12 300-600	GN12 600-700	GN13 0-50
			Client sampling date / time	17-Aug-2017 15:45	17-Aug-2017 15:45	17-Aug-2017 15:45	17-Aug-2017 15:45	21-Aug-2017 16:00
Compound	CAS Number	LOR	Unit	EB1717430-046	EB1717430-047	EB1717430-048	EB1717430-049	EB1717430-050
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.0	6.3	6.1	6.6	6.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	18	74	436	521	44
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	5.6	5.4	5.9	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	114	456	1600	2160	463
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.1	3.7	----	----	6.6
Exchangeable Magnesium	----	0.1	meq/100g	3.0	13.4	----	----	5.2
Exchangeable Potassium	----	0.1	meq/100g	0.4	0.3	----	----	1.0
Exchangeable Sodium	----	0.1	meq/100g	0.2	1.4	----	----	0.2
Cation Exchange Capacity	----	0.1	meq/100g	5.7	18.9	----	----	13.0
Exchangeable Sodium Percent	----	0.1	%	4.3	7.5	----	----	1.2
Calcium/Magnesium Ratio	----	0.1	-	0.7	0.3	----	----	1.3
Magnesium/Potassium Ratio	----	0.1	-	8.5	45.3	----	----	5.2
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	3.2	2.1	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	15.6	10.8	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.0	1.6	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	21.0	14.7	----
Exchangeable Sodium Percent	----	0.1	%	----	----	9.4	11.1	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.2	0.2	----
Magnesium/Potassium Ratio	----	0.1	-	----	----	137	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN13 100-150	GN13 150-300	GN13 400-500	GN13 500-800	GN14 0-50
			Client sampling date / time	21-Aug-2017 16:00	21-Aug-2017 16:00	21-Aug-2017 16:00	21-Aug-2017 16:00	23-Aug-2017 12:00
Compound	CAS Number	LOR	Unit	EB1717430-051	EB1717430-052	EB1717430-053	EB1717430-054	EB1717430-055
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.4	6.6	6.7	5.3
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	14	14	14	47
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.8	5.7	5.8	6.0	6.0
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	208	322	337	80	292
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	----	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	----	0.2
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.9	6.7	7.6	6.3	2.3
Exchangeable Magnesium	----	0.1	meq/100g	4.9	5.5	5.9	4.5	1.9
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.4	0.3	0.2	0.6
Exchangeable Sodium	----	0.1	meq/100g	0.2	0.3	0.4	0.3	0.2
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	5.3
Cation Exchange Capacity	----	0.1	meq/100g	11.6	13.0	14.2	11.4	----
Exchangeable Sodium Percent	----	0.1	%	1.5	2.2	2.5	2.8	4.8
Calcium/Magnesium Ratio	----	0.1	-	1.2	1.2	1.3	1.4	1.2
Magnesium/Potassium Ratio	----	0.1	-	7.8	13.9	19.9	25.2	3.3

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN14 50-150	GN14 150-300	GN14 400-600	GN14 600+	GN15 0-50
			Client sampling date / time	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	17-Aug-2017 13:30
Compound	CAS Number	LOR	Unit	EB1717430-056	EB1717430-057	EB1717430-058	EB1717430-059	EB1717430-060
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	6.8	7.6	6.7	5.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	17	146	511	764	25
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.7	6.0	6.9	6.0	5.9
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	98	1130	1870	2380	111
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	----	----	----	0.4
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	----	0.3
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	2.6	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	1.2	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	3.8	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	31.8	----	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	<0.2	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	1.2	----	----	1.5
Exchangeable Magnesium	----	0.1	meq/100g	1.6	12.8	----	----	1.2
Exchangeable Potassium	----	0.1	meq/100g	0.3	0.2	----	----	0.4
Exchangeable Sodium	----	0.1	meq/100g	0.2	3.1	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	3.3	----	----	----	3.5
Cation Exchange Capacity	----	0.1	meq/100g	----	17.4	----	----	----
Exchangeable Sodium Percent	----	0.1	%	7.3	17.8	----	----	2.4
Calcium/Magnesium Ratio	----	0.1	-	0.5	<0.1	----	----	1.2
Magnesium/Potassium Ratio	----	0.1	-	5.9	58.0	----	----	2.8
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	3.2	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.1	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	4.4	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN14 50-150	GN14 150-300	GN14 400-600	GN14 600+	GN15 0-50
			Client sampling date / time	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	23-Aug-2017 12:00	17-Aug-2017 13:30
Compound	CAS Number	LOR	Unit	EB1717430-056	EB1717430-057	EB1717430-058	EB1717430-059	EB1717430-060
				Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued								
Exchangeable Sodium Percent	----	0.1	%	----	----	----	24.1	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	----	<0.1	----

Analytical Results

Sub-Matrix: **SOIL**
(Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	GN15 100-150	GN15 150-250	GN15 250-600	GN15 600+	GN16 0-30
Client sampling date / time				17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 13:30	17-Aug-2017 10:55
				EB1717430-061	EB1717430-062	EB1717430-063	EB1717430-064	EB1717430-065
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	6.0	6.5	6.0	5.7
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	6	6	16	51	103
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	5.9	6.3	6.4	5.7	6.8
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	44	38	76	309	433
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	----	----	0.3	0.2
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	0.2	<0.1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	0.9	0.3	0.1	7.9
Exchangeable Magnesium	----	0.1	meq/100g	0.8	1.1	1.8	5.7	5.4
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	0.1	0.2	1.8
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.3	1.4	0.2
Cation Exchange Capacity	----	0.1	meq/100g	2.2	----	----	7.7	15.5
Cation Exchange Capacity	----	0.1	meq/100g	----	2.3	2.6	----	----
Exchangeable Sodium Percent	----	0.1	%	2.4	3.0	13.0	19.1	1.5
Calcium/Magnesium Ratio	----	0.1	-	1.0	0.8	0.2	<0.1	1.5
Magnesium/Potassium Ratio	----	0.1	-	3.2	4.2	16.2	32.6	3.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN16 50-150	GN16 150-300	GN16 300-600	GN17 0-50	GN17 50-150
			Client sampling date / time	17-Aug-2017 10:55	17-Aug-2017 10:55	17-Aug-2017 10:55	18-Aug-2017 09:30	18-Aug-2017 09:30
Compound	CAS Number	LOR	Unit	EB1717430-066	EB1717430-067	EB1717430-068	EB1717430-069	EB1717430-070
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	6.6	6.0	5.9	6.2
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	23	24	144	42	17
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.2	6.4	6.0	6.4	6.0
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	138	181	810	274	120
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	----	----	0.1	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.2	3.4	6.0	3.8	2.3
Exchangeable Magnesium	----	0.1	meq/100g	2.7	3.5	14.1	5.0	3.6
Exchangeable Potassium	----	0.1	meq/100g	1.0	0.8	1.6	0.7	0.3
Exchangeable Sodium	----	0.1	meq/100g	0.1	0.3	1.5	0.3	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	9.9	----
Cation Exchange Capacity	----	0.1	meq/100g	8.1	8.0	23.3	----	6.6
Exchangeable Sodium Percent	----	0.1	%	1.4	3.7	6.4	2.8	5.7
Calcium/Magnesium Ratio	----	0.1	-	1.6	1.0	0.4	0.8	0.6
Magnesium/Potassium Ratio	----	0.1	-	2.6	4.5	8.8	6.7	11.6

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN17 150-300	GN17 450-600	GN17 600-700	GN18 0-50	GN18 100-150
			Client sampling date / time	18-Aug-2017 09:30	18-Aug-2017 09:30	18-Aug-2017 09:30	23-Aug-2017 15:00	23-Aug-2017 15:00
Compound	CAS Number	LOR	Unit	EB1717430-071	EB1717430-072	EB1717430-073	EB1717430-074	EB1717430-075
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.2	6.9	7.8	5.7	5.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	73	343	436	46	21
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.0	6.9	7.4	6.8	6.3
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	513	1600	1840	380	160
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	0.2	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	<0.1	0.2
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	----	----	0.3	----	----
Exchangeable Magnesium	----	0.2	meq/100g	----	----	1.2	----	----
Exchangeable Potassium	----	0.2	meq/100g	----	----	<0.2	----	----
Exchangeable Sodium	----	0.2	meq/100g	----	----	0.5	----	----
Cation Exchange Capacity	----	0.2	meq/100g	----	----	2.0	----	----
Exchangeable Sodium Percent	----	0.2	%	----	----	24.4	----	----
Calcium/Magnesium Ratio	----	0.2	-	----	----	0.3	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.9	----	----	4.0	3.1
Exchangeable Magnesium	----	0.1	meq/100g	11.0	----	----	4.4	3.7
Exchangeable Potassium	----	0.1	meq/100g	0.2	----	----	0.5	0.1
Exchangeable Sodium	----	0.1	meq/100g	1.8	----	----	0.3	0.4
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	9.4	7.6
Cation Exchange Capacity	----	0.1	meq/100g	17.0	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	10.9	----	----	2.8	5.4
Calcium/Magnesium Ratio	----	0.1	-	0.4	----	----	0.9	0.8
Magnesium/Potassium Ratio	----	0.1	-	46.7	----	----	8.7	26.3
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	3.7	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	13.7	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	2.7	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	20.6	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN17 150-300	GN17 450-600	GN17 600-700	GN18 0-50	GN18 100-150
			Client sampling date / time	18-Aug-2017 09:30	18-Aug-2017 09:30	18-Aug-2017 09:30	23-Aug-2017 15:00	23-Aug-2017 15:00
Compound	CAS Number	LOR	Unit	EB1717430-071	EB1717430-072	EB1717430-073	EB1717430-074	EB1717430-075
				Result	Result	Result	Result	Result
ED008: Exchangeable Cations - Continued								
Exchangeable Sodium Percent	----	0.1	%	----	**13.1**	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	**0.3**	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	----	**75.7**	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN18 150-300	GN18 300-450	GN18 450-750	GN32 0-50	GN32 50-100
			Client sampling date / time	23-Aug-2017 15:00	23-Aug-2017 15:00	23-Aug-2017 15:00	21-Aug-2017 15:00	21-Aug-2017 15:00
Compound	CAS Number	LOR	Unit	EB1717430-076	EB1717430-077	EB1717430-078	EB1717430-079	EB1717430-080
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.1	6.6	7.0	5.5	5.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	37	164	1040	51	49
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.3	6.3	6.7	5.8	6.5
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	159	941	1750	229	238
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	----	----	----	0.3	0.3
Exchangeable Aluminium	----	0.1	meq/100g	----	----	----	0.2	0.2
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.2	2.4	----	3.0	2.8
Exchangeable Magnesium	----	0.1	meq/100g	3.9	12.4	----	1.4	1.4
Exchangeable Potassium	----	0.1	meq/100g	0.1	0.2	----	0.8	0.8
Exchangeable Sodium	----	0.1	meq/100g	0.8	3.8	----	0.2	0.2
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	5.7	5.5
Cation Exchange Capacity	----	0.1	meq/100g	7.1	18.8	----	----	----
Exchangeable Sodium Percent	----	0.1	%	10.8	20.0	----	3.9	3.8
Calcium/Magnesium Ratio	----	0.1	-	0.6	0.2	----	2.1	2.0
Magnesium/Potassium Ratio	----	0.1	-	35.9	57.6	----	1.6	1.7
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	1.8	----	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	15.6	----	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.2	----	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	5.8	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	23.4	----	----
Exchangeable Sodium Percent	----	0.1	%	----	----	24.5	----	----
Calcium/Magnesium Ratio	----	0.1	-	----	----	0.1	----	----
Magnesium/Potassium Ratio	----	0.1	-	----	----	101	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN32 100-150	GN32 150-300	GN39 0-50	GN39 100-150	GN39 150-300
			Client sampling date / time	21-Aug-2017 15:00	21-Aug-2017 15:00	23-Aug-2017 14:00	23-Aug-2017 14:00	23-Aug-2017 14:00
Compound	CAS Number	LOR	Unit	EB1717430-081	EB1717430-082	EB1717430-083	EB1717430-084	EB1717430-085
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.8	5.8	5.6	6.0	6.5
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	14	39	27	69
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.3	6.2	6.8	6.5	6.4
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	62	57	239	328	511
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.4	0.4	0.2	0.2	----
Exchangeable Aluminium	----	0.1	meq/100g	0.3	0.3	<0.1	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.8	1.9	4.0	2.9	2.3
Exchangeable Magnesium	----	0.1	meq/100g	1.0	1.0	4.4	4.8	9.0
Exchangeable Potassium	----	0.1	meq/100g	0.6	0.6	1.0	0.3	0.2
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.2	0.3	1.3
Cation Exchange Capacity	----	0.1	meq/100g	3.8	3.9	9.8	8.5	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	12.8
Exchangeable Sodium Percent	----	0.1	%	1.8	1.8	1.7	4.0	10.3
Calcium/Magnesium Ratio	----	0.1	-	1.8	1.9	0.9	0.6	0.2
Magnesium/Potassium Ratio	----	0.1	-	1.6	1.7	4.3	15.8	47.2

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	GN39 400-600	GN39 650+	----	----	----
			Client sampling date / time	23-Aug-2017 14:00	23-Aug-2017 14:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1717430-086	EB1717430-087	--------	--------	--------
				Result	Result	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	6.9	6.6	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	439	813	----	----	----
EA031: pH (saturated paste)								
ø pH (Saturated Paste)	----	0.1	pH Unit	6.7	6.4	----	----	----
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	2220	3560	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.3	0.8	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	17.3	19.6	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	0.2	0.2	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	2.8	4.0	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	21.8	24.5	----	----	----
Exchangeable Sodium Percent	----	0.1	%	12.7	16.2	----	----	----
Calcium/Magnesium Ratio	----	0.1	-	<0.1	<0.1	----	----	----
Magnesium/Potassium Ratio	----	0.1	-	76.2	105	----	----	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1721190**	Page	: 1 of 8
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 3986C	Date Samples Received	: 17-Oct-2017 11:30
Order number	: ----	Date Analysis Commenced	: 17-Oct-2017
C-O-C number	: ----	Issue Date	: 30-Oct-2017 10:15
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 29		
No. of samples analysed	: 29		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN66 0-20mm	GN66 20-150mm	GN66 150-300mm	GN66 400-580mm	GN66 580-800mm
			Client sampling date / time	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30	12-Oct-2017 17:30
Compound	CAS Number	LOR	Unit	EB1721190-001	EB1721190-002	EB1721190-003	EB1721190-004	EB1721190-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.7	6.6	6.8	6.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	102	67	337	770	894
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	386	332	1940	3280	3400
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	0.3	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.2	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.2	1.7	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	4.2	3.3	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	1.7	0.7	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.6	0.8	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	10.7	6.8	----	----	----
Exchangeable Sodium Percent	----	0.1	%	5.3	12.1	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	3.0	1.3	0.7
Exchangeable Magnesium	----	0.1	meq/100g	----	----	10.5	5.8	3.7
Exchangeable Potassium	----	0.1	meq/100g	----	----	0.4	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	2.8	2.5	1.8
Cation Exchange Capacity	----	0.1	meq/100g	----	----	16.8	9.8	6.4
Exchangeable Sodium Percent	----	0.1	%	----	----	16.8	25.4	28.2

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN67 0-50mm	GN67 50-100mm	GN67 150-300mm	GN67 300-600mm	GN67 600-800mm
			Client sampling date / time	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15	12-Oct-2017 16:15
Compound	CAS Number	LOR	Unit	EB1721190-006	EB1721190-007	EB1721190-008	EB1721190-009	EB1721190-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	5.9	6.3	7.4	8.1
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	48	33	54	193	680
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	352	408	610	1470	3320
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.1	0.3	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	0.1	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	2.0	2.1
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	5.2	6.2
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	1.0	1.6
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	8.3	9.9
Exchangeable Sodium Percent	----	0.1	%	----	----	----	11.9	16.0
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.6	5.1	7.4	----	----
Exchangeable Magnesium	----	0.1	meq/100g	7.9	10.7	17.8	----	----
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.1	0.7	----	----
Exchangeable Sodium	----	0.1	meq/100g	0.6	0.8	1.8	----	----
Cation Exchange Capacity	----	0.1	meq/100g	14.3	18.0	27.7	----	----
Exchangeable Sodium Percent	----	0.1	%	4.1	4.5	6.6	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN68 50-150mm	GN68 150-300mm	GN68 400-700mm	GN68 700-1000mm	GN69 0-50mm
			Client sampling date / time	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 13:15	12-Oct-2017 10:30
Compound	CAS Number	LOR	Unit	EB1721190-011	EB1721190-012	EB1721190-013	EB1721190-014	EB1721190-015
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.9	6.8	8.1	8.7	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	33	253	685	1080	106
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	164	1450	2500	4330	240
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.5	----	----	----	<0.1
Exchangeable Aluminium	----	0.1	meq/100g	0.3	----	----	----	<0.1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	1.1	0.7	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	2.9	2.3	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	1.8	1.5	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	5.8	4.4	----
Exchangeable Sodium Percent	----	0.1	%	----	----	30.3	33.3	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	1.5	4.6	----	----	5.1
Exchangeable Magnesium	----	0.1	meq/100g	1.3	9.6	----	----	1.7
Exchangeable Potassium	----	0.1	meq/100g	0.8	0.3	----	----	2.0
Exchangeable Sodium	----	0.1	meq/100g	0.3	4.1	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	4.4	18.6	----	----	8.8
Exchangeable Sodium Percent	----	0.1	%	7.6	22.1	----	----	1.0

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN69 50-100mm	GN69 150-300mm	GN69 400-600mm	GN69 630-850mm	GN71 0-50mm
			Client sampling date / time	12-Oct-2017 10:30	12-Oct-2017 10:30	12-Oct-2017 10:30	12-Oct-2017 10:30	11-Oct-2017 16:50
Compound	CAS Number	LOR	Unit	EB1721190-016	EB1721190-017	EB1721190-018	EB1721190-019	EB1721190-020
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	6.0	6.8	7.3	6.6
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	30	11	28	24	353
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	130	80	503	178	938
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.2	<0.1	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	0.1	<0.1	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	3.1	----
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	0.9	----
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	0.1	----
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	<0.1	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	4.2	----
Exchangeable Sodium Percent	----	0.1	%	----	----	----	<0.1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.6	3.9	14.1	----	----
Exchangeable Magnesium	----	0.1	meq/100g	1.0	0.9	4.8	----	----
Exchangeable Potassium	----	0.1	meq/100g	1.6	1.2	0.7	----	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	0.3	----	----
Cation Exchange Capacity	----	0.1	meq/100g	6.4	6.0	19.9	----	----
Exchangeable Sodium Percent	----	0.1	%	1.0	1.0	1.4	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	4.2
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	1.4
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	2.9
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	8.6
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	0.4

Analytical Results

Sub-Matrix: SOIL
(Matrix: SOIL)

			Client sample ID	GN71 50-120mm	GN71 150-300mm	GN71 350-600mm	GN71 650-800mm	GN73 0-50mm
			Client sampling date / time	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 16:50	11-Oct-2017 14:40
Compound	CAS Number	LOR	Unit	EB1721190-021	EB1721190-022	EB1721190-023	EB1721190-024	EB1721190-025
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.6	5.9	6.5	7.0	5.4
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	20	10	76	136	28
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	99	86	542	777	96
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	<0.1	<0.1	----	----	0.6
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	----	----	0.3
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	3.3	3.9	13.4	16.2	2.3
Exchangeable Magnesium	----	0.1	meq/100g	1.2	1.1	4.6	5.4	0.7
Exchangeable Potassium	----	0.1	meq/100g	0.9	0.3	0.4	0.4	1.4
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.2	1.1	1.6	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	5.4	5.5	19.5	23.8	5.0
Exchangeable Sodium Percent	----	0.1	%	1.5	3.8	5.8	6.8	1.3

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN73 100-200mm	GN73 300-450mm	GN73 500-700mm	GN73 700-1000mm	----
			Client sampling date / time	11-Oct-2017 14:40	11-Oct-2017 14:40	11-Oct-2017 14:40	11-Oct-2017 14:40	----
Compound	CAS Number	LOR	Unit	EB1721190-026	EB1721190-027	EB1721190-028	EB1721190-029	--------
				Result	Result	Result	Result	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.4	6.0	6.4	7.0	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	14	13	73	72	----
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	56	69	531	462	----
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	1.0	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	0.6	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	2.0	3.6	12.4	10.0	----
Exchangeable Magnesium	----	0.1	meq/100g	0.5	1.2	6.0	4.3	----
Exchangeable Potassium	----	0.1	meq/100g	1.2	0.4	0.3	0.2	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.2	1.4	1.5	----
Cation Exchange Capacity	----	0.1	meq/100g	4.7	5.4	20.1	16.0	----
Exchangeable Sodium Percent	----	0.1	%	1.3	3.3	6.9	9.3	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1727426**	Page	: 1 of 11
Client	: **UMWELT (AUSTRALIA) PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: ANNE SCHNEIDER	Contact	: Customer Services EB
Address	: 75 York street Teralba 2284	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: 4166	Date Samples Received	: 28-Dec-2017 09:15
Order number	: ----	Date Analysis Commenced	: 28-Dec-2017
C-O-C number	: ----	Issue Date	: 19-Jan-2018 14:56
Sampler	: ANNE SCHNEIDER		
Site	: ----		
Quote number	: SYBQ/277/16		
No. of samples received	: 43		
No. of samples analysed	: 43		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA032 (Saturated Paste EC): NATA accreditation does not cover the performance of this service.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H^+ + Al^{3+}).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)		Client sample ID		GN75 0-50mm	GN75 50-100mm	GN75 100-300mm	GN75 350-600mm	GN75 600-1000mm
		Client sampling date / time		21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00	21-Dec-2017 13:00
Compound	CAS Number	LOR	Unit	EB1727426-001	EB1727426-002	EB1727426-003	EB1727426-004	EB1727426-005
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	5.7	5.8	6.3	6.9
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	51	44	22	18	30
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	180	187	141	168	379
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown	Dark Brown	Dark Brown	Brown	Dark Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	3	3	4
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.2	0.1	<0.1	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	<0.1	<0.1	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	5.4	4.4	5.1	5.8	10.8
Exchangeable Magnesium	----	0.1	meq/100g	1.7	1.1	0.9	1.0	3.1
Exchangeable Potassium	----	0.1	meq/100g	1.1	1.2	0.5	0.2	0.4
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	0.2	0.2
Cation Exchange Capacity	----	0.1	meq/100g	8.4	6.8	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	----	6.6	7.2	14.6
Exchangeable Sodium Percent	----	0.1	%	1.2	0.8	0.8	2.5	1.7
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	30	23	9	15	65
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	3.38	0.99	0.53	0.27	0.33

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN80 0-50mm	GN80 50-150mm	GN80 180-300mm	GN80 300-600mm	GN80 600-250mm
			Client sampling date / time	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00	22-Dec-2017 10:00
Compound	CAS Number	LOR	Unit	EB1727426-006	EB1727426-007	EB1727426-008	EB1727426-009	EB1727426-010
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	5.7	6.0	6.4	7.0	7.0
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	62	20	22	112	407
EA032: Electrical Conductivity (saturated paste)								
ø Electrical Conductivity (Saturated Paste)	----	1	µS/cm	211	107	168	810	1740
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Dark Brown	Brown	Brown	Very Dark Greyish Brown	Dark Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	4	3	3	3
ED005: Exchange Acidity								
Exchange Acidity	----	0.1	meq/100g	0.3	----	----	----	----
Exchangeable Aluminium	----	0.1	meq/100g	<0.1	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	4.4	3.8	4.7	12.9	----
Exchangeable Magnesium	----	0.1	meq/100g	1.8	1.3	1.6	5.6	----
Exchangeable Potassium	----	0.1	meq/100g	1.4	0.7	0.2	0.5	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.1	0.4	2.0	----
Cation Exchange Capacity	----	0.1	meq/100g	7.9	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	----	5.8	7.1	21.1	----
Exchangeable Sodium Percent	----	0.1	%	0.9	1.8	6.3	9.8	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	----	----	----	10.8
Exchangeable Magnesium	----	0.1	meq/100g	----	----	----	----	3.8
Exchangeable Potassium	----	0.1	meq/100g	----	----	----	----	0.4
Exchangeable Sodium	----	0.1	meq/100g	----	----	----	----	1.0
Cation Exchange Capacity	----	0.1	meq/100g	----	----	----	----	16.0
Exchangeable Sodium Percent	----	0.1	%	----	----	----	----	6.3
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	167	17	16	19	25
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.44	0.68	0.48	0.53	0.46

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN04 0-50mm	GN04 150-300mm	GN06 0-50mm	GN06 150-250mm	GN06 300-550mm
			Client sampling date / time	18-Dec-2017 12:50	18-Dec-2017 12:50	18-Dec-2017 17:10	18-Dec-2017 17:10	18-Dec-2017 17:10
Compound	CAS Number	LOR	Unit	EB1727426-011	EB1727426-012	EB1727426-013	EB1727426-014	EB1727426-015
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	**Dark Brown**	**Brown**	**Very Dark Greyish Brown**	**Brown**	**Dark Greyish Brown**
Texture	----	-	-	**Sandy Loam**	**Loamy Sand**	**Sandy Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**
Emerson Class Number	EC/TC	-	-	**4**	**4**	**4**	**3**	**1**
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**27**	<5	<5	<5	<5
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**4.08**	**0.58**	**7.32**	**0.57**	**0.44**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN08 0-50mm	GN08 80-150mm	GN08 200-300mm	GN11 0-50mm	GN11 100-150mm
			Client sampling date / time	18-Dec-2017 13:10	18-Dec-2017 13:10	18-Dec-2017 13:10	18-Dec-2017 15:20	18-Dec-2017 15:20
Compound	CAS Number	LOR	Unit	EB1727426-016	EB1727426-017	EB1727426-018	EB1727426-019	EB1727426-020
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Brown	Brown	Very Dark Greyish Brown	Very Dark Greyish Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Loam	Sandy Clay Loam	Clay Loam	Clay Loam
Emerson Class Number	EC/TC	-	-	4	3	1	3	3
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	6	<5	<5	13	<5
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	4.23	0.38	0.34	4.31	1.62

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN12 0-20mm	GN12 20-100mm	GN12 100-300mm	GN13 0-50mm	GN13 100-150mm
			Client sampling date / time	18-Dec-2017 15:40	18-Dec-2017 15:40	18-Dec-2017 15:40	18-Dec-2017 14:30	18-Dec-2017 14:30
Compound	CAS Number	LOR	Unit	EB1727426-021	EB1727426-022	EB1727426-023	EB1727426-024	EB1727426-025
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Dark Greyish Brown	Dark Greyish Brown	Very Dark Greyish Brown	Very Dark Greyish Brown
Texture	----	-	-	Sandy Clay Loam	Gravelly Sand	Sandy Clay Loam	Clay Loam	Clay Loam
Emerson Class Number	EC/TC	-	-	4	8	1	4	3
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	26	<5	<5	20	7
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	6.21	0.87	0.49	3.07	0.95

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN15 0-50mm	GN15 100-150mm	GN17 0-50mm	GN17 150-300mm	GN32 0-50mm
			Client sampling date / time	18-Dec-2017 16:30	18-Dec-2017 16:30	18-Dec-2017 16:40	18-Dec-2017 16:40	18-Dec-2017 15:00
Compound	CAS Number	LOR	Unit	EB1727426-026	EB1727426-027	EB1727426-028	EB1727426-029	EB1727426-030
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Brown	Dark Brown	Yellowish Red	Very Dark Greyish Brown
Texture	----	-	-	Sandy Clay Loam	Gravelly Sand	Clay Loam	Clay Loam	Sandy Loam
Emerson Class Number	EC/TC	-	-	3	8	3	3	4
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	5	<5	7	<5	19
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	2.42	0.46	3.46	0.66	4.11

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN32 100-150mm	GN67 0-50mm	GN67 150-300mm	GN68 50-150mm	GN68 150-300mm
			Client sampling date / time	18-Dec-2017 15:00	19-Dec-2017 15:30	19-Dec-2017 15:30	19-Dec-2017 15:00	19-Dec-2017 13:50
Compound	CAS Number	LOR	Unit	EB1727426-031	EB1727426-032	EB1727426-033	EB1727426-034	EB1727426-035
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Brown	Very Dark Greyish Brown	Dark Greyish Brown	Dark Greyish Brown	Brown
Texture	----	-	-	Gravelly Sand	Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	8	3	1	2	2
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	5	24	<5	<5	<5
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.75	4.24	0.55	0.54	0.46

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN69 0-50mm	GN69 150-300mm	GN69 400-600mm	GN71 0-50mm	GN71 150-300mm
			Client sampling date / time	19-Dec-2017 15:15	19-Dec-2017 15:15	19-Dec-2017 14:00	19-Dec-2017 14:45	19-Dec-2017 14:45
Compound	CAS Number	LOR	Unit	EB1727426-036	EB1727426-037	EB1727426-038	EB1727426-039	EB1727426-040
				Result	Result	Result	Result	Result
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Very Dark Greyish Brown	Brown	Brown	Dark Brown	Brown
Texture	----	-	-	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam	Sandy Clay Loam
Emerson Class Number	EC/TC	-	-	4	3	3	4	3
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	44	11	<5	31	45
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	3.11	0.62	0.40	1.84	0.36

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	GN71 350-650mm	GN73 0-50mm	GN73 100-200mm	----	----
			Client sampling date / time	19-Dec-2017 14:45	19-Dec-2017 14:30	19-Dec-2017 14:30	----	----
Compound	*CAS Number*	*LOR*	*Unit*	EB1727426-041	EB1727426-042	EB1727426-043	--------	--------
				Result	Result	Result	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	**Reddish Brown**	**Very Dark Greyish Brown**	**Brown**	----	----
Texture	----	-	-	**Clay Loam**	**Sandy Clay Loam**	**Sandy Clay Loam**	----	----
Emerson Class Number	EC/TC	-	-	**3**	**4**	**4**	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**38**	**89**	**18**	----	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.36**	**4.00**	**0.64**	----	----

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APPENDIX C

Schedule of Lands

Schedule of Land – Glendell Continued Operations Project

Lot	DP	Within approved Mount Owen Continued Operations Consent Area	Within approved Glendell Consent Area
10	6830	Yes	No
8	6830	Yes	Yes
11	6830	Yes	No
13	6830	Yes	No
17	6830	Yes	No
21	6830	Yes	No
27	6830	Yes	No
31	6830	Yes	No
24	6830	Yes	No
25	6830	Yes	No
26	6830	Yes	No
2	6842	No	Yes
2A	6842	Yes	Yes
23	6842	Yes	No
9	6842	Yes	No
11	6842	Yes	No
1	48490	Yes	No
7001	93635	Yes	No
5	133183	Yes	No
1	135026	Yes	No
1	135027	No	No
1	137382	Yes	No
3	137382	No	No
3	195598	Yes	No
3	232149	No	No
4	232149	No	No
2	233019	No	No
4	237766	No	No
2	237766	No	No
15	247945	Yes	No
13	247945	Yes	No
6	255403	Yes	No
11	261916	No	No
14	261916	No	No
1	303842	No	No
1	303843	No	No
1	316522	Yes	No
1	375485	No	No
1	375486	No	No
A	380246	No	No
1	380676	Yes	No
2	534889	No	No
32	535087	Yes	No
32	545601	Yes	No
2	549723	Yes	No
31	585169	No	No
11	592404	Yes	Yes
71	625171	Yes	Yes
13	665120	Yes	No

Lot	DP	Within approved Mount Owen Continued Operations Consent Area	Within approved Glendell Consent Area
1221	709371	Yes	No
1	725524	No	No
2	730978	Yes	No
1	745486	Yes	No
123	752462	Yes	No
100	752462	Yes	No
121	752462	Yes	No
30	752462	Yes	No
102	752462	Yes	No
205	752462	Yes	No
206	752462	Yes	No
101	752462	Yes	No
207	752462	Yes	No
60	752462	Yes	No
37	752462	Yes	No
235	752462	Yes	No
217	752462	Yes	No
193	752462	Yes	No
234	752462	Yes	No
58	752462	Yes	No
190	752462	Yes	No
204	752462	Yes	No
208	752462	Yes	No
198	752462	Yes	No
120	752462	Yes	No
383	752462	Yes	No
195	752462	Yes	No
199	752462	Yes	No
191	752462	Yes	No
200	752462	Yes	No
197	752462	Yes	No
201	752462	Yes	No
203	752462	Yes	No
192	752462	Yes	No
194	752462	Yes	No
232	752470	Yes	No
228	752470	Yes	No
58	752499	No	Yes
2	776382	No	No
101	791739	Yes	No
100	791739	Yes	No
4	823167	Yes	No
5	823167	Yes	No
1	823167	Yes	No
2	823167	Yes	No
3	823167	Yes	No
15	825904	No	No
25	841160	Yes	No
26	841160	Yes	No
22	841165	Yes	No
23	841165	Yes	No

Lot	DP	Within approved Mount Owen Continued Operations Consent Area	Within approved Glendell Consent Area
21	841165	Yes	No
24	841165	Yes	No
923	844642	Yes	No
921	844642	Yes	No
922	844642	Yes	No
310	848411	No	No
311	848411	Yes	No
112	850054	Yes	No
100	858173	No	No
180	858299	Yes	No
7	859544	Yes	No
8	859544	Yes	No
2	859544	Yes	Yes
6	859544	Yes	Yes
3	859544	Yes	Yes
4	859544	Yes	No
5	859544	Yes	Yes
924	862883	Yes	No
926	862883	No	No
925	862883	Yes	No
1	865784	Yes	Yes
2	865784	Yes	Yes
354	867083	Yes	No
353	867083	Yes	No
356	867083	Yes	No
355	867083	Yes	No
352	867083	Yes	No
32	870789	Yes	No
11	873459	Yes	No
12	873459	Yes	No
14	873459	Yes	No
15	873459	Yes	No
107	880058	Yes	No
1	925901	Yes	No
1	940619	Yes	Yes
5	1012182	Yes	No
12	1017435	Yes	No
2	1041696	Yes	No
1	1041696	Yes	No
4	1072124	Yes	Yes
1	1072124	Yes	No
3	1072124	Yes	No
2	1072124	Yes	No
7	1077004	Yes	Yes
6	1077004	Yes	Yes
5	1077004	Yes	Yes
8	1077004	Yes	No
4	1077004	No	Yes
2	1077004	Yes	Yes
2	1089438	No	No
1	1089438	No	No

Lot	DP	Within approved Mount Owen Continued Operations Consent Area	Within approved Glendell Consent Area
7302	1132839	Yes	No
7303	1132839	Yes	No
7301	1132839	Yes	No
202	1154684	Yes	No
1032	1173426	Yes	No
1	1180252	Yes	Yes
2	1180252	Yes	Yes
3	1180252	Yes	Yes
4	1180252	Yes	No
1	1193186	No	No
10	1204457	Yes	No
1	1206886	Yes	No
2	1206886	Yes	No
3	1206886	Yes	No
264	1207775	Yes	No
1	1211135	Yes	No

APPENDIX D

Risk Assessment

Appendix 2 – Preliminary Environmental Risk Analysis

To assist in identifying the key environment and social issues that require detailed assessment as part of the Environmental Impact Statement (EIS), a preliminary environmental risk analysis has been completed for the Project. The preliminary environmental risk analysis has been undertaken in general accordance with the principles outlined in Australian Standard AS/NZS ISO 31000:2009. The environmental and social risks have been categorised with a Risk Ranking of high to low.

Table 1 – Likelihood Criteria and Risk Matrix

Basis of Rating	E - Rare	D - Unlikely	C - Possible	B - Likely	A – Almost Certain
LIFETIME OR PROJECT OR TRIAL OR FIXED TIME PERIOD OR NEW PROCESS / PLANT / R&D	Unlikely to occur during a lifetime OR Very unlikely to occur OR No known occurrences in broader worldwide industry	Could occur about once during a lifetime OR More likely NOT to occur than to occur OR Has occurred at least once in broader worldwide industry	Could occur more than once during a lifetime OR As likely to occur as not to occur OR Has occurred at least once in the mining / commodities trading industries	May occur about once per year OR More likely to occur than not occur OR Has occurred at least once within Glencore	May occur several times per year OR Expected to occur OR Has occurred several times within Glencore
5 Catastrophic	15 (M)	19 (H)	22 (H)	24 (H)	25 (H)
4 Major	10 (M)	14 (M)	18 (H)	21 (H)	23 (H)
3 Moderate	6 (L)	9 (M)	13 (M)	17 (H)	20 (H)
2 Minor	3 (L)	5 (L)	8 (M)	12 (M)	16 (M)
1 Negligible	1 (L)	2 (L)	4 (L)	7 (M)	11 (M)

Table 4 – Preliminary Environmental Risk Analysis

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Noise	Degradation of noise amenity (including cumulative impacts). Potential impact of road traffic noise based on the traffic movements associated with the extension of the mine life as a result of the proposed Project.	Risk that noise from mining (particularly overburden emplacement up to 200m AHD) will impact the residential receptors at Camberwell, Hebden and Falbrook areas. The construction of proposed infrastructure may result in degradation of noise amenity. Controls included as part of the Project to reduce noise impacts include truck fleet management, use of noise attenuated equipment and active management of equipment scheduling/location (e.g. night/day time dump options).	3	B	17 (H)	An assessment of the potential impacts of the Project relating to noise is required.	Yes
Blasting	Vibration impacts on structures and other sensitive receivers. Potential impacts from overpressure. Potential impacts on Road users due to temporary closures for Blasting.	Risk that active mining area is moving closer to sensitive receivers to the north. Controls to be included as part of the Project includes the use of blast design and monitoring procedures, controlled timing and frequency of blasting and notification of blasting times to surrounding residences and mining operations.	2	C	8 (M)	An assessment of the potential impacts of the Project relating to blasting is required.	Yes
Air Quality	Increased dust emissions resulting in degraded air quality and potential health impacts and impacts on amenity, including cumulative impacts. Potential visual and health impacts from blast plume.	Mining may result in degradation of local air quality through both exposure and handling of coal and overburden. In addition cumulative dust impacts associated with the construction of the proposed infrastructure and the operation of other mines in the Hunter Valley is a key issue. Dust impacts will be controlled through measures including mine design, haul road management (including watering), progressive rehabilitation and restricting or ceasing dust-generating activities during adverse meteorological conditions.	3	B	17 (H)	An assessment of the potential impacts of the Project relating to dust generation is required.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Odour	Increased odour due to fumes from blasts and fumes from spontaneous combustion	Spontaneous combustion is not an issue for the current Mount Owen Complex and is not expected to be for the proposed Project. No incidents of blast fume outside project area at Mount Owen or Glendell. Hebden Road will be in closer proximity to Glendell Pit Extension than current operations.	2	D	5 (L)	Risks associated with blast fumes will be assessed as part of the blasting and air quality assessment. An assessment of the potential impacts of spontaneous combustion the Project relating to odour is not considered a key issue of the Project.	No
Microclimate	Impact of changes in terrain may affect climate	Changes in terrain will affect climate in the immediate vicinity of emplacement areas, however the impacts are localised and restricted to areas close to overburden emplacement areas. Any impacts will be limited to the Project Area and are of small magnitude.	1	C	4 (L)	Risks associated with microclimate are not considered to warrant a detailed assessment.	No
Surface Water – Water Quality	Runoff from disturbed areas has potential to increase turbidity. Runoff from areas in contact with coal, tailings or workshops has the potential to affect water quality. Pit lake water quality has the potential to have elevated salinity.	The proposed mining activities will interact with and potentially impact on surface waters including through changes to the mine water management system, water use and catchment area changes. A range of surface water management measures, including erosion and sediment structures will be incorporated into the project design and will be discussed as part of the detailed surface water assessment for the EIS.	3	C	13 (M)	An assessment of the potential impacts of the Project on surface waters will be undertaken. Assessment to include consideration of design principles for Yorks Creek Diversion and final landform drainage design	Yes

<table>
<tr><th rowspan="2">Aspect</th><th rowspan="2">Potential Impact</th><th rowspan="2">Status and Proposed Control</th><th colspan="3">Risk Assessment</th><th rowspan="2">Further Assessment Requirements</th><th rowspan="2">Further Assess. Required</th></tr>
<tr><th>C</th><th>L</th><th>R</th></tr>
<tr><td>Surface Water - Water Availability</td><td>Potential impact to surface water quantity and availability
Final landform has potential to alter catchments relative to pre mining environments
Diversion of Yorks Creek will affect flows in Yorks Creek
Removal of upper catchment of Swamp Creek will affect flows to Swamp Creek</td><td>During mining operations, catchments will be reduced.
Final landform will alter catchment sizes relative to approved operations
Yorks Creek diverted
Reduced catchment size to be covered by licensing</td><td>3</td><td>B</td><td>17 (H)</td><td>An assessment of the potential impacts of the Project on surface waters will be undertaken.
Assessment to include consideration of design principles for Yorks Creek Diversion and final landform drainage design</td><td>Yes</td></tr>
<tr><td>Water Balance</td><td>Potential excess of water for ongoing mining operations and risk of spill</td><td>Existing site water balance model developed to identify water demand. Mount Owen Complex currently has water sharing arrangements with other Glendell owned mines as part of the Greater Ravensworth Area Water and Tailings Scheme.</td><td>3</td><td>C</td><td>13 (M)</td><td>Water balance model to be updated and included within the EIS.</td><td>Yes</td></tr>
<tr><td>Groundwater</td><td>Interactions and potential impacts on aquifers</td><td>The proposed mining activities will intercept groundwater and may result in impacts to groundwater users and flows.
Glendell Pit Extension will have a localised depressurisation effects on groundwater systems. This may affect bores and alluvial aquifers in Bowmans Creek. Aquifer systems already impacted by existing operations in area.
The current concept design of the Glendell Pit Extension maintains a minimum standoff of 200 metres from the high bank of Bowman’s Creek.
Alluvial cut-offs in Yorks creek to prevent direct connectivity of pit to Bowmans Creek alluvial aquifer
Mining of anticline likely to mitigate impacts on Bowmans Creek Alluvial aquifers
Groundwater take to be licensed</td><td>2</td><td>B</td><td>12 (M)</td><td>An assessment of the potential impacts of the Project on groundwater will be undertaken.</td><td>Yes</td></tr>
</table>

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Agricultural Lands	Impacts to Agricultural Land	Disturbance of potential agricultural land, including BSAL Project to be located within Glendell owned property. BSAL areas not impacted by mining and can be returned to grazing capability	2	B	12 (M)	An assessment of the potential impacts of the Project on agriculture and agricultural enterprises will be undertaken.	Yes
Aboriginal Cultural Heritage and archaeology	Potential impact to Aboriginal Heritage sites.	The Project will require areas of additional disturbance which and some known sites of Aboriginal Heritage will be impacted. The Area has significance to local community, Aboriginal knowledge holders and persons. A detailed Cultural Heritage assessment and Aboriginal archaeology assessment will be completed for the Project in partnership with the Registered Aboriginal Parties. The project has been designed to minimise the disturbance area and impacts to known sites of high significance.	3	A	20 (H)	An assessment of the potential impacts of the Project on Aboriginal Cultural Heritage values and archaeology is required.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Historic Heritage/ Built Heritage	Predicted impacts to historical heritage features from the Project. Relocation of Ravensworth Homestead	The Project requires relocation of Ravensworth Homestead which is listed as locally significant. An advisory committee has been formed to develop and investigate options for the potential relocation. Consultation with stakeholders not forming part of the committee will continue throughout the EIS process. The Project will require areas of additional disturbance which has the potential for some areas of historic heritage value to be impacted. Potential for impacts on historic heritage values or site as a result of blasting. Predictive Blast modelling is undertaken prior to each blast on site. Modelling incorporates consideration of meteorological conditions.	4	A	23 (H)	An assessment of the potential impacts of the Project on historic heritage values is required.	Yes
Natural Heritage	Impact on natural heritage items	There are no significant natural heritage items in the local areas that are likely to be impacted by the Project.	1	A	1 (L)	Not considered a key issue for the Project.	No
Visual Amenity	Aesthetics of mining operations and surface facilities.	Mining operations and overburden emplacement areas will be visible from New England Highway and Hebden Road. Operations (overburden emplacement) may also be visible at some residences to the south and east. Mine design will be undertaken in consideration of visual amenity requirements. Aspects of the proposed infrastructure will be visible from public viewing points therefore these aspects of the Project will also be included in the visual assessment. Glendell are seeking to design and implement a final landform that will provide undulating aspects to reduce visual impact.	2	B	17 (H)	An assessment of the potential impacts of the Project on the visual amenity of the area is required.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Greenhouse Gas	Emission of greenhouse gases from continued mining operations and infrastructure construction and contribution to climate change.	Mining equipment will require use of electricity, diesel and petrol. In addition there will be fugitive emissions from the Project. Scope 3 emissions as a result of burning product coal are also a source of greenhouse gas emissions. The construction works associated with the Project will result in energy use and the generation of greenhouse gas emissions. Mount Owen Complex currently implements a greenhouse gas management plan and energy savings action plan that identify key greenhouse gas reduction measures.	2	A	16 (M)	An assessment of Scope 1, 2 and 3 greenhouse gas emissions from the Project will be undertaken and appropriate management and mitigation measures identified.	Yes
Traffic	Additional traffic associated with the construction phase of the Project and impact on the road network. Potential road closures due to blasting within 500 m of Hebden Road. Potential road closures of Hebden Road during construction and commissioning of the realignment. Potential impact to traffic movements along different section of Hebden Road and at MIA intersections. Additional travel distance associated with the realignment of Hebden Road.	Project design includes construction of a realignment of Hebden Road and construction of a Heavy Vehicle Access Road. These proposed works will result in alterations to the existing traffic conditions and motorists may experience travel delays during construction. The realigned section of Hebden Road will be fully constructed prior to decommissioning of the existing section to minimise the construction impacts on road users. The operational workforce of the Mount Owen Complex will not increase as a result of the proposed Project due to the transition of the workforce from Mount Owen to the Glendell mine as mining ceases in the Bayswater North Pit and North Pit. Traffic and transport impacts associated with the proposed Project such as the adequacy of intersections and traffic routes will be assessed as part of the EIS.	2	A	11 (M)	Traffic impact assessment will be undertaken as part of EIS.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Access to property	Potential impacts of project on access to property	Realignment of Hebden Road will increase travel duration for residents in the Hebden area. Flood liability of road may also restrict access. Hebden Residences, Quarry Trucks, Mount Owen Complex Employees are key Hebden Road users which may be affected. The Traffic Impact assessment will assess the impacts of the proposed realignment of Hebden Road.	1	C	4 (L)	Traffic impact assessment will be undertaken as part of EIS.	Yes
Access to utilities	Potential impacts of project on access to utilities	Some realignment of local utilities will occur as part of the Project. Realignment and commissioning will occur prior to decommission of existing utilities. Hebden residences may also be affected.	1	C	4 (L)		
Offsite Parking	Not holding sufficient parking for workforce during construction and operation	The Project will provide sufficient parking spaces for the operational and construction workforce during all stages of the Project and will be located off public roads.	1	A	1 (L)	Not considered a key issue for the Project	No
Public Safety	Potential impact on public safety through changes in road conditions associated with Hebden Road realignment and increased traffic movements during construction phases are	The potential impacts can be managed to acceptable levels through standard and project specific management controls. Final landform will include pit lake and may include retained highwalls which present potential public safety risks. All impacts will be considered in specialist studies prepared for the EIS.	2	D	5 (L)	Not considered a key issue for the Project to warrant standalone assessment. Public safety risks associated with final landform to be considered in Mine Closure and Rehabilitation Assessment.	Partial

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Built features	Potential impact on built features and facilities (other than heritage items)	Roads impacted by project will be relocated. Some former farm buildings to be removed. Not currently occupied or required. Impacts of infrastructure items will be considered as part of the Social Impact Assessment.	1	C	4 (L)	Not considered a key issue for the Project	Partial
Land capability	Potential impact on land capability	Changes in terrain will affect Land Capability. Soils will be removed and reused. Final void will reduce agricultural capability but may have other (potentially higher) beneficial land uses.	2	A	16 (M)	Agriculture Impact and Mine Closure and Rehabilitation Assessments will be completed for the Project.	Yes
Land - Topography	Potential impact on topography	Mining will significantly affect the topography.	2	A	16 (M)	Agriculture Impact and Mine Closure and Rehabilitation Assessments will be completed for the Project.	
Biodiversity – Native Vegetation	Impact flora and vegetation communities including threatened species and Threatened Ecological Communities (TECs), Endangered Ecological Communities (EECs) and Endangered Populations	The Project will require areas of additional disturbance which has the potential for some areas of ecological value to be impacted, including an EEC/CEEC and listed threatened species and populations. An ecological survey is being completed within the Project area focussing on the Potential Additional Disturbance Area. The Project is designed to reduce/minimise the disturbance area and level of offset required. The mining area will be progressively rehabilitated throughout the duration of mining.	3	B	17 (H)	An assessment of the potential impacts of the Project on biodiversity values is required.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment			Further Assessment Requirements	Further Assess. Required
			C	L	R		
Biodiversity – Native Fauna	Potential impact on native fauna including threated species	Surface disturbing activities will remove habitat for some fauna. Threatened species known to and have potential to occur in Potential Additional Disturbance Area will be affected. An ecological survey is being completed within the Project area focussing on the Potential Additional Disturbance Area. The Project is designed to reduce/minimise the disturbance area and level of offset required. The mining area will be progressively rehabilitated throughout the duration of mining.	3	B	17 (H)	An assessment of the potential impacts of the Project on biodiversity values is required.	Yes
Biodiversity – Ground Water Dependent Ecosystems	Potential impact on stygofauna, hyporheic fauna and riparian vegetation dependant on colluvial flows	Depressurisation impacts on groundwater systems may impact on Stygofauna. Drawdown impacts and reduced baseflows on creeks may impact upon riparian vegetation and hyporheic fauna. Stygofauna surveys to be undertaken to understand potential impacts.	2	C	8 (M)	Stygofauna assessment to be undertaken with potential impacts considered in the groundwater Impact Assessment and the Biodiversity Assessment.	Yes
Bushfire	Potential increase in risk of bushfires as a result of the Project	The Project will not increase bushfire risk. Revegetation of disturbed areas may increase the amount of vegetation potential prone to bushfire. Management of bushfire risks will be similar to existing operations.	1	C	4 (L)	A bushfire assessment is not required for the Project.	No

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Housing	Lack of availability of accommodation in the local area	Operational workforce will remain largely unchanged throughout the life of the Project; however a moderate increase in workforce will occur associated with construction activities. The Social Impact Assessment will consider the availability of accommodation in the local area and potential impacts on accommodation supply.	2	C	8 (M)	Considered as part of the Social Impact Assessment	Yes
Undermining	The Project will result in subsidence	The Project does not involve underground workings. The Project is not subject to undermining from approved operations. Mine design has had regard to existing and proposed mining operations at Integra Underground and Liddell Coal.	1	C	4 (L)	Not considered as a risk of the Project.	No
Coastal Hazards	Impact of coastal hazards on Project	The Project Area is not subject to coastal hazards.	1	A	1 (L)	Not required	No
Socio-economic	The Project has the potential to result in a range of social and economic impacts, both positive and negative including sterilisation of coal resources if Project does not proceed Loss of Agricultural land if Project does proceed	The Project does not result in a significant increase to operational staff; however it will provide ongoing employment opportunities and provide significant employment during the construction phase. An extensive stakeholder engagement program will be developed and consultation undertaken as part of the EIS. Socio economic impacts will be identified and management measures will be proposed to manage any impacts as appropriate.	3-4	A	20-23 (H)	A detailed Social Impact Assessment and an Economic Assessment will be completed for the Project.	Yes

Aspect	Potential Impact	Status and Proposed Control	Risk Assessment C	L	R	Further Assessment Requirements	Further Assess. Required
Community - Health	Particulate matter is known to be associated with various public health impacts. Project's social impacts may have positive and negative impacts on public health outcomes	Refer to Air Quality Issues and Socio-economic issues.	2	C	8 (M)	A detailed Social Impact Assessment and an Economic Assessment will be completed for the Project. A detailed Air Quality Impact Assessment will be undertaken which assesses the project relative to accepted public health standards	Yes – covered by other studies
Community - Safety	Safety risks associated with the Project are largely related to Traffic related impacts	Refer to Traffic Impacts.	1	E	1 (L)	No required – covered by other studies	No
Final landform – overburden emplacement area design	Impact on the landscape and future land use from the final landform.	Proposed final landform will be designed to provide an integrated final landform design across both the existing approved and proposed mining areas as there will be no additional void. The mine closure and rehabilitation assessment will include the use of natural landform design methodologies to inform conceptual final landform principles based on stable natural slopes.	3	A	20 (H)	Mine closure and Rehabilitation assessment will be undertaken for the Project.	Yes
Final landform – Steep slopes	Impact on steep slopes	The Project will not impact on steep slopes. Final Landform for Project may include retained highwalls and slopes up to 18 degrees. Slopes must be designed to be long term stable.	2	C	8 (M)	Mine closure and Rehabilitation assessment will be undertaken for the Project.	Yes
Final Void	Impact on final landform from the final void.	No additional final void is created as part of the proposed Project. The Mine closure and Rehabilitation will include consideration of opportunities presented by the final void and management requirements in the final landform.	C	A	20 (H)	Mine closure and Rehabilitation assessment will be undertaken for the Project.	Yes

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