Ravensworth East Resource Recovery Project

Environmental Assessment

December 2012

RAVENSWORTH EAST
RESOURCE RECOVERY PROJECT

Environmental Assessment

December 2012

Prepared by
Umwelt (Australia) Pty Limited

on behalf of
Xstrata Mount Owen Pty Limited

Project Director: **Michelle Kirkman**
Project Manager: **Tim Browne**
Report No. **3081/R01/Final**
Date: **December 2012**

Newcastle

PO Box 3024
75 York Street
Teralba NSW 2284

Ph. 02 4950 5322

www.umwelt.com.au

Executive Summary

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres north-west of Singleton, 24 kilometres south-east of Muswellbrook and approximately 4.5 kilometres to the north of Camberwell village. The Mount Owen Complex consists of the Ravensworth East, Glendell and Mount Owen open cut mining operations. The Ravensworth East Mine is owned and operated by Xstrata Mount Owen Pty Limited (XMO). Ravensworth East Mine currently operates under DA 52-03-99 which allows for the extraction of 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the Ravensworth East Mine until 2021 (21 years after the mining lease was granted pursuant to the consent) and the emplacement of overburden within the open cut (known as West Pit) to a maximum height of RL 160 m. The extraction of all economically accessible coal resources within the current West Pit at Ravensworth East Mine, is expected to be complete by quarter three 2013.

XMO is seeking to modify DA 52-03-99 under Section 75W of the *Environmental Planning & Assessment Act 1979* to allow for the Ravensworth East Resource Recovery (RERR) Project (proposed modification) involving the continuation of mining operations at the Ravensworth East Mine within the current approval timeframe (for a further 6 years). It is proposed to relocate the existing mining fleet and workforce currently operating within the West Pit at Ravensworth East Mine to the RERR mining area when the extraction of all economically accessible coal resources within the West Pit is complete. The RERR mining area is located in an area previously disturbed by mining that was formerly known as Tailings Pit 2 (TP2).

It is proposed to mine down to a depth of approximately 200 metres targeting the Ravensworth and Bayswater coal seams, in the RERR mining area, an area previously mined to a depth of approximately 30 metres. As mining progresses within the RERR mining area, it is proposed that overburden emplacement will continue in the West Pit Overburden Emplacement Area to a maximum height of RL 180 m, which represents an increase of 20 metres in height from the currently approved RL 160 m.

No changes are proposed to the current mining methods, extraction rate, employment numbers, coal processing, product transportation or operating hours. No alterations or additions to the existing surface infrastructure facilities are proposed and no construction activities are required.

The proposed modification will provide for the continuity of mining operations and the continued employment of the existing workforce at the Ravensworth East Mine.

The key benefits of the proposed modification include:

- maximising the coal resource recovery from an area previously disturbed by approved mining operations, thus eliminating land disturbance;
- recovery of an additional approximate 6 million tonnes of ROM coal;
- continued employment of the existing workforce for a further 6 years;
- maintaining efficient use of existing infrastructure for mining, processing and transportation of coal;
- payment of royalties to the State of NSW; and
- export earnings for Australia.

Consultation

A detailed consultation process has been undertaken during the development of this Environmental Assessment (EA) to allow surrounding landholders and Government agencies the opportunity to provide feedback on their concerns regarding the proposed modification and to provide feedback on the EA findings.

Environmental Assessment

This EA includes a detailed assessment of the potential environmental and social impacts associated with the proposed modification, focussing on the assessment of potential impacts that the proposed modification may have including the predicted contribution to the cumulative impacts.

The proposed modification will not result in any significant change to the currently approved operations at the Ravensworth East Mine and will be undertaken wholly within an area previously disturbed by approved mining operations and will not result in any change to the existing workforce or require any construction works. As such, detailed aboriginal archaeology, historical heritage, traffic and land capability and agricultural assessments were not undertaken.

The potential impacts associated with the proposed modification include noise, air quality, blasting, surface and groundwater, social, greenhouse gas and energy, ecology, final land use and visual amenity. The specialist studies undertaken to support this EA indicate that the noise impacts associated with the proposed modification will be contained within the existing Mount Owen affectation zone with no additional properties being affected. The results of the air quality assessment indicate there will be no exceedance of any air quality criteria to those residences not currently subject to acquisition rights as a result of the proposed modification. Social, blasting, surface and groundwater, greenhouse gas and energy, final land use and visual impacts can be adequately managed through the update and application of currently approved management plans. Further detail regarding the outcome of these assessments is provided in **Section 6.1**.

This EA demonstrates that XMO will be able to effectively manage impacts associated with the proposed modification. This will be achieved through the ongoing implementation of environmental controls at the Mount Owen Complex and the refinement of the existing management and monitoring strategies where applicable. XMO will amend the relevant environmental management plans required under the existing development consent to provide for the refinements to the existing management controls as required.

TABLE OF CONTENTS

FIGURES

PLATES

APPENDICES

1.0 Introduction

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres north-west of Singleton, 24 kilometres south-east of Muswellbrook and approximately 4.5 kilometres to the north of Camberwell village (refer to **Figure 1.1**). The Mount Owen Complex consists of the Ravensworth East, Glendell and Mount Owen open cut mining operations. Operations within the Mount Owen Complex are undertaken pursuant to three separate development consents including Ravensworth East Mine DA 52-03-99, Glendell Mine DA 80/952 and Mount Owen Mine DA 14-1-2004.

Xstrata Mount Owen Pty Limited (XMO) is seeking to modify development consent DA 52-03-99 to allow the continuation of the existing mining operations at Ravensworth East Mine. Ravensworth East Mine is scheduled to reach the limit of approved coal extraction in quarter three 2013. The Ravensworth East Resource Recovery (RERR) Project (the proposed modification) is seeking approval for the recovery of an additional approximate 6 million tonnes of run of mine (ROM) coal and an increase in height of the existing overburden emplacement area, within the current approved life of the Ravensworth East Mine. The proposed modification would provide for continuity of mining and employment for the Ravensworth East Mine workforce within the current approval timeframe. Both the RERR mining area and the overburden emplacement area are located in an area previously disturbed by existing approved mining operations. The proposed modification is being sought under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Umwelt (Australia) Pty Limited (Umwelt) has prepared this Environmental Assessment (EA) on behalf of XMO to assess the potential environmental and social impacts of the proposed modification at Ravensworth East Mine.

1.1 The Applicant

Ravensworth East Mine, previously known as Swamp Creek Mine was acquired in 1997 by Peabody Resources Ltd (Peabody) after a period of care and maintenance. A new Mining Lease (ML) 1415 was issued in 2000 and the Ravensworth East Mine was assigned a separate mining tenement (ML 1453). DA 52-03-99 was granted in March 2000 and mining operations commenced in August 2000. In 2002 Enex Resources (now Xstrata) purchased Ravensworth Operations Pty Limited (Ravensworth Operations), which included Ravensworth East and Narama Mine (now part of Ravensworth Surface Operations).

Currently all mining operations located within the Mount Owen complex are owned by subsidiary companies of Xstrata Coal Pty Limited. XMO, formerly Hunter Valley Coal Corporation Pty Ltd (HVCC), manages the Mount Owen Complex. Xstrata currently operates the Ravensworth East and Glendell mines with Thiess Pty Ltd currently operating the Mount Owen Mine under a contract.

1.2 Overview of the Proposed Modification

Mining operations at Ravensworth East Mine are undertaken in accordance with DA 52-03-99 which allows for the extraction of 4 million tonnes per annum (Mtpa) of ROM coal until 2021. The extraction of all approved accessible coal resources within the current West Pit at Ravensworth East Mine, is expected to be complete by quarter three 2013. The proposed modification seeks to modify DA 52-03-99 under Section 75W of the EP&A Act to allow XMO to continue mining within the RERR mining area. The RERR mining area is an

FIGURE 1.1

Locality Plan

area previously disturbed by mining operations that was formerly known as Tailings Pit 2 (TP2), (refer to **Figure 1.2**).

The proposed modification does not include any changes to the current approved mining method or extraction rate, employment numbers, product transportation or operating hours. No alterations or additions to the existing surface infrastructure facilities are proposed and no construction activities are required.

More specifically the proposed modification includes:

- overburden removal and coal extraction within the RERR mining area down to a depth of approximately 200 metres, utilising the personnel and mining methods currently operating in the West Pit (subject to equipment replacement and upgrades); and

- emplacement of overburden within the West Pit overburden emplacement area to a maximum height of approximately RL 180 m, an increase of 20 metres in height from the currently approved RL160 m.

Further details of the existing and approved mining operations are provided in **Section 2.0** and further details of the proposed modification are provided in **Section 3.0**.

1.3 Overview of the Existing Environment

Ravensworth East Mine adjoins the existing Mount Owen and Glendell Mining operations which collectively form the Mount Owen Complex, as illustrated in **Figure 1.2**. The Mount Owen Complex is situated within a rural area, primarily surrounded by other mining operations, rural landholdings, biodiversity offset areas and the Ravensworth State Forest. Other mining operations located within the vicinity of the Mount Owen Complex include:

- Liddell Coal Operations to the north-west;

- Ravensworth Surface Operations to the south-west;

- Ravensworth Underground Mine to the south-west;

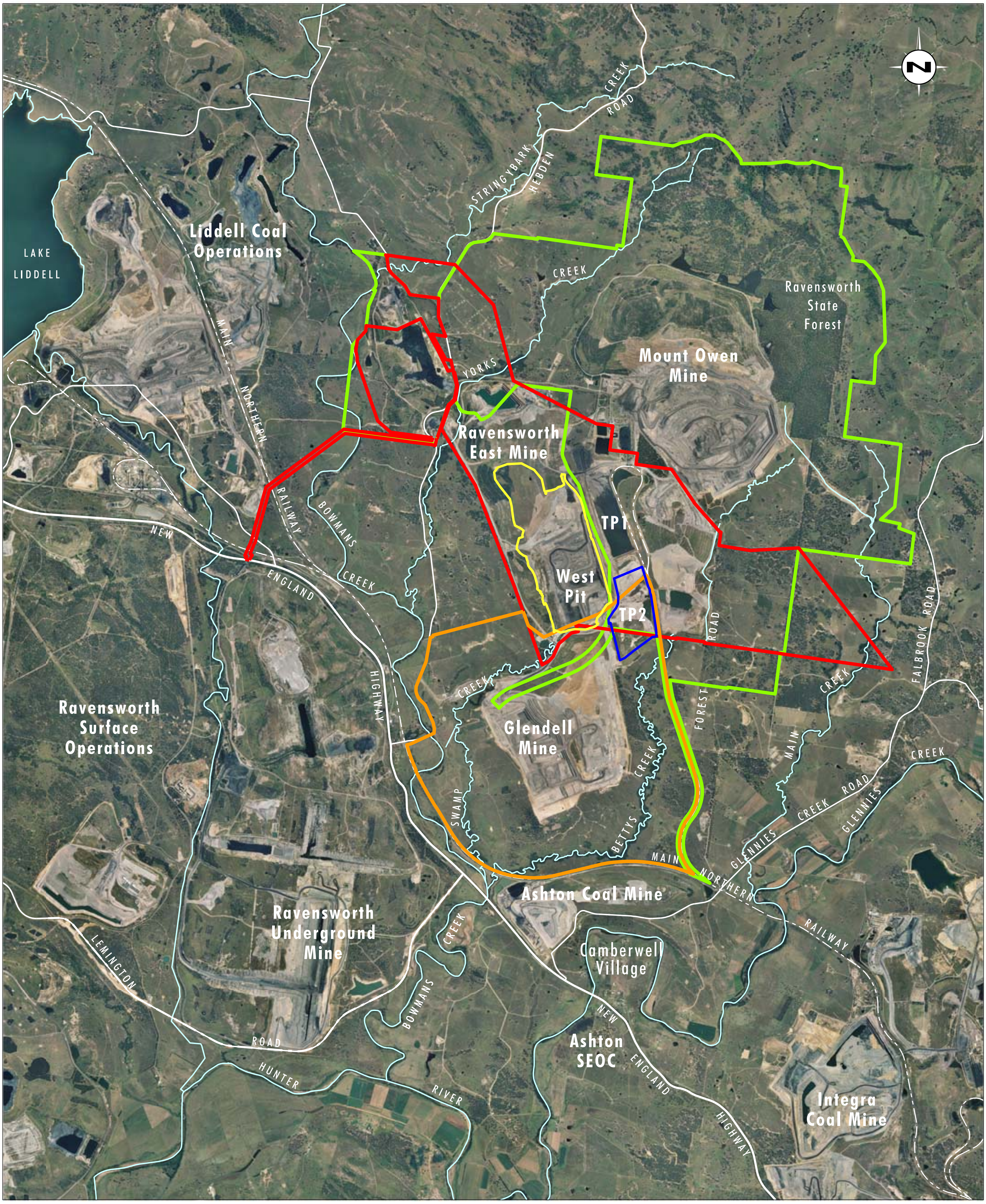
- Ashton Coal Mine to the south; and

- Integra Coal Mine to the south-east.

Other industrial areas within the vicinity of the Mount Owen Complex include the Bayswater and Liddell Power Stations located to the north-west. The Ravensworth State forest adjoins the Mount Owen Complex to the east and north-east, the remainder of the land surrounding the Mount Owen Complex consists of mine owned buffer land and rural and rural residential land holdings.

Existing mining activities have a large presence within the surrounding area and consequently a large proportion of the surrounding properties are now owned by mining companies. The majority of the surrounding private residential properties are located to the south, south-east, east and north-west of the Mount Owen Complex, with the closest private residence (which currently has the right to request acquisition by Xstrata) located approximately 3.5 kilometres to the south-east of the Ravensworth East Mine, (refer to **Figure 1.3**). The village of Camberwell is located approximately 4.5 kilometres to the south of the Ravensworth East Mine at its nearest point. The remainder of the surrounding land

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 1 2 4km
1:80 000

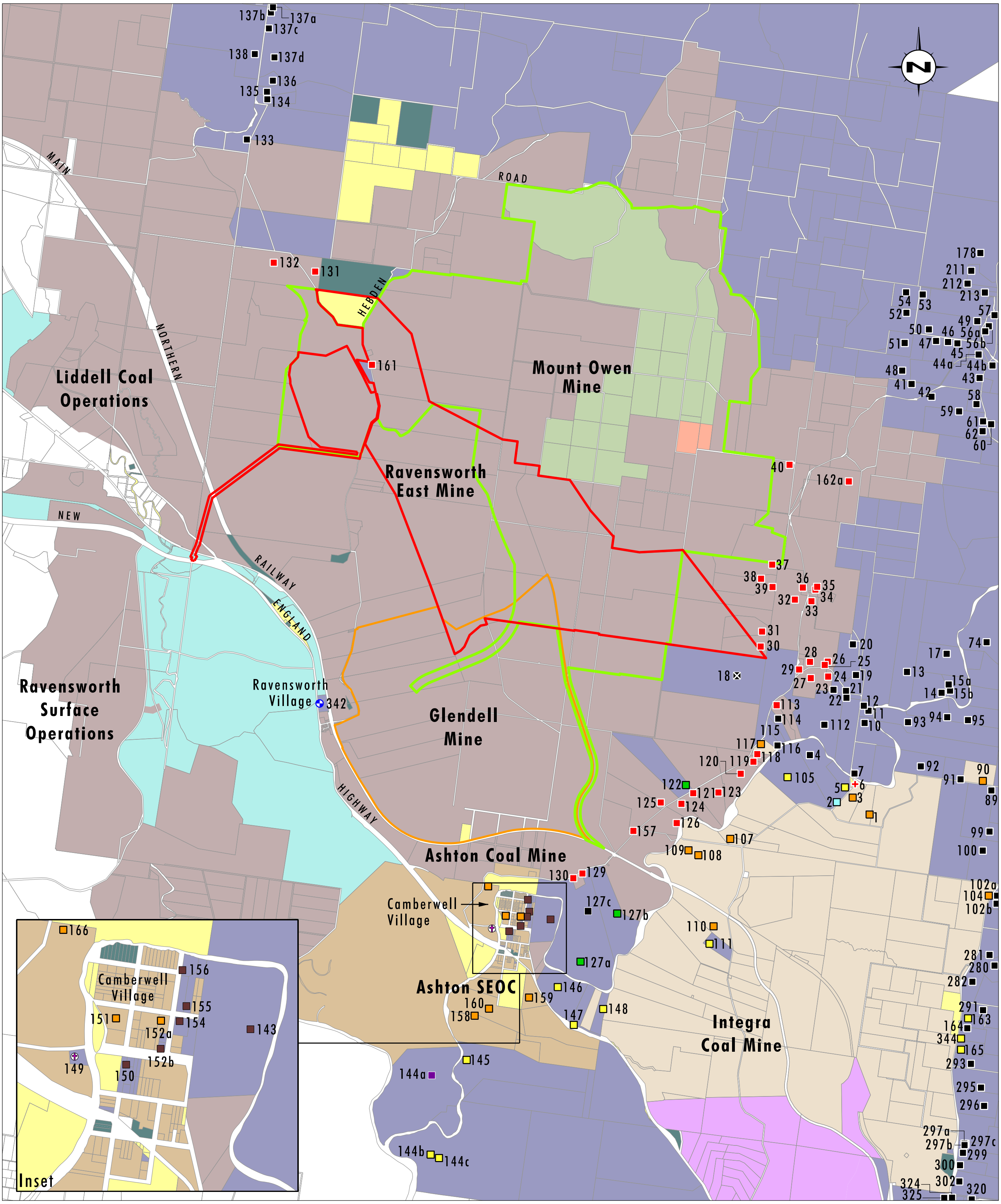
Legend

- Ravensworth East Mine DA Boundary
- Glendell Mine DA Boundary
- Mount Owen Mine DA Boundary
- West Pit Overburden Emplacement Area
- RERR Mining Area

FIGURE 1.2

Mount Owen Complex

Umwelt
Environmental Consultants



Source: Mount Owen (2011)

0 0.5 1.0 1.5km
Inset Scale 1:30 000

0 1 2 4km
Main Scale 1:90 000

Legend

- Ravensworth East Mine DA Boundary
- Glendell Mine DA Boundary
- Mount Owen Mine DA Boundary
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger

FIGURE 1.3

Land Ownership

File Name (A4): R01/3081_013.dgn
20121219 16.33

ownership is made up of Crown land, State Forest and Government authority or corporation owned land, as detailed in **Figure 1.3**.

The topography of the Mount Owen Complex is characterised by an undulating hilly landscape extending from the surrounding ridgelines to the north and east and existing overburden emplacement areas down to the existing waterways. The area surrounding the Mount Owen Complex is characterised by gently sloping alluvial plains and undulating hills. A prominent ridgeline extends north to south and is located to the east of the Mount Owen Complex. This ridgeline is a dominant topographic feature and extends to a height of approximately 360 metres AHD. The Ashton Overburden Emplacement Area is located to the immediate south of the Mount Owen Complex, which extends to the height of RL160 m. Another ridgeline is located immediately north-west of Camberwell and runs in an east to west direction to the south of the Mount Owen Complex with an elevation of approximately 115 metres AHD (refer to **Figure 1.4**).

The Mount Owen Complex is located within both the Bowmans Creek and Main Creek catchments, with Ravensworth East Mine being located specifically within the Bowmans Creek catchment. Bowmans Creek is a tributary of the Hunter River, and major tributaries of Bowmans Creek within the vicinity of Ravensworth East Mine include Yorks Creek, Swamp Creek and Bettys Creek (refer to **Figure 1.4**).

1.4 Overview of the Planning and Approval Process

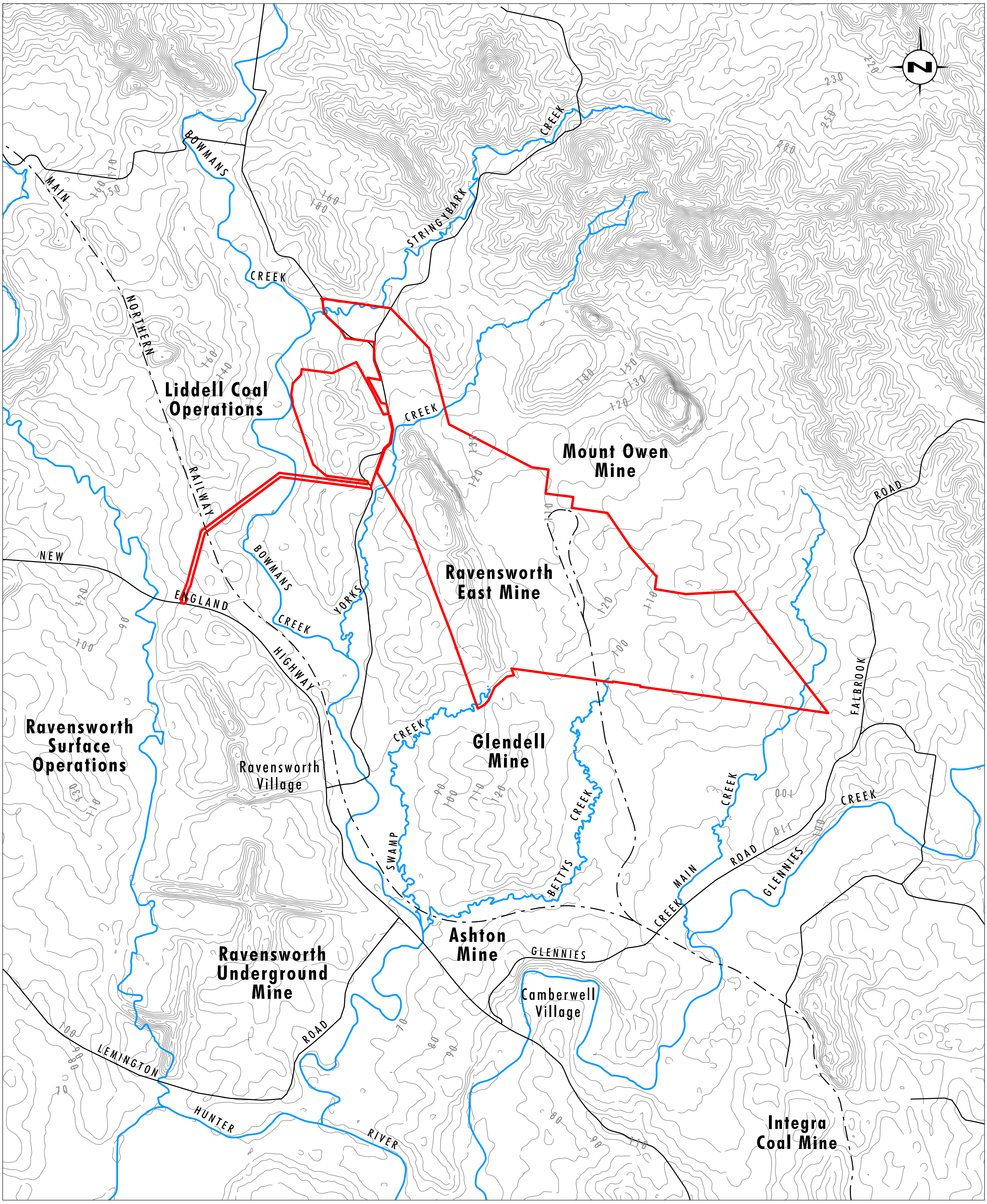
XMO is seeking a modification to development consent DA 52-03-99 pursuant to Section 75W of the EP&A Act. The Minister for Planning and Infrastructure is the consent authority for the proposed modification. A detailed discussion of the planning context for the proposed modification is included in **Section 5.0**.

1.5 Project Team

This EA was prepared by Umwelt on behalf of XMO. Specialist studies undertaken as part of the EA process include:

- Air quality assessment – PAE Holmes Pty Ltd;
- Groundwater assessment – SKM;
- Social impact assessment – Coakes Consulting;
- Water balance – Gilberts and Associates; and
- Blasting assessment – Enviro Strata Consulting.

Assessments for noise, surface water resources, visual amenity, ecology, greenhouse gas and energy and mine rehabilitation have been undertaken by Umwelt. Further details of the Project Team are provided in **Appendix 1**.



Source: Mount Owen (2011), Department of Lands (2006)
Note: Contour Interval 10m

0 1.0 2.0 4.0km
1:80 000

Legend

Ravensworth East Mine DA Boundary
Drainage Line

FIGURE 1.4

Waterways
Mount Owen Complex

1.6 EA Structure

The purpose of this EA is to identify and assess the potential environmental and social impacts associated with the proposed modification. This EA has been prepared in accordance with the requirements of the EP&A Act and the Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) (refer to the EA Statement of Authorship in **Appendix 1**). An overview of the structure of this EA is provided below.

The **Executive Summary** provides a brief overview of the proposed modification and the major outcomes of the EA.

Section 1.0 provides the background and context for the proposed modification, an overview of the existing environment and approval process, and outlines the applicant, the EA project team and the EA structure.

Section 2.0 contains a description of the existing mining operations and approvals at the Ravensworth East Mine and the interaction and management arrangements associated with the Mount Owen Complex.

Section 3.0 contains a description of the proposed modification and alternatives.

Section 4.0 describes the consultation process and the environmental and community issues identified by the community.

Section 5.0 describes the planning context for the proposed modification, including the applicability of Commonwealth and State legislation.

Section 6.0 contains the environmental assessment of the proposed modification, including the project specific and cumulative impacts as a result of the proposed modification.

Section 7.0 details the Draft Statement of Commitments to be adopted for the proposed modification in order to mitigate impacts.

Section 8.0 provides a conclusion for the environmental assessment, justification for the proposed modification and assesses consistency with the principles of Ecologically Sustainable Development (ESD).

Section 9.0 provides a list of references cited in the EA.

Section 10.0 provides a list of abbreviations and a glossary of technical terms.

2.0 Existing Operations

2.1 Open Cut Mining Operations

The Ravensworth East Mine was formerly known as the Swamp Creek Mine which had been operating since the 1960s. In 1997 a new mining lease (ML 1415) was issued after a period of care and maintenance and the mine was renamed Ravensworth East Mine. Ravensworth East Mine operates under DA 52-03-99 which originally allowed for the supply of coal to the domestic market through the transportation of ROM coal via conveyor to both the Bayswater and Liddell power stations. Subsequent modifications to DA 52-03-99 in 2000, 2003, 2004 and 2005 have included modifications to allow the extraction of coal for the export market following the processing of coal at the Mount Owen Coal Handling and Preparation Plan (CHPP), an increase in the extraction rate and the emplacement of tailings from the Mount Owen operations within Ravensworth East voids.

DA 52-03-99 allows for the extraction of 4 Mtpa of ROM coal from the Ravensworth East Mine until 2021 (21 years after the mining lease was granted pursuant to the consent) and the emplacement of overburden within the West Pit to a maximum height of RL 160 m.

Ravensworth East Mine consists of the West Pit (currently operational), the formerly mined Stage 3 Pit, the RW Pit (currently part of the tailings management system), and two shallow pits known as TP1 and TP2 (refer to **Figure 2.1**). TP1 has been used for tailings emplacement, whilst TP2 has been partially backfilled with overburden from the Glendell Mine. Approved mining operations are currently occurring within the West Pit only, where coal is extracted from the Ravensworth seams and the Bayswater seam, (part of the Burnamwood formation).

The West Pit currently operates as a multi-seam truck and excavator operation. A fleet of haul trucks transport overburden to the emplacement areas within the West Pit and the ROM coal to the Mount Owen CHPP for processing. The remainder of the mining equipment fleet consists of water carts, dozers, graders, drill rigs and fuel and service carts.

The TP1 and TP2 areas adjoin the West Pit to the east. Both TP1 and TP2 were mined as shallow box cuts to a depth of approximately 30 metres. TP1 is currently used for the emplacement of tailings from the Mount Owen CHPP in accordance with the Mount Owen DA 14-1-2004. It is proposed that TP1 will be capped using overburden from mining operations within the Mount Owen Complex by the end of 2015. The TP2 area was not required for the emplacement of tailings and is currently partially utilised for the emplacement of overburden.

2.2 Coal Processing and Transportation

All coal extracted from within the Mount Owen Complex, including from Ravensworth East Mine is transported to the Mount Owen CHPP for processing. ROM coal is hauled by truck to a ROM stockpile area where it is then delivered from hoppers and crushers to the Mount Owen CHPP. The coal is then washed and delivered to the Mount Owen product coal stockpile.

Export product coal from the Mount Owen Complex is currently loaded onto trains using the Mount Owen rail spur. Export coal processed from the Mount Owen Complex is transported to the Port of Newcastle via the existing rail spur and the Main Northern Rail Line, (refer to **Figure 2.1**). The current Ravensworth East development consent also allows for ROM coal to be transported via conveyor to both the Bayswater and Liddell power stations.

Umwelt
Environmental Consultants

Source: Mount Owen (2012)

FIGURE 2.1

Ravensworth East Mine Current Operations

File Name (A4): R01/3081_014.dgn
20120914 10.38

No changes to these arrangements are proposed in this modification.

2.3 Mining Infrastructure Areas

The operations currently being undertaken within the Ravensworth East Mine utilise both the Mount Owen and Glendell mining infrastructure areas. ROM coal extracted from the Ravensworth East Mine is transported to the Mount Owen CHPP for processing and transportation to the Port of Newcastle via the Mount Owen rail spur and Main Northern Rail Line. The offices, workshops and staff facilities used by the operational team are located within the Glendell mining infrastructure area.

The Ravensworth East infrastructure area, located on the north-west side of the Ravensworth East Mine is utilised as required to support mining and associated activities at the Mount Owen Complex.

2.4 Mine Workforce and Hours of Operation

Ravensworth East mining operations currently have approval for the full-time employment for approximately 260 people.

Mining activities at Ravensworth East Mine currently operate 24 hours per day, 7 days per week.

No changes to these arrangements are proposed as part of this modification.

2.5 Rejects and Tailings Management

Tailings emplacement is undertaken at the Mount Owen Complex within disused mining areas in accordance with the Mount Owen Tailings Management Strategy. The current status of the tailings emplacement areas are provided in **Table 2.1** and the location of the tailings emplacement areas are shown on **Figure 2.1**.

Table 2.1 – Mount Owen Complex Tailings Emplacement Areas

Void	Status
North Void – Stage 1 (NVS1)	Emplacement ceased, capping underway
North Void – Stage 2 (NVS2)	Emplacement ceased, top up use only
Tailings Pit 1 (TP1)	Emplacement ceased, top up use only
RW Pit	Tailings emplacement commenced 2012
Eastern Rail Pit (ERP)	Tailings emplacement commenced 2012
West Pit	Tailings emplacement will commence following completion of mining in approximately Q3 2013

Coarse reject material from the Mount Owen CHPP is incorporated into the overburden emplacement areas within the Mount Owen Complex. Tailings from the Mount Owen CHPP are pumped to the tailings emplacement areas as required. Typically more than one tailings emplacement area within the Mount Owen Complex is utilised allowing the emplacement of tailings to be alternated between facilities to allow additional time for the tailings to consolidate, which assists with later capping rehabilitation works.

Rehabilitation of the tailings emplacement areas is undertaken once the tailings have sufficiently consolidated, which occurs approximately 3 to 5 years after the emplacement of tailings has ceased.

2.6 Existing Development Consents

The existing development consents for the current Mount Owen Complex operations include:

- Ravensworth East Mine (DA 52-03-99);
- Mount Owen Mine (DA 14-1-2004); and
- Glendell Mine (DA 80/952).

The proposed RERR mining area is located partially within the Ravensworth East, Glendell, and Mount Owen development consent boundaries (refer to **Figure 1.2**).

The Mount Owen and Glendell Operations and associated development consents are not proposed to be modified as part of this proposed modification.

2.6.1 Ravensworth East Mine DA 52-03-99

The Ravensworth East Mine operates under development consent DA 52-03-99 which allows the *development of an open cut coal mine and associated surface facilities* in accordance with the Environmental Impact Statement (ERM 1999) for the Ravensworth East Mine and subsequent Statements of Environmental Effects 2000, 2002, 2004, 2005 supporting modification applications.

2.7 Other Key Approvals

There are a number of other environmental and operational approvals issued under various pieces of legislation which apply to Ravensworth East Mine. These approvals are summarised in **Sections 2.7.1** to **2.7.3** and discussed in **Section 5.0**.

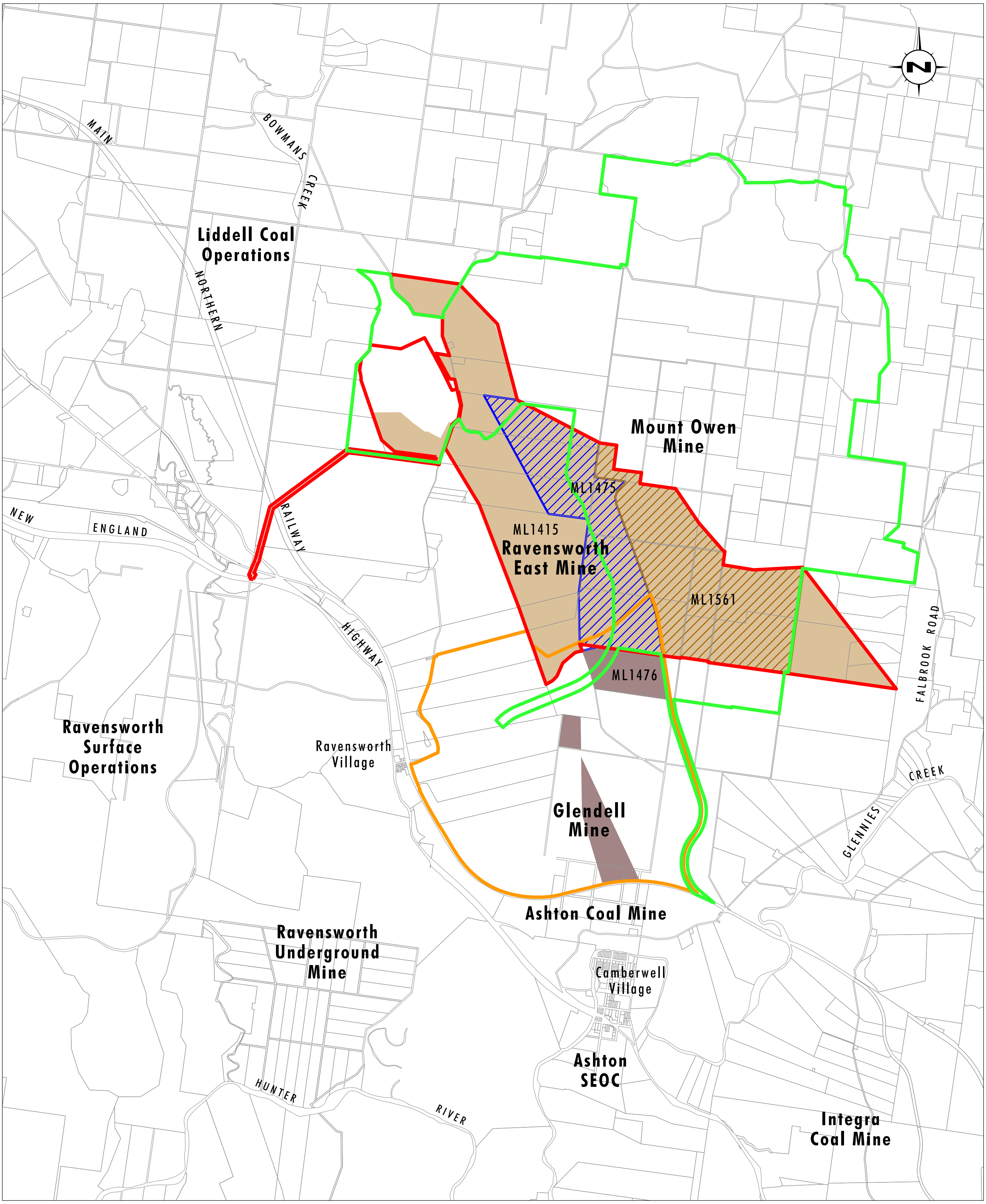
2.7.1 Mining Leases

The mining leases which apply to the Ravensworth East Mine and the RERR mining area are shown in **Table 2.2**. The location of these leases is illustrated in **Figure 2.2**.

Table 2.2 – Relevant Mining Leases

Mining Lease	Held by	Date of Expiry
ML 1415	Ravensworth East	04/07/2020
ML 1475	Ravensworth East	24/11/2021
ML 1561	Ravensworth East	17/02/2026
ML 1476	Glendell	24/11/2021

Umwelt
Environmental Consultants



Source: Mt Owen (2011)

0 1.0 2.0 4.0km
1:80 000

Legend
- Ravensworth East Mine DA Boundary
- Glendell Mine DA Boundary
- Mount Owen Mine DA Boundary
- ML1415
- ML1475
- ML1476
- ML1561

FIGURE 2.2

Ravensworth East Mining Titles

File Name (A4): R01/3081_015.dgn
20121213 10.04

2.7.2 Environmental Protection Licence

The Ravensworth East Mine operates under Environment Protection Licence (EPL) 10860. The EPL covers the scheduled activities 'mining for coal' and 'coal works' within the Ravensworth East Mine. The Mount Owen Mine and Glendell Mine operate under separate EPLs.

EPL 10860 details air, blasting and water quality controls and monitoring requirements specific to the Ravensworth East operations. The EPL applies specific requirements relating to monitoring locations for air quality and water discharge, the sampling method required and monitoring frequency.

2.7.3 Water Licences

The Ravensworth East Mine currently holds four water licences administered by the NSW Office of Water (NOW) including:

- two for pumping water from Glennies Creek;
- one for water monitoring bores;
- one for the diversion of Swamp Creek; and
- groundwater licences for a total of 1160 mega litres (Mount Owen Complex).

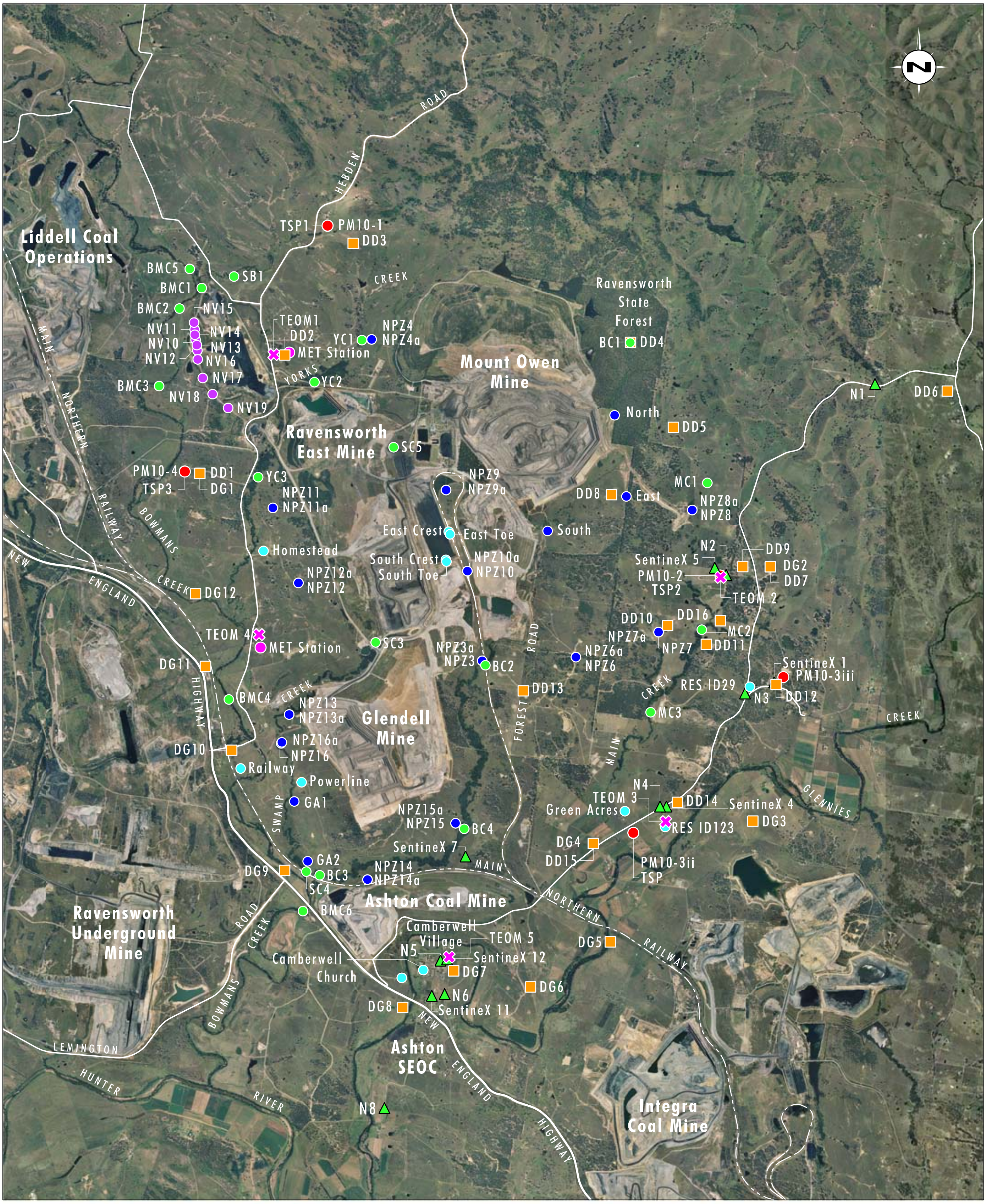
2.8 Existing Environmental Management and Monitoring Systems

The Mount Owen Complex is committed to maintaining responsible environmental management practices to ensure potential environmental impacts associated with the mining operations are minimised. The Mount Owen Complex operates under a comprehensive Environmental Management System (EMS). This EMS provides a framework for environmental management and brings together all aspects of environmental management at the Mount Owen Complex.

The EMS covers the design, construction, operation, maintenance and rehabilitation of all operations and infrastructure within the Mount Owen Complex. The EMS enables XMO to adopt a continuous improvement approach to environmental management issues and implements best practice environmental management wherever reasonable and feasible. It also allows operations within the complex to be managed effectively to enable the prevention or minimisation of any environmental impacts associated with mining operations.

Monitoring (including noise, dust, blasting, ground and surface water) is undertaken at the Mount Owen Complex in order to collect information to minimise the environmental impact of the mining operations and to evaluate the effectiveness of the environmental management system and the rehabilitation works. The monitoring network currently implemented at the Mount Owen Complex is illustrated on **Figure 2.3**.

Umwelt
Environmental Consultants



Source: Mount Owen (2012), Google Earth (2008)

Legend

- Depositional Dust Monitoring
- HVAS Location (dust)
- Blast Monitoring Location
- Noise Monitoring Location
- MET Station Location
- Groundwater Monitoring Location
- Piezo (groundwater) Monitoring Location
- Surface Water Monitoring Location
- TEOM Monitoring Location

FIGURE 2.3

Mount Owen Complex Monitoring Locations

File Name (A4): R01/3081_032.dgn
20121213 10.23

3.0 Description of the Proposed Modification

3.1 Open-Cut Mining Operations and Overburden Emplacement

As outlined in **Section 1.2** the proposed modification is seeking approval to allow mining within the RERR mining area (previously known as TP2) located to the south-east of the West Pit at Ravensworth East Mine. The proposed modification will also require a minor amendment to the existing Ravensworth East DA consent boundary (refer to **Figure 3.1**). It is proposed to mine economically recoverable resources down to a depth of approximately 200 metres, targeting the Bayswater seam, in an area previously mined to approximately 30 metres. The RERR mining area is entirely contained within an area previously disturbed by approved mining activities. Overburden and coal extraction in the RERR mining area will require the disturbance of 60.4 hectares of mine rehabilitation (comprising of 7.3 hectares of immature rehabilitation forest complex and 53.1 hectares of rehabilitation grassland complex).

As outlined in **Section 2.1**, the West Pit is currently operating as a multi-seam truck and excavator operation. The extraction of all economically accessible coal resources within the West Pit is expected to be completed within quarter three, 2013. The proposed modification would involve the utilisation of the existing mining methods and the workforce from the West Pit to operate in the RERR mining area as the West Pit mining operations are progressively completed, allowing for continuity of mining and employment for the existing workforce.

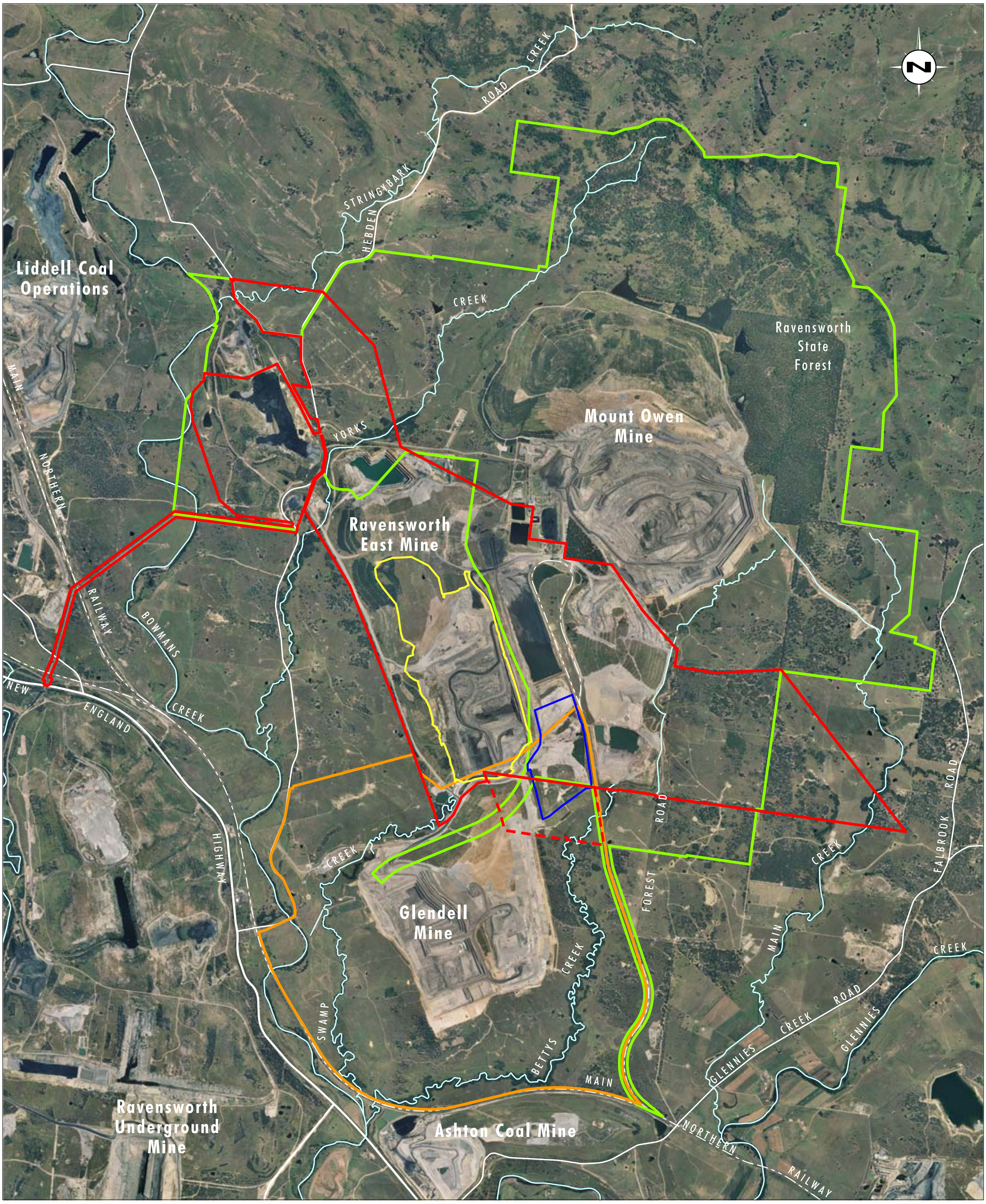
The Ravensworth East Mine development consent currently allows for up to 4 Mtpa of ROM coal to be extracted from the operation. Coal extraction within the RERR mining area will be undertaken within current approved extraction rates. Mining will target the Ravensworth seams and the Bayswater seam and will produce in the order of approximately 6 million tonnes of ROM coal over six years (including overburden removal and emplacement). Conceptual mine plans for the proposed modification are illustrated in **Figures 3.2** to **3.4**.

Mining operations associated with the proposed modification would initially involve the excavation of overburden emplaced within the RERR mining area previously as part of approved mining operations. This overburden would be transported and emplaced within the West Pit Overburden Emplacement Area. As mining progresses within the RERR mining area, overburden emplacement will continue within the West Pit Overburden Emplacement Area to an approximate height of RL 180m, an increase of 20 metres in height from the currently approved RL 160m. The height of the proposed overburden emplacement area will be approximately RL 180 with undulations in areas to allow a more natural profile to be achieved. The increase in height will allow for additional area for the emplacement of overburden and consequently assist with drainage of the proposed final landform.

Emplacement of overburden at the West Pit Overburden Emplacement Area will result in the disturbance of approximately 54.2 hectares of an area previously rehabilitated.

No changes are proposed to the currently approved employment numbers, coal processing, product transportation or the operating hours. No alterations or additions to the existing surface infrastructure facilities are proposed and no construction activities are required.

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 1 0 3km
1:60 000

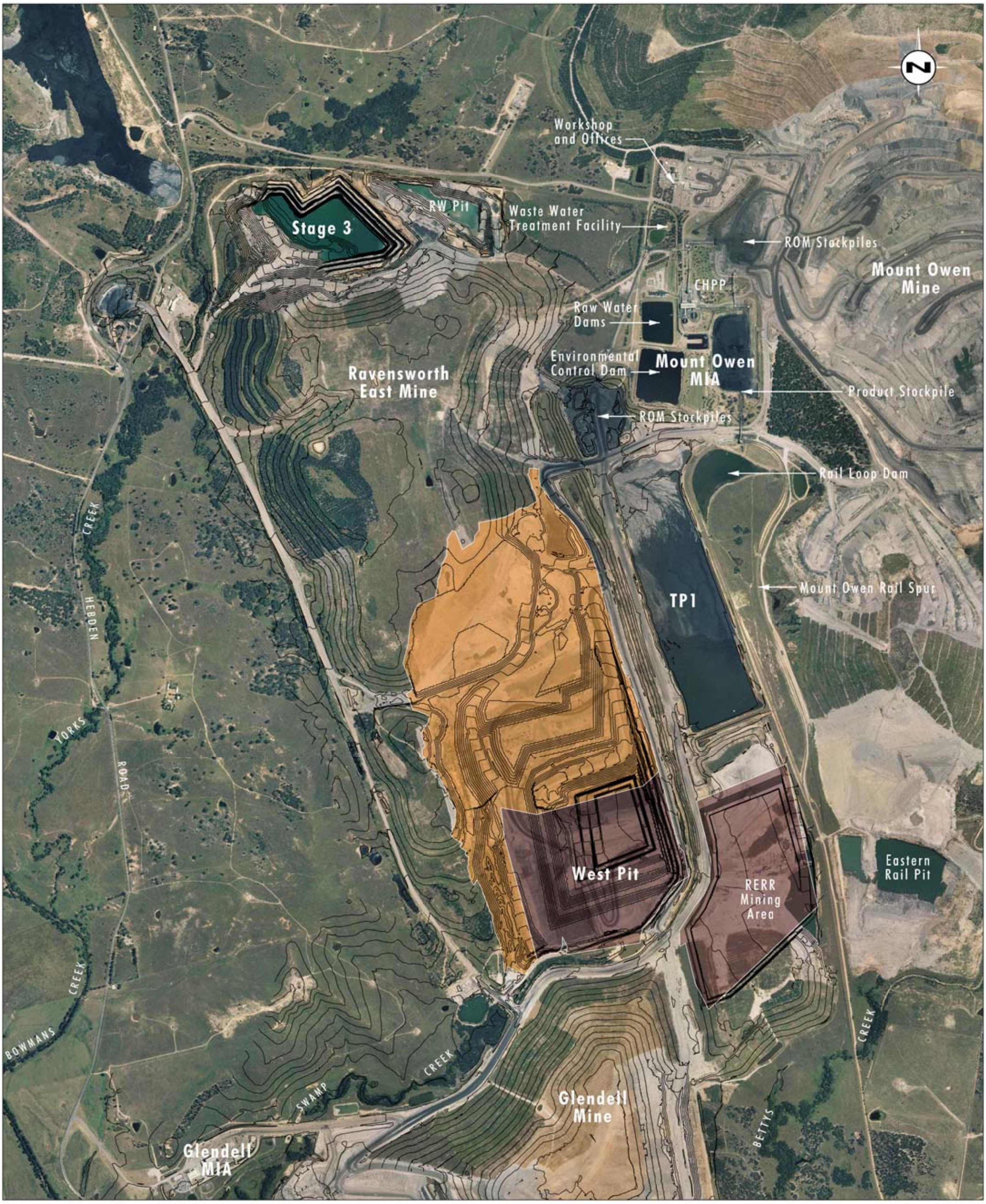
Legend

- Ravensworth East Mine DA Boundary
- Glendell Mine DA Boundary
- Mount Owen Mine DA Boundary
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Proposed Ravensworth East Mine DA Boundary Amendment

FIGURE 3.1

Proposed RERR Layout

File Name (A4): R01/3081_036.dgn
20120921 9.14



Source: Mount Owen (2012)

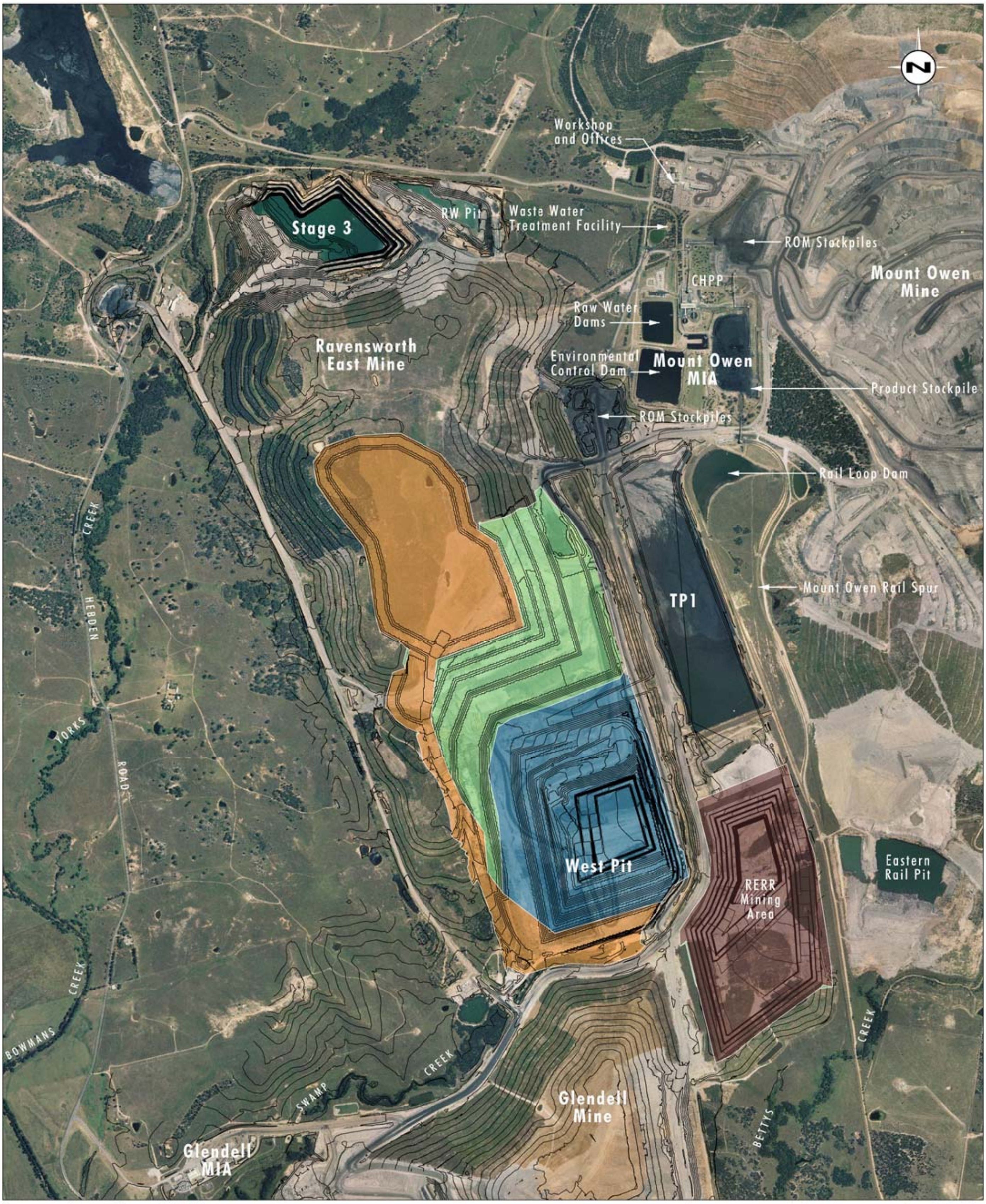
0 0.5 1 1.25km
1:25 000

Legend
- Active Dump
- Active Mining

FIGURE 3.2

RERR Conceptual Mine Plan 2013 (Year 1)

Umwelt
Environmental Consultants



Source: Mount Owen (2012)
Note: Contour Interval 5m

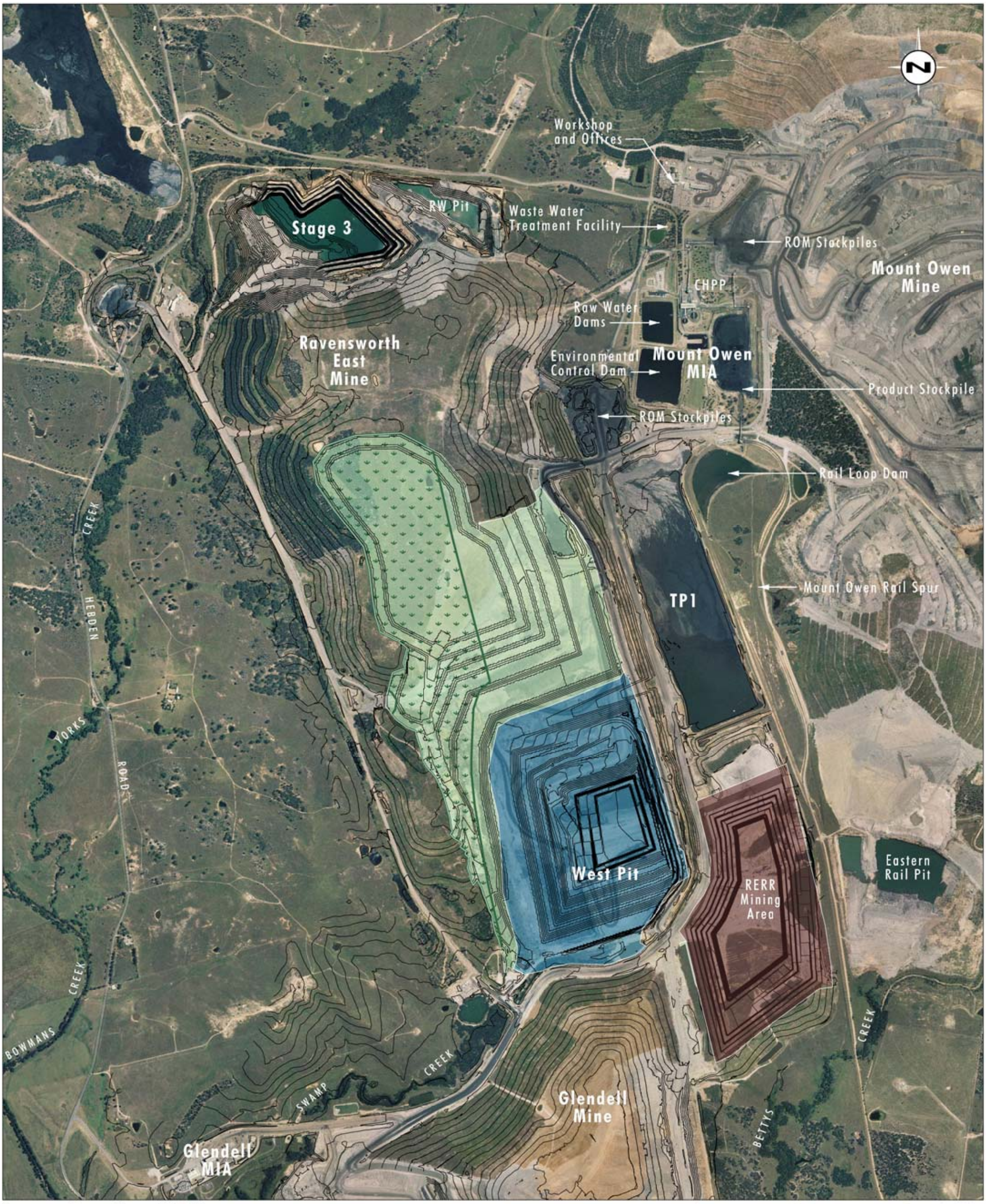
0 0.5 1 1.25km
1:25 000

Legend

- Active Dump
- Active Mining
- Rehabilitation
- Tailings Emplacement

FIGURE 3.3

RERR Conceptual Mine Plan 2016 (Year 4)



Source: Mount Owen (2012)
Note: Contour Interval 5m

Legend
RERR Void
Rehabilitation
Tailings Emplacement
Treed Rehabilitation Area

FIGURE 3.4

RERR Conceptual
Mine Plan 2017 (Year 5)

3.2 Coal Processing and Transportation

No changes are proposed to the current approved mining extraction rate, CHPP throughput, product transportation or tailings emplacement as part of the proposed modification. Consistent with the currently approved operations as described in **Section 2.2**, ROM coal extracted from the RERR mining area will continue to be hauled by truck to Mount Owen CHPP for processing and stockpiling prior to transportation by rail to the Port of Newcastle.

As outlined in **Section 2.5** tailings emplacement at the Mount Owen Complex is undertaken in accordance with the Mount Owen Tailings Management Strategy and the relevant development approvals for Ravensworth East, Mount Owen and Glendell mines.

There is sufficient capacity for the emplacement of tailings in the current emplacement areas within the Mount Owen Complex (including the West Pit void) to support all currently approved mining operations at the Mount Owen Complex including tailings associated with the proposed modification. These tailings emplacement areas will require an approval under Section 100 of the *Coal Mine Health and Safety Act 2002*. Coarse rejects from the Mount Owen CHPP will continue to be incorporated into the overburden emplacement areas. Rehabilitation of the tailings emplacement areas would be undertaken once the tailings have sufficiently consolidated which generally occurs approximately 3 to 5 years after the emplacement of tailings has ceased.

No changes are proposed to the existing train loading and transport system as part of this modification. As detailed in **Section 2.2**, export coal processed from the RERR mining area will continue to be transported to the Port of Newcastle via the existing rail spur and Main Northern Rail line.

The current Ravensworth East development consent allows for ROM coal to be transported via conveyor to both the Bayswater and Liddell power stations. It is proposed that this be maintained to allow for the ongoing use of the existing conveyor to transport ROM coal to Bayswater and Liddell power stations, as required.

3.3 Rehabilitation

The West Pit Overburden Emplacement Area will be progressively rehabilitated as mining progresses, until the final landform is achieved. **Figures 3.2** to **3.4** illustrate how proposed mining operations and rehabilitation works will progress within the West Pit and the RERR mining area. Rehabilitation works would consist of the shaping of the West Pit Overburden Emplacement area to create a suitable final landform. It is proposed that the West Pit Overburden Emplacement Area be completed to a final RL of approximately 180 metres, an increase of 20 metres from the currently approved height (RL 160 m) to allow suitable undulations to be formed to provide a more natural final landform to be established with adequate surface drainage. Topsoil (or other suitable material) will then be spread over the overburden emplacement area and revegetation works then undertaken.

One void will remain at the completion of mining in approximately 2018. This void would be retained to provide for long term tailings storage associated with future mining operations within the Mount Owen Complex. However should the intended use (ongoing tailings emplacement) not be realised, the management measures associated with the void have been investigated and are discussed further in **Section 6.10**.

Further detail regarding mine rehabilitation and closure is provided in **Section 6.10**.

3.4 Alternatives

The proposed modification would enable the continuation of mining operations at Ravensworth East Mine once mining is complete within the West Pit. The alternatives to the proposed modification considered by XMO include:

- do nothing and close the West Pit operations when mining ceases;
- extension of the southern boundary of the existing West Pit; and
- alternative RERR Mining Area to the south of the currently proposed location.

The location of alternatives considered are indicated on **Figure 3.5** and discussed further in **Sections 3.4.1** to **3.4.4**.

3.4.1 Do Nothing

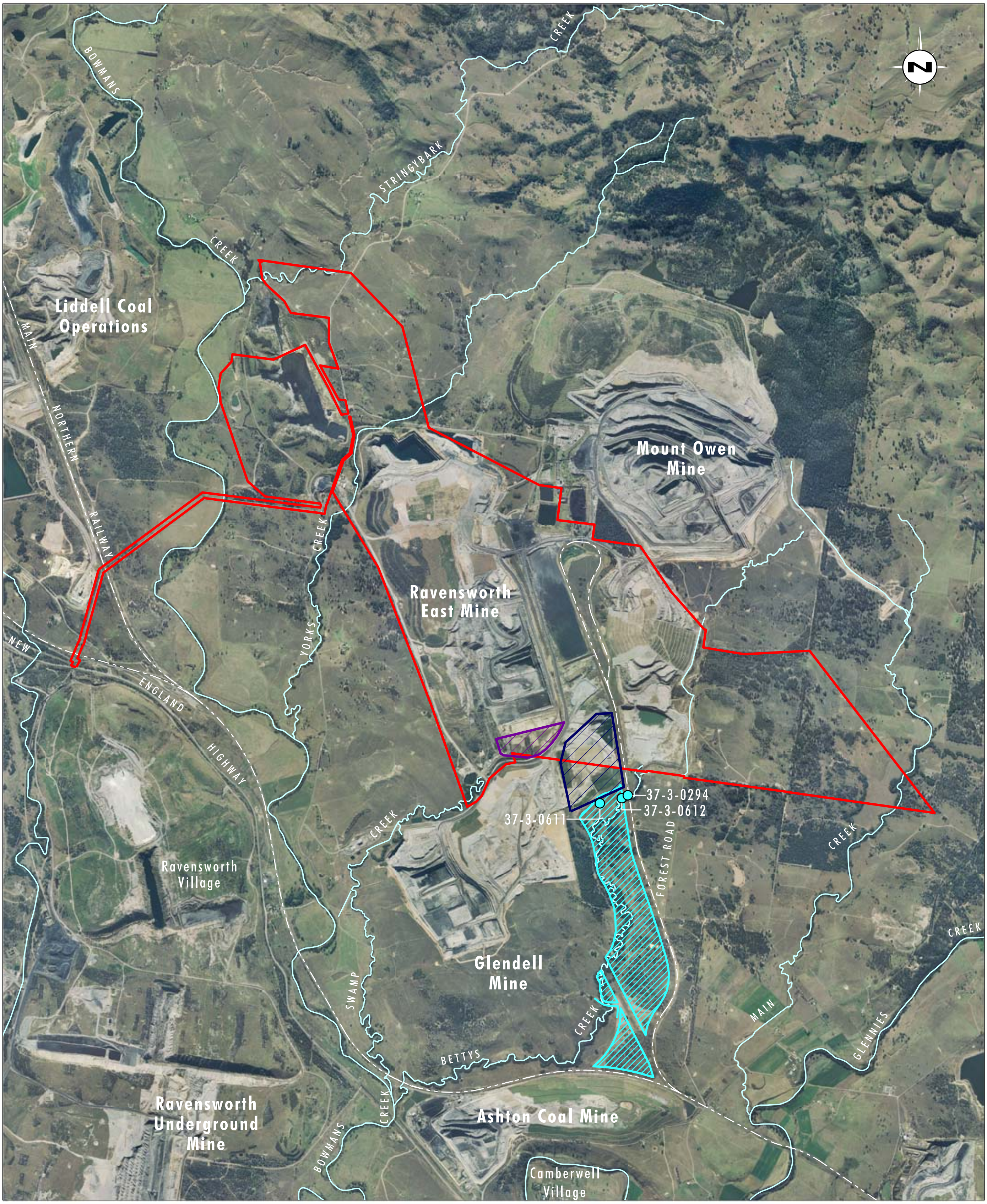
The alternative of not proceeding with the proposed modification would result in the discontinued employment for the current Ravensworth East Mine employees working within the West Pit and not maximising the coal resource recovery from an area previously disturbed by approved mining operations. As the proposed modification would utilise existing infrastructure in addition to being located wholly within an area that has previously been disturbed, it allows for the efficient extraction of approximately 6 Mt of coal resource with minimal environmental impacts. In order to continue the current West Pit mining operations and ensure the continued employment of the existing employees and allow for the efficient extraction of an economically viable coal resource, the 'do nothing' option is not desirable.

3.4.2 West Pit Extension (south)

Active mining is currently being undertaken within the West Pit and an extension of the West Pit to the south was also investigated. This alternative option would have allowed the continuation of the existing operations within the West Pit however would require the re-location of the existing Swamp Creek diversion. Furthermore, this option would not realise a comparable resource recovery (approx 1 Mt compared to 6 Mt with RERR). XMO considered that in comparison to the proposed modification, this option is not preferred at this time.

3.4.3 Alternative RERR Mining Area Location

A proposed mining area located slightly to the south of the current RERR mining area was also considered. During the preparation of the EA, a number of constraints were identified including the adjoining Glendell Habitat Management Area (HMA) and an existing archaeological site. This alternative would also require the disturbance of previously undisturbed ground and the disturbance of a larger area of rehabilitation. Based on these factors, this option was refined through a redesign of the mine plans by moving the pit shell to the north to ensure that impact on the Glendell HMA and the known archaeological site was avoided. An added advantage of this redesign is an improved strip ratio and an overall reduction of impacts as the RERR mining area is located entirely on previously disturbed land.



Source: Mount Owen (2011)

Legend

- Ravensworth East DA Consent Area
- Alternative RERR Mining Location
- West Pit Extension
- Glendell Habitat Management Area
- Drainage Line
- Artefact Scatter

FIGURE 3.5

RERR Alternatives

File Name (A4): R01/3081_022.dgn
20120920 11.54

4.0 Stakeholder Consultation and Social Impact and Opportunities Assessment

XMO actively engage and consult with the community to provide information relating to the environmental, social and operational performance of the Mount Owen Complex and to enable the community to provide feedback.

The purpose of the stakeholder engagement process for the proposed modification was to provide the community an opportunity to be involved in the environmental and social assessment process and to provide information to XMO for consideration during the proposed modification planning and environmental assessment stage.

4.1 Government Agency Consultation

Consultation with the State Government agencies and Singleton Shire Council included an outline of the key aspects of the proposed modification, the approach to the environmental assessment and stakeholder engagement program. Where relevant the preliminary results of the environmental assessment were also discussed. Further detail regarding the consultation undertaken with the NSW state government agencies and Singleton Shire Council is detailed in **Table 4.1.**

Table 4.1 – NSW Government Consultation

Government Agency	Date	Comments	How comments have been addressed
Department of Planning & Infrastructure (DP&I)	05/07/2012	DP&I confirmed S75W to be most appropriate approval pathway and a PEA and DGR's would not be required	N/A
	07/08/2012	DP&I confirmed that the application would be subject to a public exhibition period.	N/A
NSW Office of Water (NOW)	02/08/2012	EA to address licensing requirements for the proposed modification in relation to the relevant water sharing plan to demonstrate that the project fits within the rules of the Plan; and EA to include clarification of any new approvals required.	Refer to **Sections 6.5** and **6.6.**
	22/11/2012		Refer to **Sections 6.5** and **6.6.**
Office of Environment & Heritage (OEH)	22/08/2012	The air quality assessment to include an assessment of PM_{10} 24hr cumulative impacts.	A detailed air quality assessment was undertaken to support this EA, the outcome of this assessment is discussed further in **Section 6.4** and the Air Quality Impact Assessment is provided in full as **Appendix 4**.
		The EA must include adequate assessment of the impact on previously rehabilitated areas and confirmation of the maintenance of current rehabilitation commitments.	Refer to **Section 6.10**.

Table 4.1 – NSW Government Consultation (cont)

Government Agency	Date	Comments	How comments have been addressed
Dam Safety Committee (DSC)	15/08/2012	As the RERR mining area is located within the TP1 (tailings emplacement area) notification zone the DSC confirmed approval from the DSC will be required.	XMO will gain DSC approval prior to the commencement of mining operations within the RERR mining area.
Department of Trade & Investment, Regional Infrastructure & Services (DTIRIS) – Mineral Resources & Energy	23/08/2012	No specific issues in relation to the RERR project were raised.	N/A
Singleton Shire Council	17/07/2012	No specific issues in relation to the RERR project were raised.	N/A

4.2 Community and Other Stakeholder Engagement

4.2.1 Community Consultation

Individual meetings were undertaken with 29 landholders and residents located in close proximity to the Ravensworth East Mine to explain the proposed modification and provide the landholders with the opportunity to comment on the proposed modification to be documented in the EA and considered in the environmental studies.

This consultation process was facilitated by Coakes Consulting as part of a Social Impact and Opportunities Assessment (SIOA). The SIOA program is designed to identify, consider and manage the potential impacts of the proposed modification on the local community and more specifically to identify any social impacts and opportunities, management and enhancement strategies and allow for integration of the SIOA study outcomes with the EA. The SIOA report is presented in full in **Appendix 2**.

Due to the small scale of the proposed modification, very limited concerns specifically associated with the proposed modification were raised by the neighbouring landholders. The majority of the perceived impacts and opportunities identified by the community during the consultation process were related to the Mount Owen Complex as a whole and/or the cumulative impacts of mining. Further detail is provided in **Section 4.3.1**.

4.2.2 Consultation with Integra Coal Mine

XMO held a meeting with Integra Coal management on the 15 August 2012 to discuss the mining operations associated with the proposed modification and the intention to retain the void for long term tailings storage.

Integra raised the issue of blasting vibration impacts on underground workings from mining operations within the RERR mining area. Integra requested the implementation of a Personnel Withdrawal Protocol to address this issue, similar to that implemented for the management of blasting activities within the Eastern Rail Pit at Mount Owen Mine. The Blast Impact Assessment for RERR addressed this issue and XMO propose to re-implement the Personnel Withdrawal Protocol as suggested by Integra Coal and in accordance with the blast impact assessment recommendations for this proposed modification. Further discussion regarding the Personnel Withdrawal Protocol is provided in **Section 6.3**.

4.2.3 Consultation with Mount Owen Workforce

Consultation with the current Mount Owen employees was undertaken in the form of toolbox talks to ensure all employees were informed of the details and progress of the proposed modification.

4.3 Social Impact and Opportunities Assessment

The SIOA involved a series of assessment phases including community profiling, the scoping and assessment of issues and opportunities, the development of a strategy to mitigate and manage the social impacts and a monitoring framework. The full community profile and the scoping and assessment of the issues and opportunities raised are provided in **Appendix 2**. The key issues/impacts identified by the community are discussed in **Section 4.3.1**.

4.3.1 Social Impact Assessment

The concerns raised by the community were considered during the preparation of this EA. Concerns regarding the impact of mining operations, particularly noise and dust, are not attributed to specific areas or projects within the Mount Owen Complex but are seen as impacts generated by the Mount Owen Complex and surrounding mining operations as a whole.

4.3.1.1 Proposed Modification Specific Issues

Only a very limited number of issues/impacts identified by neighbouring landholders were specifically associated with the proposed modification. In fact most landholders stated they had no concerns about the proposed modification (refer to **Figure 4.1**). The small number of landholders who identified RERR-specific impacts believed that existing impacts from the Mount Owen Complex may be exacerbated by the proposed modification including impacts of noise, dust and blasting. They also identified concerns regarding mining methods and operations (although the proposed modification does not alter existing mining methods or operations) and the perceived proximity to neighbouring landholders (although the proposed modification sits within the existing Mount Owen Complex).

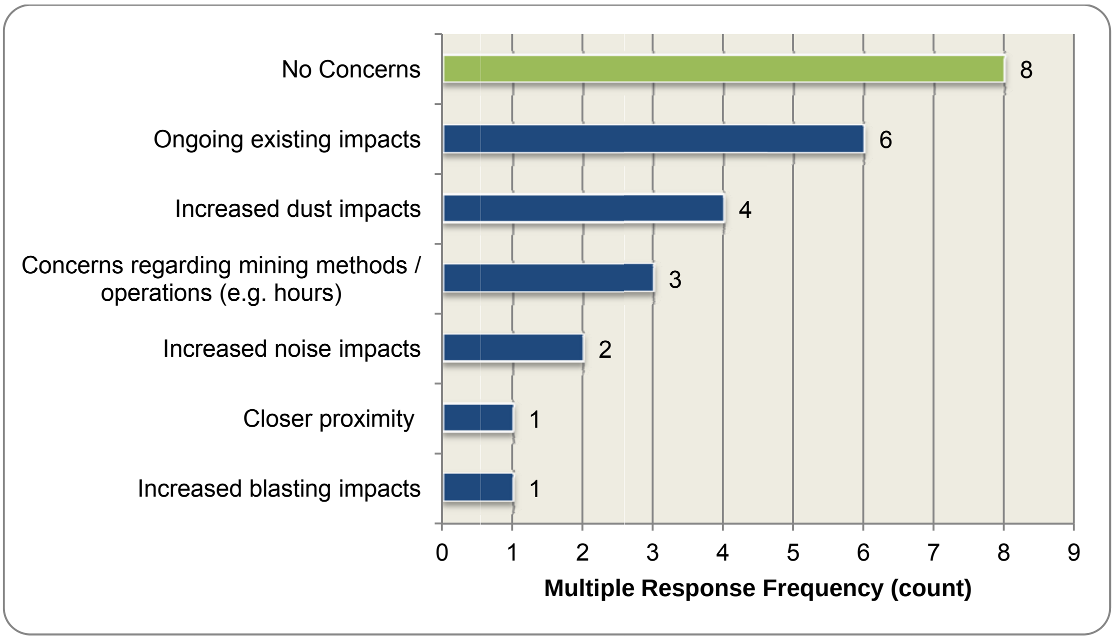
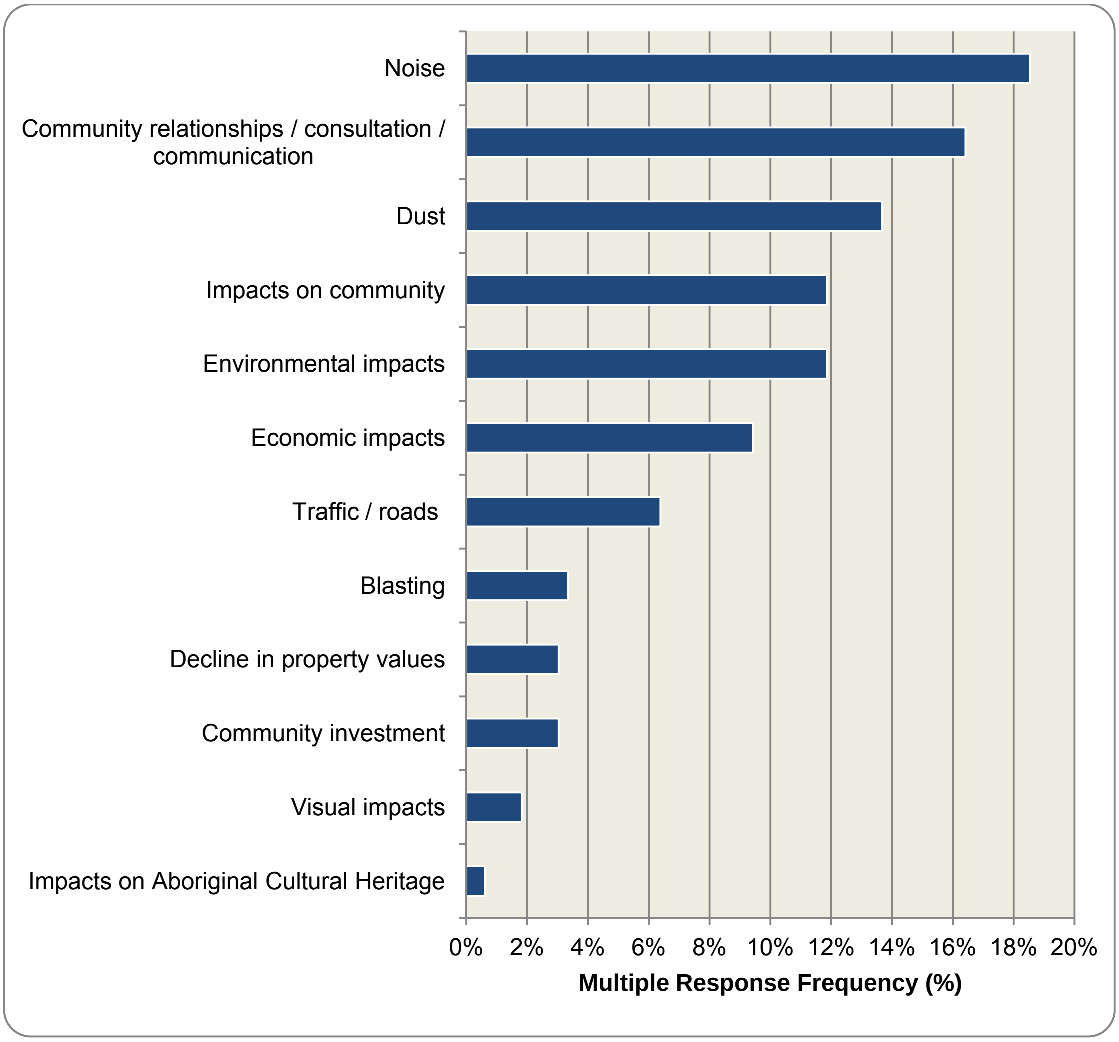


Figure 4.1 – Issues/Impacts Associated with the Proposed Modification Specifically, Identified By Neighbouring Landholders (Coakes 2012)

4.3.1.2 Existing Cumulative Issues

Overall a range of existing and cumulative issues were identified by landholders relating to the Mount Owen Complex and mining more generally within the Hunter Region. As illustrated in **Figure 4.2**, the issue/impact identified most frequently across the landholders consulted were noise (19 per cent), followed by a historical lack of consultation and communication with the community (17 per cent), dust (14 per cent) and community and environmental impacts (e.g. impacts on housing, sense of place) (12 per cent). Issues less frequently raised included those relating to; economic impacts, traffic, decline in property values, community investment, blasting, visual amenity and Aboriginal Cultural Heritage.

It is important to reiterate that these key themes raised by the landholders relate to cumulative impacts associated with mining at the Mount Owen Complex as well as positive impacts associated with the proposed modification and mining more generally.



Note: All response frequency counts are multiple response frequencies as each respondent may identify more than one issue/impact.

Figure 4.2 – Key Issue Themes Raised by Neighbouring Landholders (Coakes 2012)

4.3.1.3 Social Opportunities and Impact Assessment and Environmental Assessment Integration

The approach to the environmental assessment for the proposed modification focuses on the assessment of any potential impact the proposed modification may have and also the potential contribution to the cumulative impacts.

The specialist studies undertaken to support this EA indicate that the noise impacts associated with the proposed modification will be contained within the existing Mount Owen affectation zone and no additional properties will be affected. The results of the air quality assessment indicate there will be no exceedance of any air quality criteria to those residences not currently subject to acquisition rights as a result of the proposed modification. Blasting, surface and groundwater, rehabilitation and visual impacts can be adequately managed through the update and application of applicable management plans. Further detail regarding the outcome of these assessments is provided in **Section 6.1**.

Further information regarding the approach to the environmental assessment is provided in **Section 6.0**.

4.3.2 Social Impact Management and Enhancement

Through consultation with neighbouring landholders, it is evident that issues/impacts specifically associated with RERR are minimal. Of more concern to the local community are the issues/impacts associated with the Mount Owen Complex as a whole and the cumulative issues associated with mining in the region generally.

Existing operations within the Mount Owen Complex are currently managed in accordance with the existing EMS and associated management plans as outlined in **Section 2.8**. Based on the detailed environmental assessment completed for the proposed modification (detailed in **Section 6.0**), XMO propose to manage mining activities associated with the proposed modification in accordance with these management plans which would be updated should approval be granted.

The management and enhancement strategy detailed in **Table 4.2** has been developed and implemented based on the operations of the Mount Owen Complex, of which the proposed modification is a part. Accordingly, XMO propose to manage the social impacts identified by the SIOA process through the continued implementation of management and enhancement strategies, as shown in **Table 4.2**.

Table 4.2 – Management and Enhancement Strategy

Management Category	Management and Enhancement Strategy
Communication	• Feedback to the community regarding the outcome of the EA for the RERR project; • Regular updates to the community regarding operations at the Mount Owen Complex; • Distribution of a Bi-annual Community Newsletter; and • Continuation of the 24-hour Community Response Hotline.
Engagement	• Continuation of the Mount Owen Complex Community Consultative Committee meetings; • Continuation of household near neighbour visits, on request by the community; • Continuation of periodic Mount Owen Open days; • Continue to build the relationship and support of the local Mt Pleasant Public School; and • Continuation of the local employment and training programs.
Impact Management and Monitoring	• Implementation of technical strategies as outlined within this EA as part of ongoing operational guidelines for the Mount Owen Complex; and • Continuation of ongoing social impact monitoring, in accordance with the XMO Social Involvement Plan.
Investment	• Continual improvement and update of the XMO Social Involvement Plan; and • XMO will continue to actively pursue ongoing opportunities to use and invest in local facilities where appropriate and in accordance with XMO Social Involvement Plan.

5.0 Planning Context

The following section identifies the relevant Commonwealth and State planning and environmental legislation, including the relevant planning approval process applicable to the proposed modification.

5.1 Commonwealth Legislation

Table 5.1 provides a review of the relevant Commonwealth legislation applicable to the proposed modification and identifies where further approvals are required.

Table 5.1 – Summary of Commonwealth Legislation Applicable to the Proposed Modification

Planning Provision	Comments	Further Approval Required
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Under the EPBC Act 1999, approval from the Minister for Sustainability, Environment, Water, Population and Communities is required for any action that would result in a significant impact to Matters of National Environmental Significance (MNES). MNES are defined in the following categories: • World Heritage property; • National Heritage place; • Wetlands of international importance (Ramsar wetland); • Threatened species and communities; • Migratory species; • Nuclear actions; • Marine areas or reserves; and • Commonwealth land. The Ecological Assessment undertaken as part of this Environmental Assessment identifies that no threatened or migratory species were recorded or considered likely to occur and the test of significance undertaken indicates the proposed modification is not expected to significantly impact on any MNES. The proposed modification therefore does not require approval from the Commonwealth Minister for the Environment.	No
Native Title Act 1993	The *Native Title Act 1993* is administered by the National Native Title Tribunal who is responsible for maintaining a register of Native Title claimants and bodies to whom Native Title rights have been gained. The Act prescribes that Native Title can be extinguished under certain circumstances, including the granting of freehold land. A Native Title Assessment has been undertaken across the Mount Owen Complex, the assessment concluded Native Title has been extinguished, within the RERR mining area and the West Pit overburden emplacement area.	No

5.2 New South Wales Legislation

5.2.1 *Environmental Planning and Assessment Act 1979*

As discussed in **Section 1.4**, it is proposed to modify DA 52-03-99 under Section 75W of the EP&A Act. The approach was confirmed through consultation with DP&I during consultation for the Environmental Assessment. Further details of this approval path are provided below.

The EP&A Regulation clause 8J(8) prescribes how, in certain circumstances, a development consent can be modified under Section 75W of the EP&A Act. Clause 8J(8) states that:

> (8) For the purposes only of modification, the following development consents are taken to be approvals under Part 3A of the Act and section 75W of the Act applies to any modification of such a consent:
>
> (a) a development consent granted by the Minister under section 100A or 101 of the Act,
> (b) a development consent granted by the Minister under *State Environmental Planning Policy No 34—Major Employment-Generating Industrial Development*,
> (c) a development consent granted by the Minister under Part 4 of the Act (relating to State significant development) before 1 August 2005 or under clause 89 of Schedule 6 to the Act,
> (d) a development consent granted by the Land and Environment Court, if the original consent authority was the Minister and the consent was of a kind referred to in paragraph (c).
>
> The development consent, if so modified, does not become an approval under Part 3A of the Act.

DA 52-03-99 was granted under Part 4 of the EP&A Act in 1999, classified as State Significant Development. Clause (c) of Section 8J(8) of the EP&A Regulation applies to DA 52-03-99.

Part 3A of the EP&A Act has recently been repealed, however Schedule 6A, Clause 12 of the EP&A Act provides for the continued use of Section 75W to modify the development consents referred to in Clause 8J(8) of the EP&A Regulation. Schedule 6A, Clause 12 of the EP&A Act states:

> **12 Continuing application of Part 3A to modifications of certain development consents**
> Section 75W of Part 3A continues to apply to modifications of the development consents referred to in Clause 8J(8) of the *Environmental Planning and Assessment Regulation 2000*, and so applies whether an application for modification is made before or after the commencement of this clause.

Given the RERR Project requires only a minor modification to the existing mining operations at the Ravensworth East Mine with no change to the current mining methods, extraction rate, employment numbers, coal processing, product transportation or operating hours, section 75W of the EP&A Act is considered the appropriate approval pathway for the proposed modification.

5.2.2 Other State Legislation and Environmental Planning Instruments

A summary of the other State environmental and planning legislation potentially relevant to the proposed modification is provided in **Table 5.2**.

Table 5.2 – Summary of State Legislation and Environmental Planning Instruments Relevant to the Proposed Modification

Act	Comment	Further Approval Required for Proposed Modification
Mining Act 1992	Under this Act a mining lease is required before any mining or specified mining activity can be carried out on the land. Currently Ravensworth East Mine operates under ML 1415, ML 1475 and ML 1561. The RERR mining area is also partly located within ML 1476 held by Glendell. The *Mining Act 1992* requires all mining operations to be subject to a Mining Operations Plan (MOP) approved by the Director General of the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).	Existing MOP will be revised to include the proposed RERR mining area and associated operations.
Coal Mine Health and Safety Act 2002	The principal aim of the *Coal Mine Health and Safety Act 2002* is to secure the objectives of the *Work Health and Safety Act 2011* in relation to coal operations. It does this by imposing certain specific safety requirements on coal mines. This includes the requirement to comply with minimum barriers for underground mining workings and the requirement to obtain consent from the Minister for Mineral Resources for the establishment of tailings emplacement areas. The proposed modification does not seek approval for any new tailings emplacement areas. The emplacement of tailings as outlined in **Section 2.5** is conducted in accordance with currently approved operations. These tailings emplacement areas will require an approval under Section 100 of the Act.	Yes
Protection of the Environment Operations Act 1997 (PoEO Act)	The Ravensworth East Mine currently operates under Environment Protection Licence (EPL) 10860. The PoEO Act is administered by the Office of Environment and Heritage (OEH) and requires licences for environmental protection including waste, air, water and noise pollution control.	No
Water Management Act 2000	The *Water Management Act 2000* regulates the use and interference with surface water and groundwater in NSW. The *Water Management Act 2000* applies to water sources which are governed by an operational Water Sharing Plan. Under Part 3 of the *Water Management Act 2000*, a Water Sharing Plan may be prepared for the management of water resources in a specified area. The surface waters and associated alluvial aquifers of York's Creek, Swamp Creek and Bettys Creek catchment areas are included in the Jerry's Water Source within the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (2009). No further approval under the *Water Management Act 2000* will be required for the proposed modification (refer to **Section 6.6**).	No

Table 5.2 – Summary of State Legislation and Environmental Planning Instruments Relevant to the Proposed Modification (cont)

Act	Comment	Further Approval Required for Proposed Modification
Water Act 1912	This Act has been repealed by the *Water Management Act 2000*; however, some of the licensing provisions remain in force where the water source is not covered by a water sharing plan. The Ravensworth East Mine catchment areas are included in the Jerry's Water Source within the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (2009). The proposed modification will not require any further Part 5 licences.	No
Environmentally Hazardous Chemicals Act 1985	The OEH is granted power under the *Environmentally Hazardous Chemicals Act 1985* to assess and control chemicals and declare substances to be chemical wastes. A licence is required for any storage, transport or use of prescribed chemicals. The proposed modification will not result in any changes to the storage, transport or use of prescribed chemicals. No further approval will be required.	No
National Parks and Wildlife Act 1974	This Act is the principle legislation dealing with the management of Aboriginal heritage and protection of native flora and fauna. The proposed modification will be undertaken entirely within an area of the Mount Owen Complex previously disturbed by approved mining activities therefore no Aboriginal sites will be impacted. No further approvals will be required under this Act.	No
Heritage Act 1977	The *Heritage Act 1977* provides for the conservation and management of the state's built, marine, moveable and natural heritage. The proposed modification will be undertaken entirely within an area of the Mount Owen Complex previously disturbed by approved mining activities therefore no heritage items will be impacted. No further approvals will be required under this Act.	No
Roads Act 1993	The *Roads Act 1993* is administered by Roads and Maritime Services (RMS), local council or the Department of Lands depending on the classification of the road. The RMS has jurisdiction over major roads, the local council over minor roads, and the Department of Lands over road reserves. The Act requires that applications for the closure of Crown roads be made to the Minister. Consent under Section 138 of the *Roads Act 1993* is required in order to undertake works within a road reserve. The proposed modification does not require any works to or the closure of any roads. Therefore no further approval will be required under this Act.	No

Table 5.2 – Summary of State Legislation and Environmental Planning Instruments Relevant to the Proposed Modification (cont)

Act	Comment	Further Approval Required for Proposed Modification
Crown Lands Act 1989	The Act provides for the administration and management of Crown land in the eastern and central divisions of the State. Crown land may not be occupied, used, sold, leased, dedicated, reserved or otherwise dealt with unless authorised by this Act or the *Crown Lands (Continued Tenures) Act 1989*. The proposed modification is subject to land owned entirely by XMO, therefore there would be no impact on any Crown Land and no further approvals will be required under this Act.	No
Dams Safety Act 1978	The *Dams Safety Act 1978* requires that large dams that may constitute a hazard to human life and property must be periodically reviewed by the NSW Dams Safety Committee. These dams are known as prescribed dams and are listed in Schedule 1 of the Act. The proposed modification will not require the construction of any new dams. The RERR mining area is located within the TP1 (tailings emplacement area) notification zone. Therefore the Dam Safety Committee will require notification.	No
Energy Efficiency Opportunities Act 2006	The Energy Efficiency Opportunities Act aims to improve the identification and evaluation of energy efficiency opportunities to encourage implementation of cost effective energy efficiency opportunities. XMO currently participate in Energy Efficiency Opportunity Programs and Energy Savings Action Plan Programs which will continue for the proposed modification.	No
Energy and Utilities Administration Act 1987	The *Energy and Utilities Administration Act 1987* requires the development of energy savings action plans and water savings plans. XMO currently participate in Energy Efficiency Opportunity Programs and Energy Savings Action Plan Programs which will continue for the proposed modification.	No
Protection of the Environment Administration Act 1991	The Protection of the Environment Administration Act requires development to be consistent with the principles of Ecologically Sustainable Development. The principles of Ecologically Sustainable Development, as it relates to the proposed modification are addressed in **Section 8.0**.	No

Table 5.3 outlines the relevant State Environmental Planning Policies (SEPP) required to be considered in relation to the proposed modification.

Table 5.3 – Relevant SEPPs for Consideration in Relation to the Proposed Modification

NSW Legislation – Environmental Planning Instruments		
Planning Provision	**Comment**	**Relevance**
State Environmental Planning Policy (State & Regional Development) 2011	The project approved under DA 52-03-99 was of a classification listed in the SEPP and would have been classified as State significant development.	As the original approval is classified as State Significant Development the current proposed modification is to be considered under Section 75W of the EP&A Act.
State Environmental Planning Policy (Mining, Petroleum Production & Extractive Industries) 2007	Regulates the permissibility of mining and mining related development and specifies matters that must be considered in assessing mining developments requiring consent under Part 4 of the EP&A Act.	The Proposed modification is not considered exempt or complying development and therefore requires development consent.
State Environmental Planning Policy 33 (Hazardous & Offensive Development) 1992	SEPP No. 33 requires the consent authority to consider whether an industrial proposal is a potentially hazardous industry or a potentially offensive industry. A hazard assessment is completed for potentially hazardous development to assist the consent authority to determine acceptability.	The proposed modification will not result in any changes to the existing XMO mining operations which would alter this classification. Therefore no further consideration of SEPP33 will be required.
State Environmental Planning Policy 44 (Koala Habitat Protection)	SEPP No. 44 restricts a Council from granting development consent for proposals on land identified as core koala habitat without preparation of a plan of management.	The ecological assessment undertaken for the proposed modification included an assessment under SEPP44 which indicated the RERR mining area and the West Pit Overburden Emplacement Area is not considered to comprise potential koala habitat, as described under SEPP44, (refer to **Section 6.7.4.4** for further detail).

5.2.3 Upper Hunter Strategic Regional Land Use Plan 2012

In 2012, the NSW Government released its *Strategic Regional Land Use Policy* (SRLUP) for the Upper Hunter and the NSW *Aquifer Interference Policy – Stage 1*, developed by NOW as a component of the SRLUP. The SRLUP aims to provide a balance between important agricultural, mining and energy sectors while ensuring the protection of the high value conservation lands and water sources.

The SRLUP seeks to apply a gateway process to all SSD that involves new Greenfield projects and brownfield projects involving expansion beyond the existing lease area for mining or coal seam gas that is on Biophysical Strategic Agricultural Land (BSAL) or Critical Industry Clusters (CICs) and to development which is considered to be an aquifer interference activity. The SRLUP requires all State Significant Development applications for mining and coal seam gas which have the potential to impact on agricultural resources or industries to provide an Agricultural Impact Statement (AIS).

The proposed modification is wholly located within existing mining leases and will be entirely contained within an area previously disturbed by approved mining operations, therefore will not directly impact any BSAL or CICs, and will not result in any additional impacts to either surface waters or aquifers within the area of the proposed modification or surrounds. It is therefore considered that an AIS is not required as the proposed modification will not result in any further impact on agricultural land use or on any groundwater bores associated with agriculture. **Section 6.10** provides detail regarding the rehabilitation, post mining landform and use.

5.2.4 Singleton Local Environmental Plan 1996

The Singleton Local Environmental Plan 1996, which regulates permissibility and planning considerations in the Singleton LGA identifies the site as being zoned Rural 1(a). The proposed modification is permissible under the Singleton LEP.

6.0 Environmental Assessment

6.1 Identification of Potential Environmental Impacts

As discussed in **Section 3.0**, the proposed modification would allow the continuation of mining operations at the Ravensworth East Mine within an area already subject to mining activities and would not result in substantial changes to the approved operations. **Table 6.1** has been completed as part of a risk assessment process for the proposed modification to identify those environmental and social aspects which could potentially be impacted as a result of the proposed modification and which required further detailed assessment as part of this EA.

The key issues relevant to the proposed modification were identified through:

- the outcome of extensive prefeasibility assessment;
- a risk assessment conducted by XMO;
- detailed baseline studies; and
- issues raised by the community (refer to **Section 4.0**).

Table 6.1 – Potential Environmental Impacts Associated with the Proposed Modification

Aspect	Environmental Assessment	Further Assessment Required for Proposed modification?
Noise	Mining operations within the RERR mining area and the proposed increase in height of the overburden emplacement area have the potential to affect noise emissions from the Ravensworth East Mine.	Yes, refer to **Section 6.2**
Blasting	There will be no change to the blasting activities currently undertaken on site, however given the change in location of the current mining operations the blasting impacts have been assessed in relation to the surrounding community, infrastructure and adjacent Integra Underground Mine.	Yes, refer to **Section 6.3**
Air Quality	Mining operations within the RERR mining area and the proposed change to the emplacement of overburden have the potential to affect air quality emissions of the Ravensworth East Mine.	Yes, refer to **Section 6.4**
Groundwater	The proposed modification seeks approval to mine to a depth of approximately 200 metres. A groundwater assessment has been undertaken to assess the potential groundwater impacts associated with the proposed modification.	Yes, refer to **Section 6.5**
Surface Water	The proposed modification will result in minor changes to the interaction of the mining operations with surface waters. An assessment was completed to assess potential surface water impacts.	Yes, refer to **Section 6.6**

Table 6.1 – Potential Environmental Impacts Associated with the Proposed Modification (cont)

Aspect	Environmental Assessment	Further Assessment Required for Proposed modification?
Water Balance	The proposed modification will result in minor changes to the water inflows and outflows associated with the mining operations. An assessment was completed to assess potential surface water impacts.	Yes, refer to Section **6.6.4.2**
Ecology	A detailed ecological assessment has been undertaken as the proposed modification requires the disturbance of an area of immature rehabilitated forest complex and grassland vegetation.	Yes, refer to **Section 6.7**
Greenhouse Gas and Energy	The proposed modification is not considered to have the potential to significantly change the energy use or contribute to greenhouse gas emissions of the Mount Owen Complex. However the impacts associated with the energy usage required for the removal of the additional 6 million tones of ROM coal and associated overburden emplacement has been assessed.	Yes, refer to **Section 6.8**
Visual Amenity	The proposed modification has minimal potential to alter the current visual amenity of the landscape with views of the surface operations not likely to change significantly from that currently approved. However, as the height of the overburden emplacement area is proposed to increase 20 metres as a result of the proposed modification, a visual amenity assessment has been completed.	Yes, refer to **Section 6.9**
Rehabilitation and Mine Closure	The proposed modification will result in an alternative final landform than that currently approved. An assessment has therefore been undertaken to address the rehabilitation and final landform associated with the conceptual mine plans.	Yes, refer to **Section 6.10**
Social Impact and Opportunities	A detailed consultation process and Social Impact and Opportunities assessment has been undertaken to assess the potential impacts of the proposed modification on the surrounding landholders and to identify any opportunities for ongoing management strategies.	Yes, refer to **Section 4.3**
Soils, land capability and agricultural suitability	The proposed modification will be entirely contained within an area previously mined. Therefore, there would be no additional impact associated with the proposed modification on soils, land capability and agricultural suitability. Sediment and erosion control are addressed as part of the surface water assessment, see **Section 6.6**.	No

Table 6.1 – Potential Environmental Impacts Associated with the Proposed Modification (cont)

Aspect	Environmental Assessment	Further Assessment Required for Proposed modification?
Public infrastructure and Traffic	The proposed modification will not result in any changes to the interaction of the current mining operations with public infrastructure, as there will be: • No increase in current employees; • No construction activities required; • No changes to impacts on services and service infrastructure requirements; and • No change to the existing road network or the current road or rail traffic movements.	No
Aboriginal Archaeology/Cultural Heritage	The proposed modification is within an area which has been previously subject to mining activities; therefore there will be no impacts on Aboriginal archaeology or cultural heritage.	No
Historical Heritage	The proposed modification would occur within an area of the site which has been previously subject to mining activities; therefore there will be no historical heritage impacts.	No
Economic	The current economic benefit provided by Ravensworth East Mine would continue as a result of the proposed modification, therefore no additional economic assessment has been undertaken. Further detail regarding the economic benefit of the proposed modification is provided in **Section 8.0**.	No

6.2 Noise Impact Assessment

6.2.1 Background

Ravensworth East Mine adjoins the Mount Owen and Glendell mining operations which collectively form the Mount Owen Complex (refer to **Figure 1.2**). The predominant land use surrounding the Mount Owen Complex is mining with a number of additional mining operations also located within the vicinity of the Mount Owen Complex including:

- Liddell Coal Operations to the north-west;
- Ravensworth Surface Operations to the south-west;
- Ashton Coal Mine to the south;
- Integra Coal Mine to the south-east;
- Ravensworth Underground Mine to the south-west; and
- Ashton South East Open Cut (approved but not yet operating).

Due to existing mining activities having a considerable presence within the surrounding area, a large proportion of the surrounding properties are now owned by mining companies. The nearest privately owned residences to Ravensworth East Mine are located in the vicinity of Glennies Creek Road 3.5 kilometres to the south-east, Camberwell Village and Middle Falbrook 4.5 kilometres to the south and east respectively of Ravensworth East Mine (refer to **Figure 1.3**).

This Noise Impact Assessment (NIA) has been undertaken in accordance with the *NSW Industrial Noise Policy* (INP) (NSW Environment Protection Authority (EPA) 2000) and the associated *Application Notes – NSW Industrial Noise Policy* (EPA July 2012).

6.2.2 Ambient Noise Levels and Project-specific Criteria

The existing noise environment in the area surrounding the RERR mining area and the West Pit Overburden Emplacement Area is monitored on a regular basis in accordance with the *Mount Owen Complex Noise Monitoring Program* (Mount Owen Complex 2011). The Mount Owen Complex also has a continuous noise monitoring network. Noise monitoring data from the Mount Owen Complex continuous noise monitors SentineX 1, SentineX 4 and SentineX 12 (refer to **Figure 2.3**) are considered to be representative of the ambient noise levels at the private residences nearest to the RERR mining area and the West Pit Overburden Emplacement Area.

The Rating Background Level (RBL), intrusiveness criteria, mean L_{Aeq} and corresponding amenity criteria were determined, in accordance with the INP (EPA 2000), using monitoring data from the Mount Owen Complex continuous monitoring network for the period 29 February 2012 to 30 May 2012.

From the analysis of the continuous noise monitoring data, it was found that the ambient noise levels in the region surrounding the RERR mining area and the West Pit Overburden Emplacement Area were dependent on the proximity to existing mining activities such as the Mount Owen Mine, Glendell Mine, Ravensworth East Mine, Ravensworth Underground Mine (surface infrastructure) to the West, Ravensworth Surface Operations to the south-west, Integra Mine and Ashton Mine, and features such as the New England Highway and the Main Northern Railway line. The ambient noise levels were also affected by insects, birds and local traffic. Although Ravensworth East Mine fleet would have been a contributing noise source to the continuous noise monitoring network, the existing site operations have minimal acoustic influence on the measured noise levels.

To enable the analysis of the contribution of mining activities to the existing noise environment, the determination of the RBL and mean L_{Aeq} included a 1000Hz low pass filter to remove the contribution of rural noise sources such as bird and insect noise. The determination of the Project Specific Noise Levels (PSNLs) is detailed in **Table 6.2**.

Table 6.2 – Determination of the Project Specific Noise Levels, dB(A)

Representative Monitoring Location	SentineX 1 Middle Falbrook Road	SentineX 4 Glennies Creek Road	SentineX 12 Camberwell Village
Indicative Noise Amenity Screen	**Rural**	**Rural**	**Rural**
Assessment of Day-time Noise Levels [1]			
Rating Background Noise Level [2]	33	37	38
Intrusiveness Criteria	38	42	43
Acceptable Noise Level	50	50	50
Mean Measured L_{Aeq} [2]	56	60	53
Amenity Criteria	46	50 [4]	43 [4]
Day-time PSNL [5]			
$L_{Aeq, 15minute}$	**38**	**42**	**43**
$L_{Aeq, day}$	**-**	**-**	**43**
Assessment of Evening Noise Levels [1]			
Rating Background Noise Level [2]	33 (39) [3]	37 (40) [3]	38 (45) [3]
Intrusiveness Criteria	38	42	43
Acceptable Noise Level	45	45	45
Mean Measured L_{Aeq} [2]	38	49	48
Amenity Criteria	45	39 [5]	38 [5]
Evening PSNL [5]			
$L_{Aeq, 15minute}$	**38**	**42**	**43**
$L_{Aeq, evening}$	**-**	**39**	**38**
Assessment of Night-time Noise Levels [1]			
Rating Background Noise Level [2]	33 (34) [3]	37	38 (40) [3]
Intrusiveness Criteria	38	42	43
Acceptable Noise Level	40	40	40
Mean Measured L_{Aeq} [2]	38	47	49
Amenity Criteria	**36**	37 [4]	39 [4]
Night-time PSNL [5]			
$L_{Aeq, 15minute}$	**38**	**42**	**43**
$L_{Aeq, night}$	**36**	**37**	**39**
Night-time Sleep Disturbance Criteria			
$L_{A1, 1minute}$	**48**	**52**	**53**

Note 1: For Monday to Saturday, Day-time 7.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 7.00 am. On Sundays and Public Holidays, Day-time 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.

Note 2: The RBL and Mean Measured L_{Aeq} results are based on the mining noise contribution to the background noise environment and excludes rural noise sources such as bird and insect noise as per the EPA INP Application Note 2012. The industrial contribution was determined by filtering out noise data above 1000Hz when determining the RBL and Mean Measured L_{Aeq}.

Note 3: Set Evening/Night-time RBL at the Day-time RBL. Due to the Evening/Night-time RBL, shown in brackets, is higher than the Day-time RBL as per the EPA INP Application Note 2012.

Note 4: Set the Amenity Criteria at 10 dB below the existing mean LAeq as the existing noise levels are unlikely to decrease in future.

Note 5: According to Section 2.4 of the INP and EPA INP Application Note 2012 on the determination of PSNLs: Where the intrusiveness criteria ($L_{Aeq,15minute}$) is greater than the amenity criteria ($L_{Aeq,day/evening/night}$) only the corresponding intrusiveness PSNL is applied as this is the most stringent of the two noise levels. Where the amenity criteria is greater than the intrusiveness criteria both the corresponding amenity and intrusiveness PSNLs are applied.

The PSNL was determined using the methodology outlined in the INP (EPA 2000) and the supporting EPA INP application notes (EPA July 2012). As a 24 hour 7 day per week operation, activities associated with the proposed modification would be essentially the same during the day time, evening and night-time. That is, the location and number of machines operating are independent of the time of day and the day of the week. Therefore, under normal operating conditions achieving the night-time PSNL would result in the day time and evening PSNLs also being achieved.

The INP (EPA 2000) addresses potential cumulative noise impacts from existing and proposed developments in an area by ensuring that appropriate noise emission criteria and consent limits are established with a view to maintaining acceptable amenity noise levels for residential receivers. The most stringent of the amenity criteria derived for the RERR mining area and West Pit Overburden Emplacement Area operations are 36 dB(A) $L_{Aeq, Night}$ in the area of Middle Falbrook, 37 dB(A) $L_{Aeq, Night}$ for the Glennies Creek region and 39 dB(A) $L_{Aeq, Night}$ in the vicinity of Camberwell Village. This highlights the need to protect the night-time amenity noise levels as this is the primary period when cumulative noise levels from industrial operations have the potential to impact on the amenity noise level of the surrounding region. The night time cumulative noise impact criteria for all mining sources would be the night time Acceptable Noise Level of 40 dB(A) $L_{Aeq, night}$.

Criteria for assessing sleep disturbance were determined in accordance with the EPA INP application note for the assessment of sleep disturbance (EPA July 2012). The most stringent of the night time sleep disturbance criteria is 48 dB(A) $L_{A1, 1 minute}$.

6.2.3 Noise Modelling Methodology

Section 6 of the INP (EPA 2000) requires noise level predictions to take into account all significant noise sources that may reasonably be expected when the plant or facility in question is fully operational. One method of determining the impact of numerous noise sources at a receiver is to develop a computer model of the proposed operations using a commercially available software package. The model used for this assessment was Environmental Noise Model (ENM), developed by RTA Technology Pty Ltd. ENM is recognised and accepted by the EPA as a computer modelling program suited to predicting noise impacts from industrial noise sources.

The computer model incorporated identifiable noise source data, meteorological data and surrounding terrain characteristics including a representative proposed mine plan. The model was used to predict the contributed noise levels from the RERR mining area and the West Pit Overburden Emplacement Area at the nearest potentially affected receivers for conceptual year 4 of the proposed modification. Year 4 of the proposed modification is considered to be representative of the worst case acoustic impacts for the entirety of the proposed modification due to the location of major noise sources in relation to privately owned residences and the relatively exposed position of overburden emplacement activities.

Noise source models representative of the acoustically significant plant and equipment proposed for use during the life of the mine were developed for ENM. Representative sound power levels (SWL) for the plant and equipment are based on the existing fleet of equipment as used in the West Pit. The modelled SWLs for the equipment over the life of the mine are presented in **Table 6.3**.

Table 6.3 – Modelled Sound Power Levels, dB(A)

Equipment Description	No.	SWL[1]	Comment
500 tonne Excavator (EX5500)	1	118	Hydraulic excavator for coal and overburden
250 tonne Excavator (EX2500)	1	116	Hydraulic excavator for coal and overburden
Haul Truck 240 tonne	6	116	Hauling overburden
Haul Truck 180 tonne	6	116	Hauling coal and overburden
Bulldozers – pushing – reversing	3	111 116	Working with the excavators, coal recovery, management of the emplacement areas, road maintenance and reshaping of dumps for rehabilitation
Rubber Tyre Dozer	1	113	Management of overburden emplacement areas
Grader	2	116	Road maintenance
Drill	1	113	Site preparation for blasting
Water Cart	1	115	Road maintenance

Note 1: The above schedule of equipment and SWLs are based on the existing fleet of equipment as used in the West Pit. The SWLs of the equipment are considered indicative rather than mandatory. The actual performance requirements of the equipment will be determined based on how the proposed modification will meet the relevant Project noise criteria.

Meteorological analyses for the Mount Owen Complex were detailed in the Noise Impact Assessments contained in *Environmental Impact Statement – Mount Owen Operations* (Umwelt 2003) and *Environmental Assessment for the Modification of Glendell Mine Operations* (Umwelt 2007). These two assessments note that the region in the vicinity of Ravensworth East Mine has three primary meteorological scenarios of interest for noise impact assessment. These are:

- north-westerly gradient winds up to 3 m/s;
- winter night time (6.00 pm to 7.00 am) inversion conditions with north-westerly drainage flow; and
- calm isothermal conditions.

While south-easterly gradient winds up to 3 m/s are typical of the region, they have not been considered in this assessment. This is due to the lack of meteorological driven noise propagation from Ravensworth East Mine towards the nearest privately owned residences to the north-west. The nearest privately owned residences are generally located to the south, south-east and east of Ravensworth East Mine (i.e. in the opposite direction from the south-easterly gradient wind).

The meteorological conditions modelled are presented in **Table 6.4**.

Table 6.4 – Modelled Meteorological Scenarios

Meteorological Scenario	Temperature	Humidity (%)	10m Wind Speed (m/s)	Wind Direction (degrees)	Vert Temp Gradient (°C/100 m)
Gradient Winds	12	85%	3	315	0
Winter Night Time	12	85%	2	315	3
Calm	12	85%	0	0	0

6.2.4 Noise Predictions

The Ravensworth East mining fleet will continue to operate in the proposed RERR mining area as it currently does in the West Pit, that is, continuously 7 days per week 24 hours per day. As a result, the most stringent noise criteria that the mining operation will need to achieve is the night-time amenity PSNL ($L_{Aeq, night}$).

The Single Point Calculation feature of ENM was used to determine noise levels at the nearest residential receiver locations under the relevant meteorological conditions previously indentified, in accordance with the INP (EPA 2000). Noise predictions at the nearest private residences for the proposed modification alone are contained in **Table 6.5**. Contour calculations were also performed for the three modelled meteorological conditions and are presented in **Figures 6.1**, **6.2** and **6.3**.

Table 6.5 – Predicted Noise Levels, dB(A) – The Proposed Modification Alone

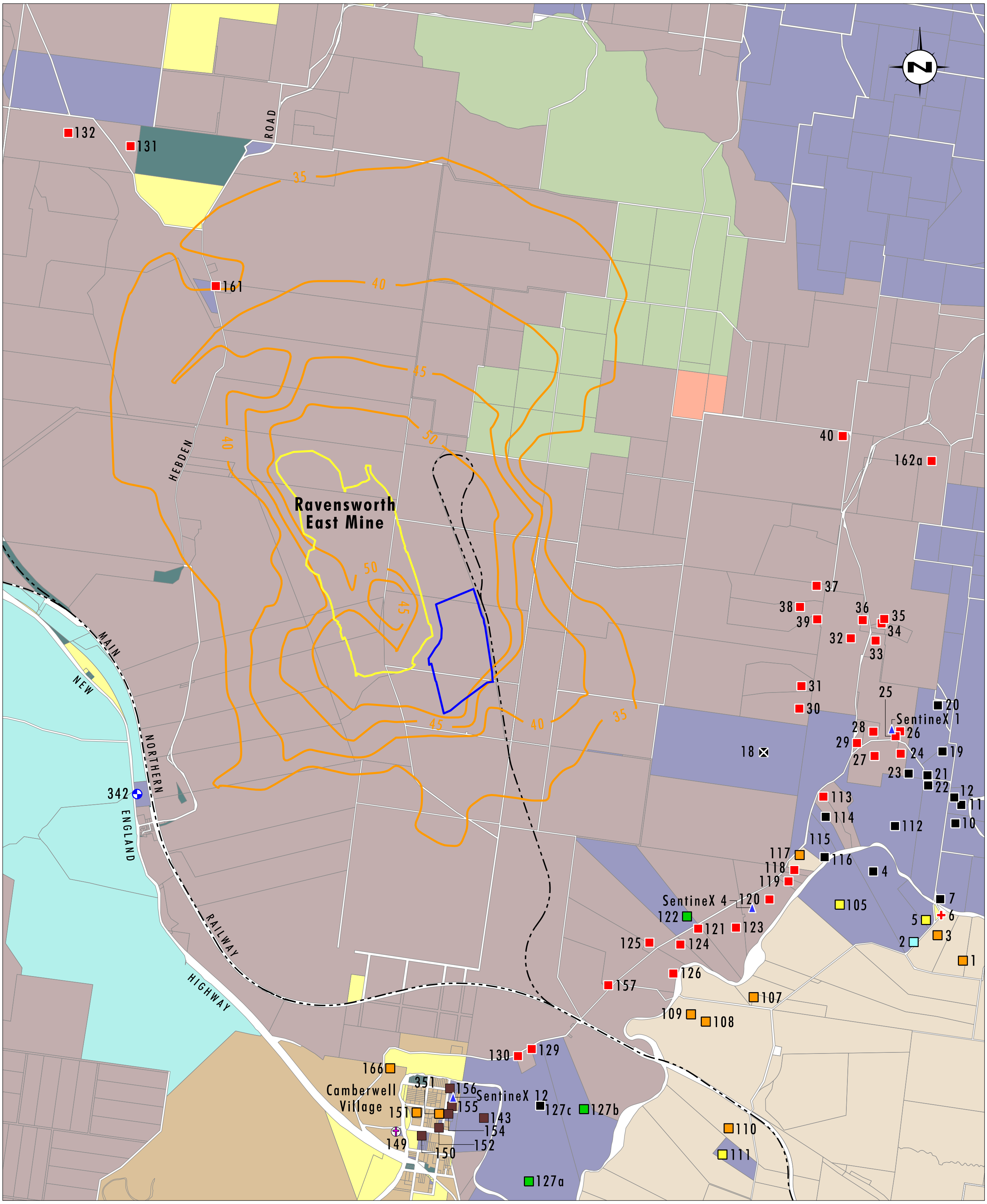
Modelled Receiver Location	Meteorological Scenario	Target Project Specific Noise Levels, dB(A)		Predicted Noise [4] Level, dB(A)	
		$L_{Aeq, 15min}$	$L_{Aeq, period}$	$L_{Aeq, 15min}$	$L_{Aeq, period}$
Residence 20 (SentineX 1)[1]	Gradient Winds	38	36 [2]	28	27
	Winter Night Time			29	28
	Calm			21	20
Residence 23 (SentineX 1)[1]	Gradient Winds	38	36 [2]	32	32
	Winter Night Time			33	32
	Calm			21	20
Residence 114 (SentineX 1)[1]	Gradient Winds	38	36 [2]	30	29
	Winter Night Time			31	30
	Calm			22	21
Residence 122 (SentineX 4)[1]	Gradient Winds	42	37 [2]	37	36
	Winter Night Time			37	36
	Calm			27	26
Residence 143 (SentineX 12)[1]	Gradient Winds	43	38 [3]	32	31
	Winter Night Time			32	31
	Calm			15	14
Residence 155 (SentineX 12)[1]	Gradient Winds	43	38 [3]	32	31
	Winter Night Time			32	31
	Calm			15	14

Note 1: The PSNL for the receiver location corresponds to the representative continuous noise monitoring location shown in brackets.
Note 2: The Night-time Amenity PSNL is the most stringent in the region of Glennies Creek and Middle Falbrook Road.
Note 3: The Evening Amenity PSNL is the more stringent for Camberwell village at LAeq, evening = 38 dB(A) than the Night-time Amenity PSNL.
Note 4: The calculated LAeq, period is based on 80 to 90 per cent machine utilisation of the period.

The target project specific noise levels presented in **Table 6.5** are the most stringent of the day, evening and night-time project-specific noise criteria. The modelling results indicate the operational noise levels from the RERR mining area and the West Pit Overburden Emplacement Area will not exceed the target project-specific noise criteria for all private residences under the meteorological conditions modelled.

Cumulative noise sources for the region surrounding Ravensworth East Mine include Mount Owen Mine to the immediate north-east, Glendell Mine to the immediate south, the

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 1.0 2.0 3.0km
1:60 000

Legend

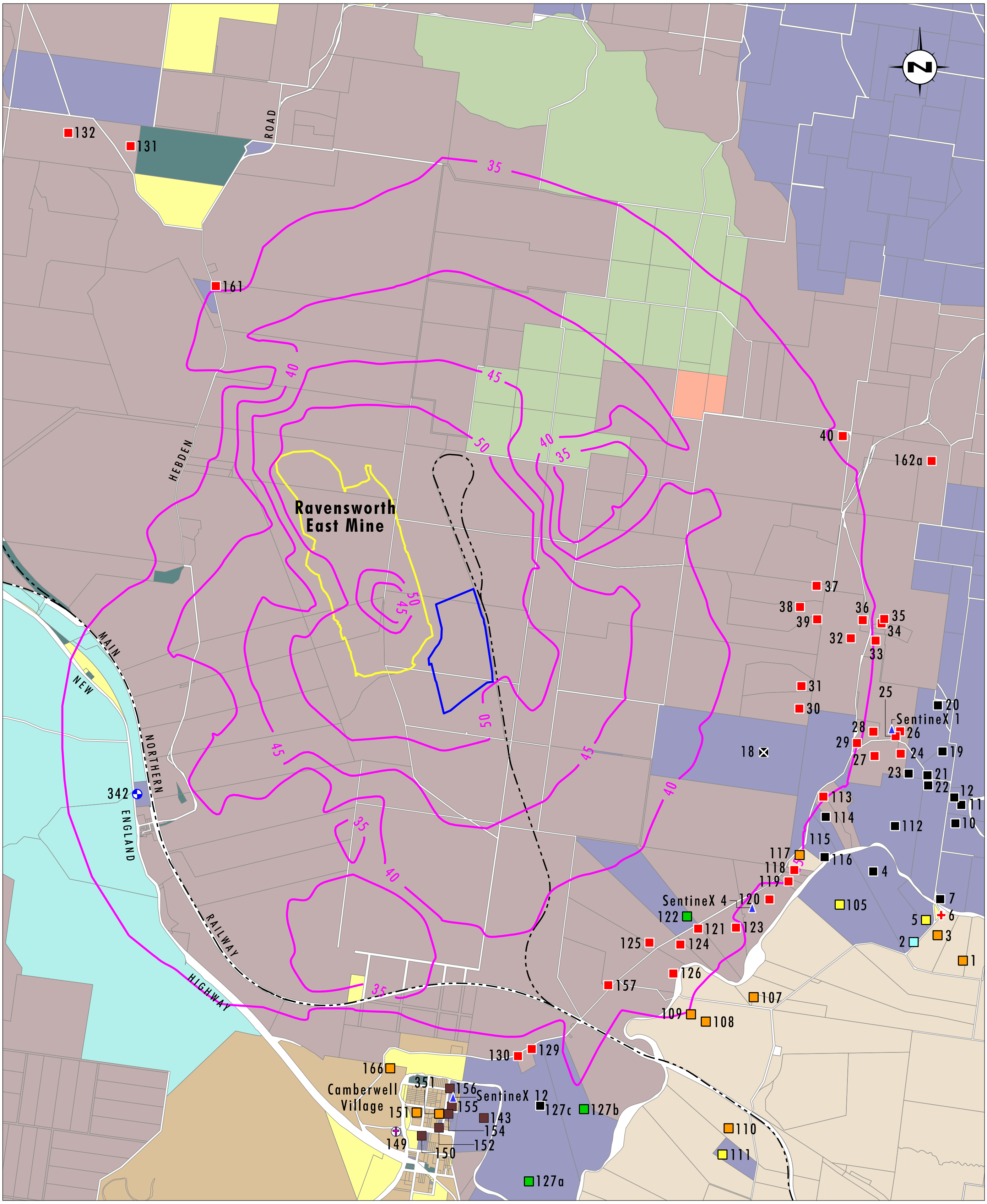
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Private Residence
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Mine Owned Residence - Xstrata
- SentineX
- Predicted Noise Levels Calm Neutral Conditions

FIGURE 6.1

RERR Conceptual Mine Plan 2016 (Year 4) Predicted Noise Levels Calm Neutral Conditions

File Name (A4): R01/3081_023.dgn
20121218 16.46

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 1.0 2.0 3.0km
1:60 000

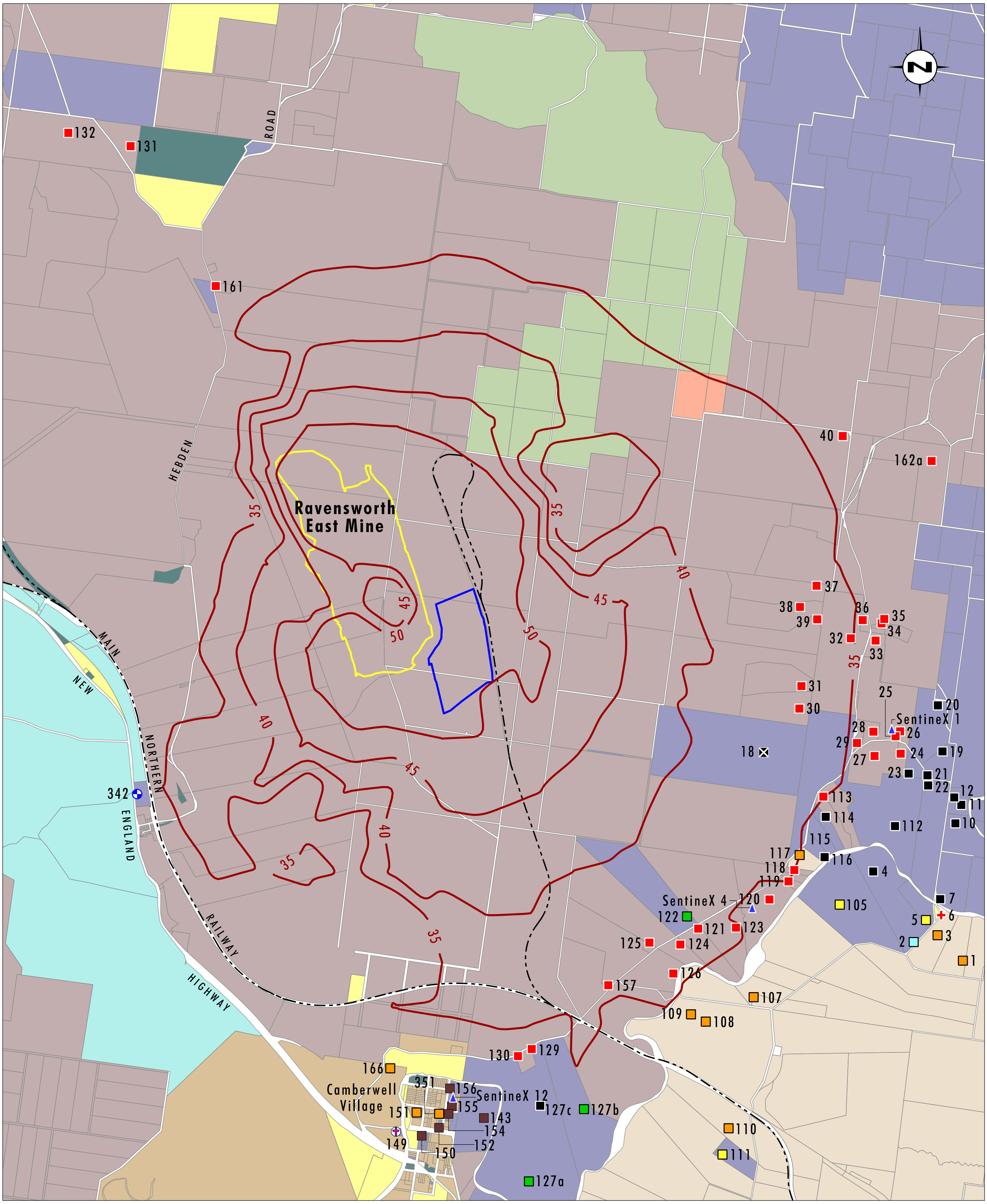
Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Private Residence
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Mine Owned Residence - Xstrata
- SentineX
- Predicted Noise Levels NW drainage flow of 2 m/s with a 3°C/100m inversion

FIGURE 6.2

RERR Conceptual Mine Plan 2016 (Year 4) Predicted Noise Levels NW drainage flow of 2 m/s with a 3°C/100m inversion

File Name (A4): R01/3081_029.dgn
20121218 16.47



Source: Mount Owen (2012)

0 1.0 2.0 3.0km
1:60 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Private Residence
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Mine Owned Residence - Xstrata
- SentineX
- Predicted Noise Levels 3 m/s NW Wind

FIGURE 6.3

RERR Conceptual Mine Plan 2016 (Year 4) Predicted Noise Levels 3 m/s NW Wind

File Name (A4): R01/3081_030.dgn
20121218 16.51

Main Northern Railway line to the south, Ravensworth Underground Mine (surface infrastructure) to the West, Ravensworth Surface Operations to the south-west; Integra Coal Open Cut and Underground Mines to the south-east and Ashton Coal Mine to the south and the Ashton South east Open Cut (approved, but not yet operating) (refer to **Figure 1.2**). Due to the relative locations of the nearest private residences to Ravensworth East Mine and the cumulative noise sources in the surrounding region, worst case cumulative noise impacts from the proposed modification are most likely to occur during times of wind conditions from the north-west.

Under winds from the north-west, propagation of noise to the modelled receiver locations is likely to be enhanced from the proposed modification, Mount Owen Mine operations and Glendell Mine operations while at the same time limiting the propagation of noise from the other potential contributors to the cumulative noise environment.

To determine the potential night-time cumulative noise impacts from the proposed modification, the predicted noise levels from the RERR mining area and the West Pit Overburden Emplacement Area were added to the predicted noise levels as given in the project application documentation for Mount Owen Mine Operations and Glendell Mine Operations (refer to *Environmental Impact Statement – Mount Owen Operations* Umwelt 2003 and *Environmental Assessment for the Modification of Glendell Mine Operations* Umwelt 2007). The cumulative noise impacts were calculated using the results from the north-westerly gradient winds meteorological scenarios which resulted in the worst case predicted impacts from all three mining operations.

The results from the cumulative noise assessment are compared to the Recommended Acceptable Amenity Criteria from Section 2 of the INP (EPA 2000) and are summarised in **Table 6.6**.

Table 6.6 – Predicted Cumulative Noise Levels, dB(A)

Modelled Receiver Location	Predicted Noise [1] Level from the Proposed modification, dB(A) LAeq, night	Combined [2] Predicted Noise Impacts from Mount Owen Mine and Glendell Mine , dB(A) LAeq, night	Predicted Cumulative Noise Level, dB(A) LAeq, night	Recommended Acceptable Amenity Criteria (dB(A) LAeq, night)
Residence 20	27	34	35	40
Residence 23	31	34	36	40
Residence 114	29	32	34	40
Residence 122	36	38	**40**	40
Residence 143	31	33	35	40
Residence 155	31	35	36	40

Note 1: Predicted noise levels from the proposed modification under north-west gradient winds of 3m/s.

Note 2: Based on maximum combined predicted noise levels for years 6 to 10 for Mount Owen Mine Operations and Glendell Mine Operations under north-west gradient winds of 3m/s.

Based on the above assessment it is expected that the proposed modification should not have a discernible impact on the existing noise amenity at any of the nearest privately owned residences with the exception of Residence 122, refer to **Figure 1.3**. The proposed modification is predicted to meet but not exceed the Recommended Acceptable Amenity Criteria at Residence 122. Residence 122 has existing acquisition rights from Xstrata Mount Owen Complex.

6.2.5 Noise Management and Monitoring

The noise performance of Ravensworth East Mine along with Glendell Mine and Mount Owen Mine are measured, managed and assessed in accordance with the Mount Owen Complex Noise Monitoring Program (Mount Owen Complex 2011). The monitoring program is based around a combination of continuous noise monitors and an attended noise monitoring program. The continuous noise monitors are used as a management tool and are set to alarm in situations where predefined noise levels from the Mount Owen Complex are exceeded. Noise mitigation measures are also implemented at the Mount Owen Complex including noise attenuation fixed to select equipment and when possible alternate overburden dumping locations (when meteorological conditions are unfavourable).

As part of the noise monitoring program, monitoring results from the operations that comprise the Mount Owen Complex are regularly reviewed to assess compliance with each operations Noise Impact Assessment predictions and project-specific noise criteria. The results of the noise compliance review are reported in accordance with the individual requirements of each mining operation's Project Approvals and Environmental Protection Licences.

The Mount Owen Complex Noise Monitoring Program outlines how the ongoing performance assessment of operational noise impacts is undertaken. This includes the regular assessment of continuous monitoring data against the noise predictions in the Mount Owen Operations EIS and Glendell Mine EA. Any anomalous results from the monitoring program are assessed as soon as possible with reference to digital audio recordings, operational factors, meteorological conditions and external influences. The results are reported to the mine management as appropriate.

Additionally, the continuous monitoring network reports recorded noise levels to the mine every day and sends alarms when predefined noise levels have been exceeded. This information allows the mining operations to compare their actual performance with the performance predicted in the EIS/EA for that stage of the operation. This process provides XMO with the information needed to proactively manage noise impacts on surrounding noise receiver areas.

6.3 Blasting

A blast impact assessment has been undertaken by Enviro Strata Consulting (ESC) for the proposed modification, and is presented in full in **Appendix 3**.

The blasting assessment addresses the ground vibration and airblast/overpressure impacts associated with the proposed modification in relation to the following key areas:

- surrounding residential community;
- existing infrastructure; and
- Integra Underground Mine.

6.3.1 Conceptual Blast Design

The extraction of coal from the RERR mining area would include the extraction of the Ravensworth, Ravensworth North Upper and Lower and the Bayswater seams down to a depth of approximately 200 metres. The RERR mining area has been partly used for overburden emplacement associated with current approved operations at Glendell. This overburden will need to be removed in order to allow for further mining in the RERR mining area. Given the nature of this unconsolidated material, it will not require blasting. Blasting will be required to fragment the ground below this and above the target coal seams. Blasting of the coal seam may also be required.

Blasting will be undertaken in accordance with the existing Blast Management Plan (BMP) (XMO 2012) for the Mount Owen Complex. The BMP includes the relevant development consent conditions and the requirements of the Environment Protection Licence's applicable to the Mount Owen Complex.

Detailed geological plans were used to estimate the quantity of coal seams and the thickness of the overburden and interburden material that will require blasting within the RERR mining area. The estimated interburden thickness between coal seams varies from 3.9 metres to 26 metres. Therefore for modelling purposes, three bench heights were selected to represent the possible range of benches being 4, 16 and 26 metre benches.

The Mount Owen Complex generally utilises two different types of blasting products including standard ammonium nitrate/fuel oil (ANFO) for dry conditions and Heavy ANFO for wet conditions. A summary of the blast design parameters for the proposed modification is presented in **Table 6.7**.

Table 6.7 – Summary of Blast Design Parameters Used for Modelling

Bench Height	ANFO MIC (kg)	Heavy ANFO MIC (kg)	Explosive Column (m)	Stemming Column (m)
4m	26	39	1	3
16m	311	466	12	4
26m	549	824	21	5

6.3.2 Ground Vibration and Air Blast Predictive Models

The ground and air vibration predictive model is based on blast monitoring data collected from blasts undertaken within the West Pit at Ravensworth East Mine and the Barrett Pit at Glendell Mine and uses the contour line assessment technique. The analysed samples of data include more than 170 blasts collected over a one year period. The results from the current monitoring locations were considered representative for the analysis as both pits are located adjacent to or within close proximity to the RERR mining area.

A vibration predictive model for underground conditions in relation to the Integra Underground Mine (Integra) was developed following blasting in the Eastern Rail Pit at Mount Owen Mine in 2005 and 2006, given the Eastern Rail Pit's proximity to Integra. The study was supported by surface monitoring undertaken using multiple monitoring stations placed either directly above the underground monitoring stations or in approximately the same direction as the underground workings. Given the similarities between the location of the mining operations at the Eastern Rail Pit and the RERR mining area, refer to **Figure 2.1**, findings of the previous study are considered applicable to the proposed modification and the blast impact assessment. The model used for this assessment is based on actual ground vibration measurements from various blasts and considers the results of previous studies conducted for mining and blasting completed within the Eastern Rail Pit. Full details regarding the modelling methodology are provided in the Blast Impact Assessment contained in **Appendix 3**.

6.3.3 Airblast and Ground Vibration Impact Assessment Criteria

The relevant blasting criteria in relation to human comfort and blast damage from the ANZECC guidelines '*Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibrations*', Australian Standard AS2187-2:2006 '*Explosives Storage and Use – Part 2: Use of Explosives*' and Australian Coal Association Research Program guidelines is presented in **Tables 6.8** and **6.9**.

Table 6.8 – Residential Blast Impact Assessment Criteria

Receiver	**Peak Particle Velocity (mm/s)**	**Allowable Exceedance**	**Overpressure (dBL)**	**Allowable Exceedance**
Residence on privately owned land	5	5% of the total number of blasts over a 12 month period	115	5% of the total number of blasts over a 12 month period
	10	0%	120	0%

Table 6.9 – Infrastructure Blast Impact Criteria

Receiver	**Peak Particle Velocity (mm/s)**	**Allowable Exceedance**	**Overpressure (dBL)**	**Allowable Exceedance**
St Clements Church, Camberwell	2	5% of the total number of blasts over a 12 month period	no limit specified	no limit specified
	5	0%	no limit specified	no limit specified
Main Northern Railway culverts and bridges	25	0%	no limit specified	no limit specified
Rail Spur (rail line)	200	0%	no limit specified	no limit specified
Rail Spur (railway cuttings)	250	0%	no limit specified	no limit specified
Rail Spur (railway embankments)	300	0%	no limit specified	no limit specified
Electricity Transmission Poles	50	0%	no limit specified	no limit specified
Ravensworth Homestead	5	0%	no limit specified	no limit specified
TP1 Tailings Dam (DSC)	50	0%	no limit specified	no limit specified

Blast emission criteria for underground mines are generally specified by two different criteria, including the Safe Vibration Limit and the Vibration Limit for Personnel Withdrawal, presented in **Tables 6.10** and **6.11**. Safe vibration limits are site specific. The criteria used for the Blast Impact Assessment is based on previous studies undertaken in 2005, 2006 and

2007 in relation to blasting interactions between the Eastern Rail Pit at Mount Owen Mine and Integra Underground Mine.

Table 6.10 – Criteria for Safe Vibration Limit and Vibration Limit for Personnel Withdrawal

Safe Vibration Limit	250 mm/s
Vibration Limit for Personnel Withdrawal	10 mm/s

Table 6.11 – Criteria Limits for Mine Infrastructure

Occupied non-sensitive sites (factories and commercial premises)	25 mm/s
Unoccupied structures of reinforced concrete or steel construction	100 mm/s
Site specific frequency-dependent damage limit criteria applies for structures of masonry, plaster and plasterboard construction	NA

6.3.4 Blast Impact Assessment Results

6.3.4.1 Private Residences

The majority of the residences with the potential to be impacted by blasting in the RERR mining area are located to the south and south-east with the closest private residence located approximately 3.5 kilometres to the south-east, refer to **Figure 1.3**.

Given the location of the RERR mining adjacent to the West Pit and within proximity to the Barrett Pit and the similarities in the blasting activities to be undertaken for the proposed modification it is considered that the impact of blasting within the RERR mining area should not significantly differ from that currently occurring.

The model simulated the impact of ground vibration and airblast on the surrounding residences as a result of the proposed modification. The worst case blasting scenario was assessed. The modelling indicates that the estimated ground vibration levels would be well below the 5 mm/s ground vibration criteria at all private residences, with the highest estimated vibration level for Residence 122 (closest private residence), in the order of 1.3 mm/s. The modelling of the airblast impact on the surrounding residences indicates that the estimated airblast levels would be below the 115 dBL vibration limit criteria at all private residences, with the highest estimation level at Residence 122 in the order of 114 dBL.

6.3.4.2 Infrastructure

Due to the nature of blasting there is some risk related to blasting in close proximity of infrastructure. The risks can range from flyrock, ground vibration, airblast and even fume exposure if associated mine personnel are involved. Generally, this risk reduces with increased distance from the blasting area. The blasting impact assessment included an overview of the minimum distances within which blasting can safely occur between the RERR mining area and the infrastructure with the potential to be impacted as part of the proposed modification.

The impact of blasting activities has been assessed in relation to the following public infrastructure:

- 330 kV and 132 kV powerlines;
- Main Northern Rail Line;

- Ravensworth homestead (currently owned by XMO);
- St Clements Church, Camberwell;
- Telstra tower; and
- Hebden Road.

It is noted that the Ravensworth Homestead and the St Clements Church in Camberwell Village are locally listed heritage items under the Singleton Local Environment Plan.

Additionally, the impact of blasting activities has been assessed in relation to the following mine infrastructure:

- Water and tailings dams;
- Mount Owen rail spur;
- Glendell Mine Infrastructure Area; and
- Mount Owen Mine Infrastructure Area.

The locations of the identified infrastructure are shown on **Figure 6.4**. With the exception of the TP1 tailings dam and the Mount Owen Rail Spur the remainder of the identified infrastructure are located outside of the 500 metre exclusion buffer. The Mount Owen Complex operates using a standard 500 metre exclusion zone, as this distance is used as a standard widely across the mining industry to address the issue of flyrock impact and potential risks.

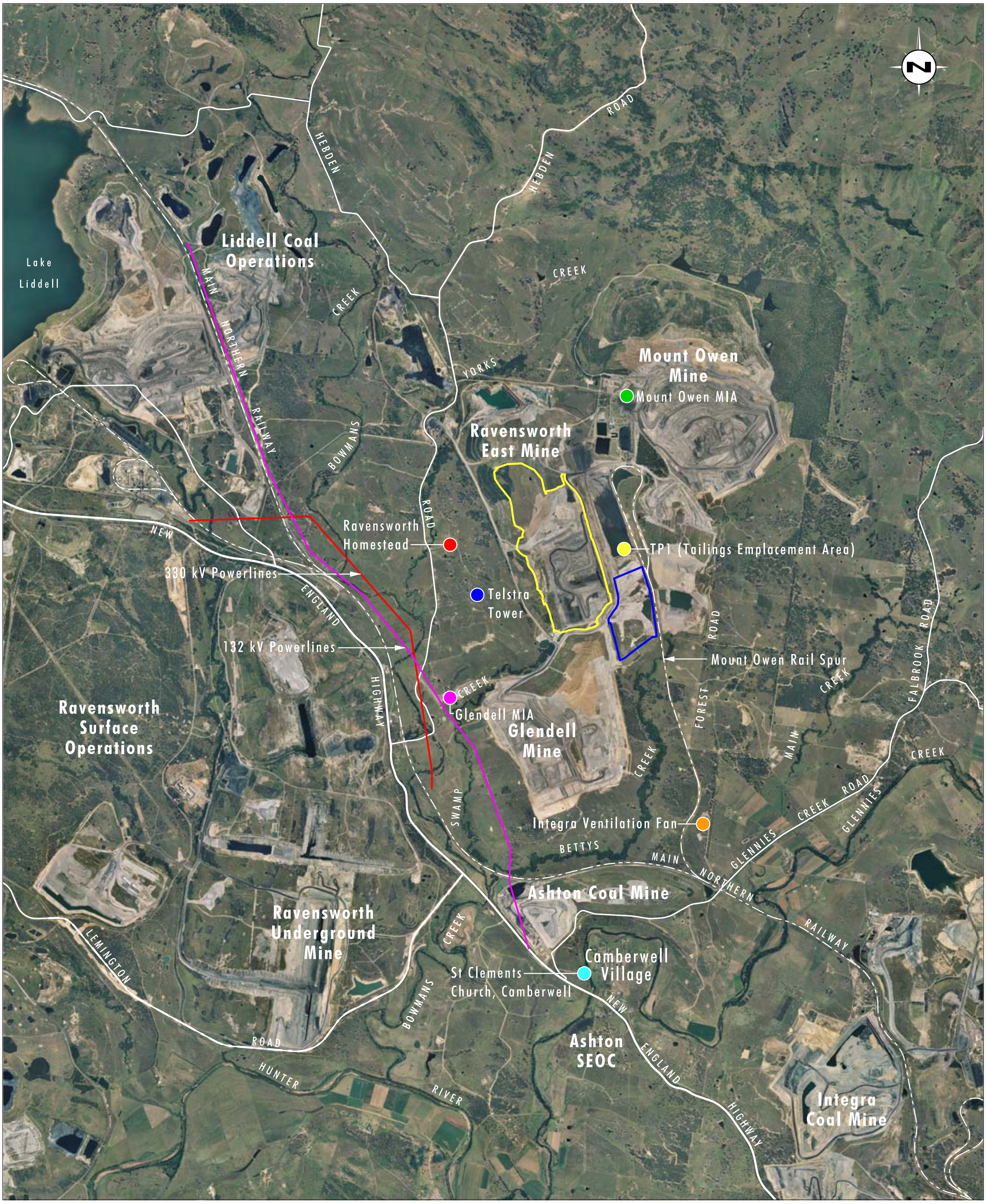
The modelling results in relation to the TP1 Tailings Dam indicate that blasting 4 to 16 metre benches can be undertaken under the existing blast design parameters without any restrictions. However additional blast management measures will be required when blasting the maximum bench size of 26 metres within a 100 metre radius of the TP1 dam wall. The additional blast management measures include limiting the charge mass via the introduction of deck charges or blasting smaller bench sizes than the 26 metre bench height in this location. The additional management measures are required to achieve the vibration limit criteria of 50 mm/s set for the TP1 dam wall by the Dam Safety Committee.

During 2005 and 2006 comparable blasting activities were undertaken in the Eastern Rail Pit at the Mount Owen Complex which is located at a similar distance to the rail spur. During that time there was no observed impact on the rail spur and no incidents were reported. The management of blasting in the Eastern Rail Pit was adequately managed through the implementation of a blasting protocol (including management of train clearance, allowance for appropriate delay in train movements and post blast track inspection). XMO will update and implement a similar protocol for the management of blasting in relation to the existing rail spur, within the RERR mining area.

The modelling results in relation to the Mount Owen rail spur indicate that blasting 4 metre benches can be undertaken without any restrictions. However the 16 and 26 metre benches will require additional blast management measures including the application of deck charges or smaller bench blasting. This additional management of the vibration levels includes the determination of the blast design parameters based on the actual distance between the rail spur and the blast area and the applicable vibration limit criteria.

The vibration predictions for the 330 kV and 132 kV powerlines located to the west of the Mount Owen Complex are estimated to be below 2 mm/s compared with the criteria of

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 1 2 4km
1:80 000

Legend
West Pit Overburden Emplacement Area
RERR Mining Area
132kV Powerlines
330kV Powerlines

FIGURE 6.4

Existing Infrastructure Subject to Blast Impact Assessment

File Name (A4): R01/3081_035.dgn
20121214 16.03

50 mm/s. The vibration estimates for the Ravensworth Homestead and St Clements Church are predicted to be below 2.1 and 0.8 mm/s respectively which is below the criteria of 5 mm/s for the Ravensworth Homestead and 2 mm/s for St Clements Church.

The modelling results indicate that the vibration impacts on all other infrastructure including the Telstra tower, Hebden Road, the water and tailings dams (with the exception of TP1) and the Glendell and Mount Owen MIA's are considered low (generally no higher than 6 mm/s) and will be within acceptable limits.

6.3.4.3 Integra Underground Mine

The Mount Owen Complex mining leases and the Integra mining leases overlap within the RERR mining area. The Mount Owen Complex holds the extraction rights of the upper seams (extending down to the Bayswater seam) and Integra holds the extraction rights of the lower mining seams extending from the currently mined Upper Liddell seam to the Middle Liddell and Barrett seams. The base of the RERR pit will be located approximately 250 metres above the Integra underground workings. The Blast Impact Assessment provides vibration estimates and blast emission criteria associated with the potential vibration exposure as a result of the proposed modification in relation to underground workings, ventilation fans and associated surface infrastructure at Integra Underground Mine.

A worst case scenario has been applied to the modelling which takes into account the possibility that blasting of the RERR mining area coincide with the underground extraction activities at Integra. The blast assessment considers the probability that the underground workforce will be present during surface blasting activities within the RERR mining area.

The vibration modelling results in relation to the impact on Integra surface infrastructure revealed low vibration exposure no higher than 1.9 mm/s for all associated infrastructure facilities compared with a criteria of 25 mm/s (factories/commercial premises) and 100 mm/s (unoccupied reinforced concrete or steel infrastructure).

The safe vibration limit associated with vibration exposure at the Integra underground workings is 250 mm/s. The highest prediction indicated by the assessment results is 27 mm/s, which is within the required criteria limit. XMO will update and implement the blasting protocol similar to that previously implemented when blasting was conducted within the Eastern Rail Pit at Mount Owen Mine, to ensure the protection of the personnel at Integra. The protocol includes blast notification, vibration predictions, monitoring and underground personnel management.

XMO will also implement an ongoing process of review and refinement of blasting practices as mining develops to confirm the predicted vibration limits, as underground mining conditions are better understood.

6.3.5 Management and Monitoring

Mount Owen Complex operates seven blast monitoring stations as illustrated in **Figure 2.3**. Four monitoring stations are placed in strategic locations and are considered representative for the local community including:

- Green Acres;
- Camberwell Village;
- Resident ID 29; and

- Resident ID 123.

The following monitoring stations are representative of the surrounding infrastructure:

- Camberwell Church;
- Ravensworth Homestead;
- Powerlines; and
- Railway.

The monitoring stations located at Resident 29 and 123, relate specifically to the Mount Owen operations with the remainder of the monitoring locations relating to Glendell and Ravensworth East Mine operations. These monitoring stations would also be utilised for blast impact monitoring for the proposed modification.

XMO currently manage blasting activities at the Mount Owen Complex in accordance with the Blast Management Plan. The purpose of the Blast Management Plan is to ensure the effective management and monitoring of blasting activities at the Mount Owen Complex including:

- management and monitoring controls to achieve the maximisation of blast efficiency;
- minimisation of blast fume, ground vibration and airblast;
- minimisation of blast dust plume through use of the existing predictive model to assess the potential impacts prior to blasting; and
- ensuring compliance with site specific blasting requirements.

Blasting activities within the RERR mining area will be undertaken in accordance with the existing Blast Management Plan. The Blast Management Plan will also be updated to include the following:

- Implementation of additional blast management measures (including limiting the charge mass via the introduction of deck charges or blasting smaller bench sized that the 26 metre bench height in this location) when undertaking blasting at the maximum bench size of 26 metres within a 100 metre radius of the of the northern area of the RERR pit adjacent to the TP1 dam wall, to ensure compliance with the vibration limit criteria of 50 mm/s set by the Dam Safety Committee.

- Blasting of 16 to 26 metre benches will require the implementation of a blast management protocol (including management of train clearance, allowance for appropriate delay in train movements and post blast track inspection) for the management of blasting activities in relation to the Mount Owen rail spur. The protocol is to be included in the Mount Owen Blast Management Plan and will include the implementation of additional management measures such as the application of deck charges, use of smaller bench blasting, or minimisation of vibration through changes to blast initiation timing. The blast design will also be managed according to the applicable vibration limit criteria and the actual distance from the blast area, as shown in **Table 6.12**.

Table 6.12 – Minimum Distance Requirements for Mount Owen Rail Spur to Determine Blast Design Parameters

Vibration Limit (mm/s)	Estimated Minimum Distance from Rail Spur (m)			
	16m Bench		26m Bench	
	MIC 311kg	MIC 466kg	MIC 549kg	MIC 824kg
200	90	110	120	150
250	78	95	105	127
300	70	85	92	113

- Implementation of an ongoing process of review and refinement of blasting practices and blast design parameters as mining develops to confirm the predicted vibration limits, as underground mining conditions are better understood.
- Implementation of a personnel withdrawal protocol in consultation with Integra, including blast notification, vibration limits and underground personnel management, similar to that previously implemented when blasting was conducted within the Eastern Rail Pit at Mount Owen Mine.

6.4 Air Quality

A comprehensive assessment of potential air quality impacts associated with the proposed modification has been prepared by PAE Holmes, and is included in **Appendix 4**. An overview of the air quality assessment is provided in this section.

6.4.1 Climate and Meteorology

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the proposed modification. Climatic information collected from Jerry's Plains weather station located approximately 19 kilometres from the Ravensworth East Mine includes temperature, humidity, wind and rainfall data.

On an annual basis, winds are predominantly from the north-north-west, north-west, south-east and south-south-east directions. The predominant wind direction in summer is from the south-south-east and south-east while winter shows more prominent winds from the north-west and north-north-west. On an annual basis the percentage of calms is 3.3 per cent.

6.4.2 Air Quality Goals

The former NSW Department of Environment and Conservation's (now the Office of Environment and Heritage – OEH) guidelines, *'Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW, August 2005'* (NSW DEC 2005) specify air quality assessment criteria relevant for assessing impacts from dust generating activities.

The assessment criteria are based on considerations of possible nuisance and health effects and provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants. These criteria are consistent with the criteria Mount Owen Complex is required to meet under current development consent conditions.

The air quality goals relate both to dust concentration and dust deposition which are discussed further in **Sections 6.4.2.1** and **6.4.2.2**.

6.4.2.1 Dust Concentration

Dust concentration refers to airborne dust and is measured in micrograms per cubic metre (µg/m³). Relevant criteria for dust concentration are defined in terms of two classes, total suspended particulates (TSP) and Particulate Matter (PM_{10}).

TSP relates to all suspended particles which are usually in the size range of zero to 50 micrometres (µm). Particle sizes larger than 50 µm typically settle out of the atmosphere too quickly to be regarded as air pollutants, however these particles are measured in dust deposition levels (refer to **Section 6.4.2.2**). The human respiratory system has in-built defensive systems that prevent particles larger than approximately 10 µm from reaching the more sensitive parts of the respiratory system. PM_{10} refers to particulate matter with a diameter less than 10 µm.

Standards for dust concentration are referred to as long term (annual average) and short term (24 hour maximum) goals. Relevant goals for TSP and PM_{10} are outlined in **Table 6.13** in relation to both Project-specific and cumulative goals applied at a regional level. The TSP and PM_{10} annual average goals relate to the total dust in the air and not just the dust from the proposed modification.

Table 6.13 – Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source	Project Only/Cumulative
TSP	90 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)	Cumulative
PM_{10}	50 $\mu g/m^3$	24-Hour	NSW DEC (2005) (assessment criteria)	Project only
	30 $\mu g/m^3$	Annual	NSW DEC (2005) (assessment criteria)	Cumulative
	50 $\mu g/m^3$	24-Hour	NEPM (allows five exceedances per year)	Cumulative

Notes: $\mu g/m^3$ – micrograms per cubic metre.

* For coal mining operations in rural areas, PM_{10} 24 hour maximum criterion is taken to be non-cumulative for assessment purposes, provided the mine operates with best practice dust control measures.

6.4.2.2 Dust Deposition

Dust deposition levels refer to the quantity of dust particles which settle out of the air as measured in grams per square metre per month (g/m^2/month) at a particular location.

The OEH expresses dust deposition criteria in terms of an acceptable increase in dust deposition over the existing background deposition levels. **Table 6.14** shows the maximum acceptable increase in dust deposition from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance impacts (NSW DEC 2005).

Table 6.14 – Dust Deposition Criteria

Pollutant	Averaging Period	Maximum Increase in Deposited Dust Level (project only)	Maximum Total Deposited Dust Level (cumulative)
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

6.4.3 Existing Air Quality

Extensive air quality monitoring networks have been established within the upper Hunter Region predominantly to monitor air quality impacts from existing mining operations. The Mount Owen Complex currently operates an air quality monitoring network which monitors dust deposition, TSP and PM_{10} concentration levels. The location of monitors are shown in **Figure 2.3**. The data collected includes all emission sources in the vicinity of the proposed modification, including any contribution from existing operations at the Mount Owen Complex, other nearby mining operations and other localised activities. Other sources of particulate matter in the area include mining activities, traffic on unsealed roads, local building and construction activities, farming and to a lesser extent traffic from the other local roads and other sources such as wood-burning fires.

The Mount Owen Complex monitoring network consists of 28 dust deposition gauges. There are also 5 High Volume Air Samplers (HVAS) measuring both TSP and PM_{10} 24-hour average concentrations, and 5 PM_{10} Tapered Element Oscillating Microbalance instruments (TEOMs). The locations of the monitoring sites are shown on **Figure 2.3**.

6.4.3.1 Dust Concentration

A summary of the annual average PM_{10} concentration from 1996 to 2011 is provided in the Air Quality Assessment Report, contained in **Appendix 4**. The majority of the annual average PM_{10} concentrations for each monitoring station were below the OEH criteria of 30 µg/m^3. However, monitoring point PM_{10}/5 (refer to **Figure 2.3**) indicated three exceptions to this in 2002, 2003 and 2004 where the annual average PM_{10} concentrations were 31 µg/m^3, 38 µg/m^3 and 36 µg/m^3, respectively.

The annual average TSP monitoring results for each of the four TSP HVAS monitors are presented in **Appendix 4**. The annual average TSP concentrations have remained below the OEH's criterion of 90 for all years, except at TSP/3 in 2009. The highest TSP concentration at TSP/3 in 2009 was 265 μg/m^3 on 8 December. Concentrations at all four TSP monitors were above the OEH criterion on this day which corresponded with severe weather conditions were experienced in the Hunter region.

6.4.3.2 Dust Deposition

Annual average dust deposition monitoring results from 1998 to 2011 are contained within the Air Quality Assessment and the locations of each gauge are shown in **Figure 2.3**. Across the dust deposition monitoring network, all dust gauges with the exception of DD2, DD5, DD8 and DD11 have recorded annual average deposition levels below the OEH's annual average criteria of 4 g/m^2/month. DD2, DD5, DD8 and DD11 are located very close to the existing mining operations at the Mount Owen Complex which is considered to account for the increased levels recorded at these monitoring locations and these gauges are not considered representative of dust levels at residences.

6.4.4 Air Quality Assessment Methodology

Predicted air quality impacts as a result of the proposed modification have been assessed following OEH's guidance document titled 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW' (DEC 2005).

Modelling of local meteorological data was undertaken using TAPM (developed by the CSIRO Division of Atmospheric Research) which generates gridded prognostic data for the CALMET model. For the Air Quality impact assessment a CALMET/CALPUFF modelling approach was used.

The conceptual mine plan for 2016 was modelled as it was considered representative of the likely ‘worst case’ year in respect of potential air emission impacts. This takes into consideration mine and overburden production/dumping rates, the extent of disturbance, predominant wind directions as well as proximity of proposed dust generating activities to nearest potentially affected residences.

In addition, a cumulative air quality model was developed to assess the combined effects of other mines operating concurrently with the proposed modification. Emissions from other approved mines were derived from estimates provided in past air quality impact assessments. It should be noted that only those mines which are currently approved to be operating in 2016 have been included in this assessment (Mount Owen Mine, Glendell Mine, Liddell Coal Operations, Ravensworth Surface Operations Integra Coal Mine, Ashton MIA for underground workings and the recently approved Ashton South East Open Cut).

The calculated emissions take into account proposed air pollution controls and mitigation strategies including passive controls such as those built into the mine plan (for example the length of haul roads) and active controls which include the intensity of watering and extent of rehabilitation. These mitigation strategies are further discussed in **Section 6.4.7**.

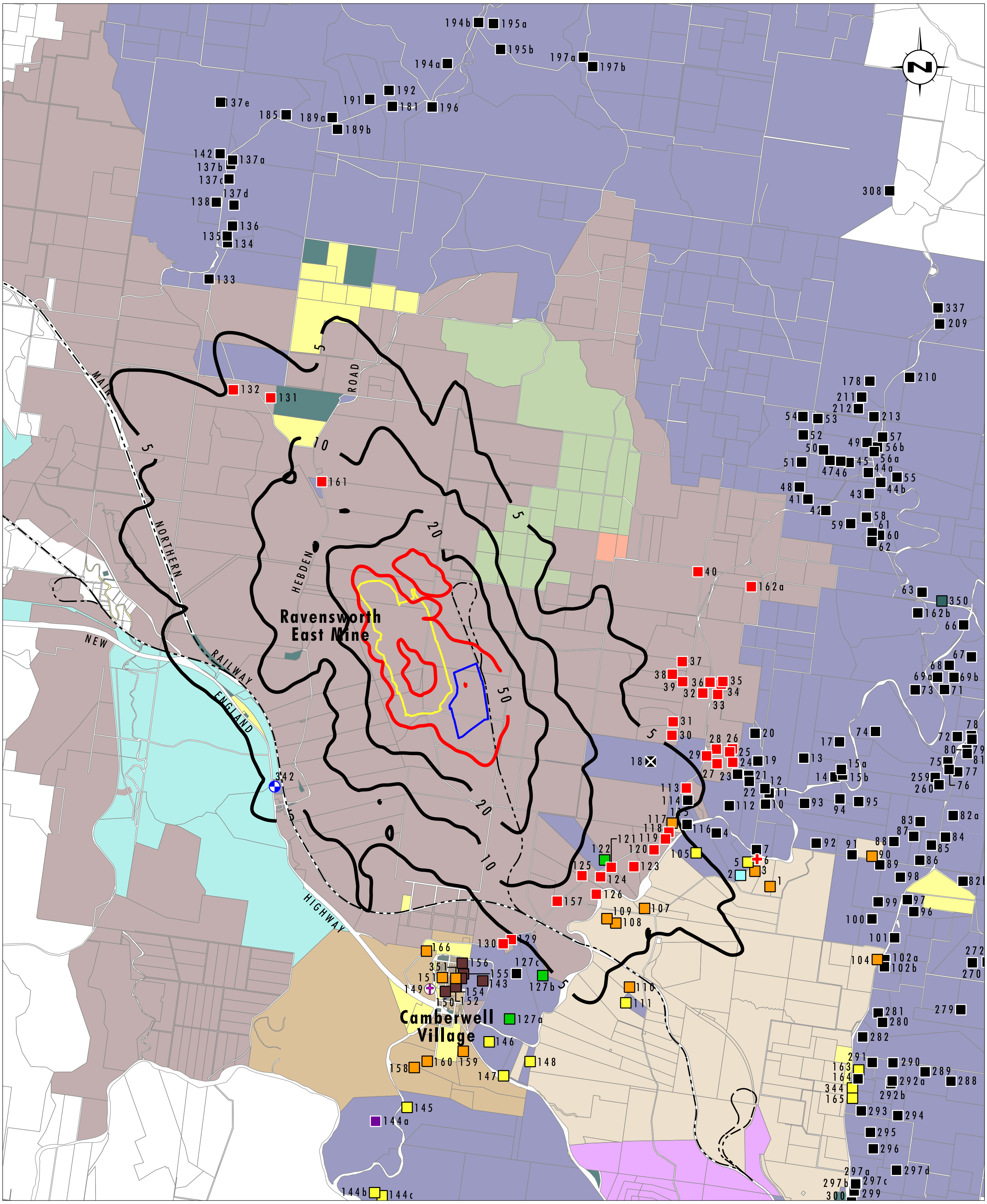
6.4.5 Air Quality Impact Assessment Results

The results of the air quality modelling predictions indicate there will be no exceedance of any Air Quality Criteria to those residences not currently subject to acquisition rights as a result of the proposed modification. The majority of sensitive receivers in the area surrounding the RERR mining area are located to the south-east. The proposed mining operations are located further away from these residences than a number of existing mining operations in the local area. The contribution of this proposed modification to air quality impacts experienced at these residents is predicted to be very low.

Potential air quality impacts associated with the proposed modification were assessed in accordance with the methodology discussed in **Section 6.4.4**. Dust impacts were predicted in the form of single point calculations at the nearest private residences to the proposed modification. Dust contours have been derived from these results to approximate air quality impacts over a defined area.

A comparison of the model predictions for the proposed modification alone with air quality criteria described in **Section 6.4.2** demonstrates that there are no privately owned residences that are predicted to experience maximum 24 hour average PM_{10} concentrations above the 50 μg/m^3 criterion as illustrated on **Figure 6.5**.

Additionally there are no predicted exceedances at any private residences of annual average PM_{10} concentrations above the 30 μg/m^3 criterion, annual average TSP concentrations, above the 90 μg/m^3 criterion or annual average dust deposition above the criterion for the proposed modification alone.



Source: Mount Owen (2012), PAE Holmes (2012)

0 1.0 2.5 5.0km
1:100 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mt Pleasant Primary School
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Predicted 24hr Average PM_{10} Contour
- 50 $\mu g/m^3$ Criteria Contour

FIGURE 6.5

Predicted 24hr Average PM_{10} Concentrations due to emmisions from the RERR only (conceptual mine plan 2016, Year 4)

File Name (A4): R01/3081_037.dgn
20121218 16.54

6.4.6 Cumulative Emissions

6.4.6.1 Cumulative Annual Average Impacts

The Air Quality Assessment has provided an assessment of the predicted cumulative annual average PM_{10}, TSP concentrations and dust deposition levels, which includes the assessment of the contribution of the proposed modification, nearby and distant mines and other non-mining sources.

The model results indicate that the predicted annual average cumulative PM_{10}, concentrations may exceed criteria at four private residences (111, 145, 147 and 148), refer to **Figure 6.6**. Further analysis of the modelled results at these residences was undertaken and the results of this analysis is summarised in **Table 6.15**.

Table 6.15 – Predicted annual PM_{10} contributions of various sources to ground level concentrations (μg/m³)

Mine/Source	Residence 111^	Residence 145^	Residence 147^	Residence 148^
Proposed Modification	0.6	0.1	0.2	0.2
Mount Owen Complex	5	0.5	0.5	0.5
Distant Mines and other sources	5	5	4	4
Nearby mines	28*	>200+	29+	29+

^ Currently subject to acquisition rights * Predominately Integra Operations, +Predominately Ashton SEOC Operations

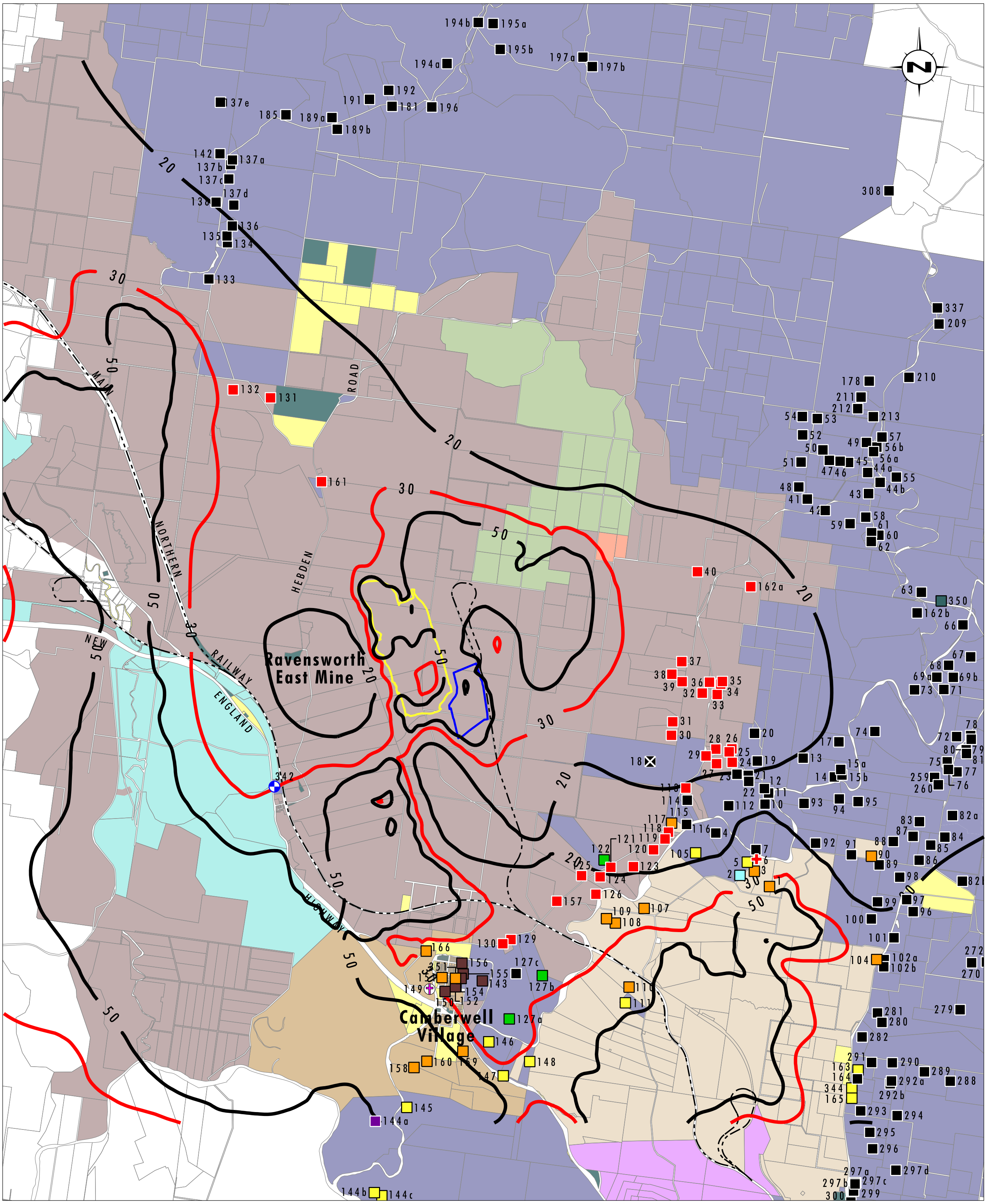
The analysis of the contribution to annual PM_{10} concentrations at these locations shows that the value is predominately due to other surrounding mines, particularly Ashton South East Open Cut. It is therefore unlikely that the proposed modification will have any measurable impact on the annual PM_{10} concentrations at residence 111, 145, 147 and 148. Additionally these residences are currently subject to acquisition rights by Ashton Coal and Integra.

There are no privately owned residences not currently subject to acquisition rights from previous mining approvals that are predicted to experience annual average TSP (refer to **Figure 6.7**) or dust deposition levels (refer to **Figure 6.8**) above the assessment criteria as a result of the cumulative emissions.

6.4.6.2 Cumulative 24 Hour Average PM_{10} Concentrations

Due to the difficulties in predicting cumulative 24-hour PM_{10} emissions, such as day to day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity, a Monte Carlo Simulation was carried out. The Monte Carlo Simulation is a statistical approach which includes selecting three private residents for the cumulative analysis based on their proximity to the proposed operations. The simulation combines the frequency distributions of two data sets (in this case, monitoring data and modelled results) to create a third 'cumulative' data set and associated frequency distribution.

Residence 122 (closest private residence within the current XMO acquisition zone), 114 (closest privately owned residence outside current XMO acquisition zone) and 156 (to represent residences in Camberwell Village) were chosen to represent groups of residences, and data from the five TEOMs and five HVAS monitors surrounding the Mount Owen Complex were used to represent the background values for each of the receptors.



Source: Mount Owen (2012) PAE Holmes (2012)

0 1.0 2.5 5.0km
1:100 000

Legend

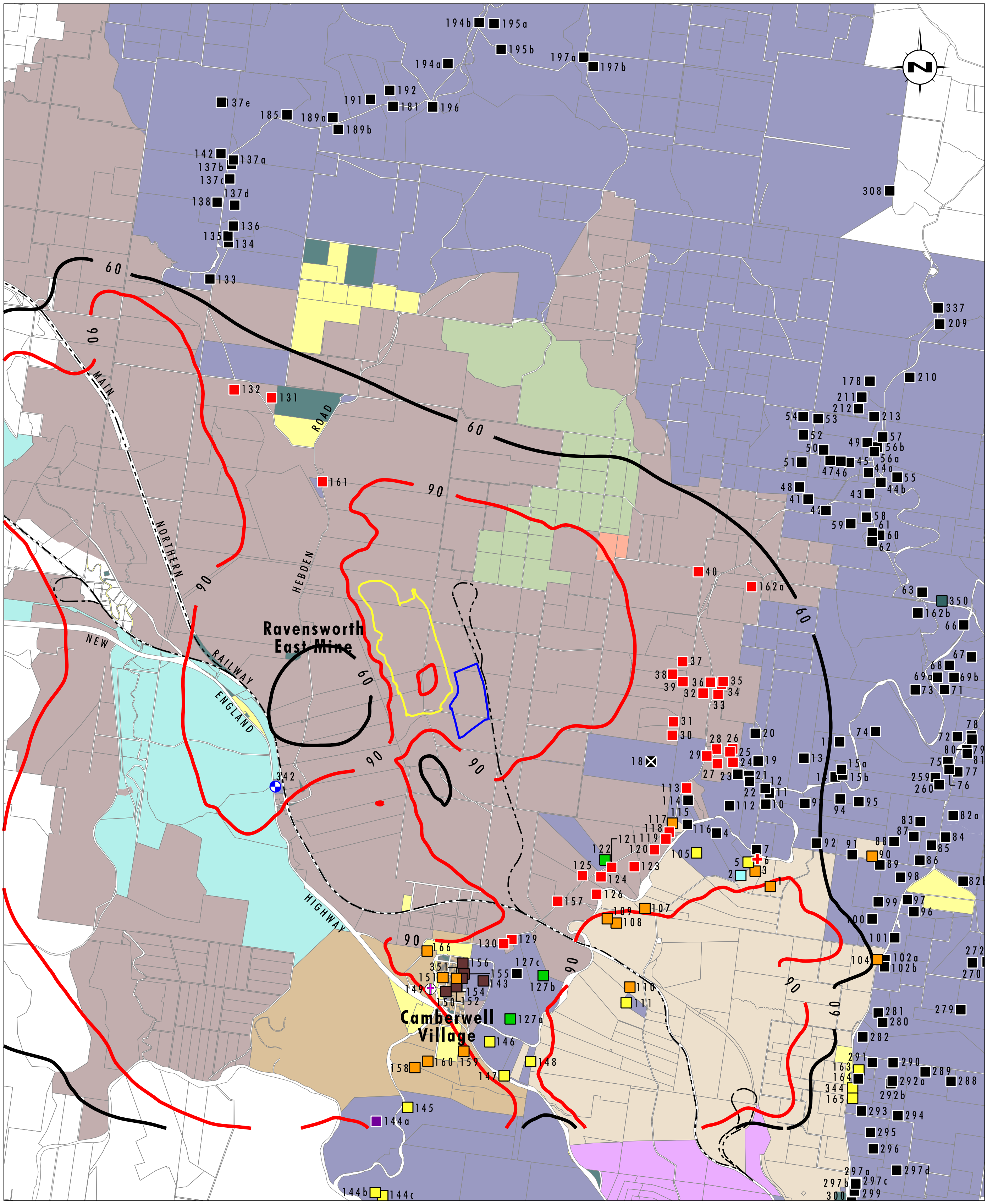
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mt Pleasant Primary School
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Predicted Annual Average Cumulative PM_{10} Contour
- 30 $\mu g/m^3$ Criteria Contour

FIGURE 6.6

Predicted Annual Average Cumulative PM_{10} Concentrations (conceptual mine plan 2016) (Year 4)

File Name (A4): R01/3081_038.dgn
20121218 16.55

Umwelt
Environmental Consultants



Source: Mount Owen (2012) PAE Holmes (2012)

0 1.0 2.5 5.0km
1:100 000

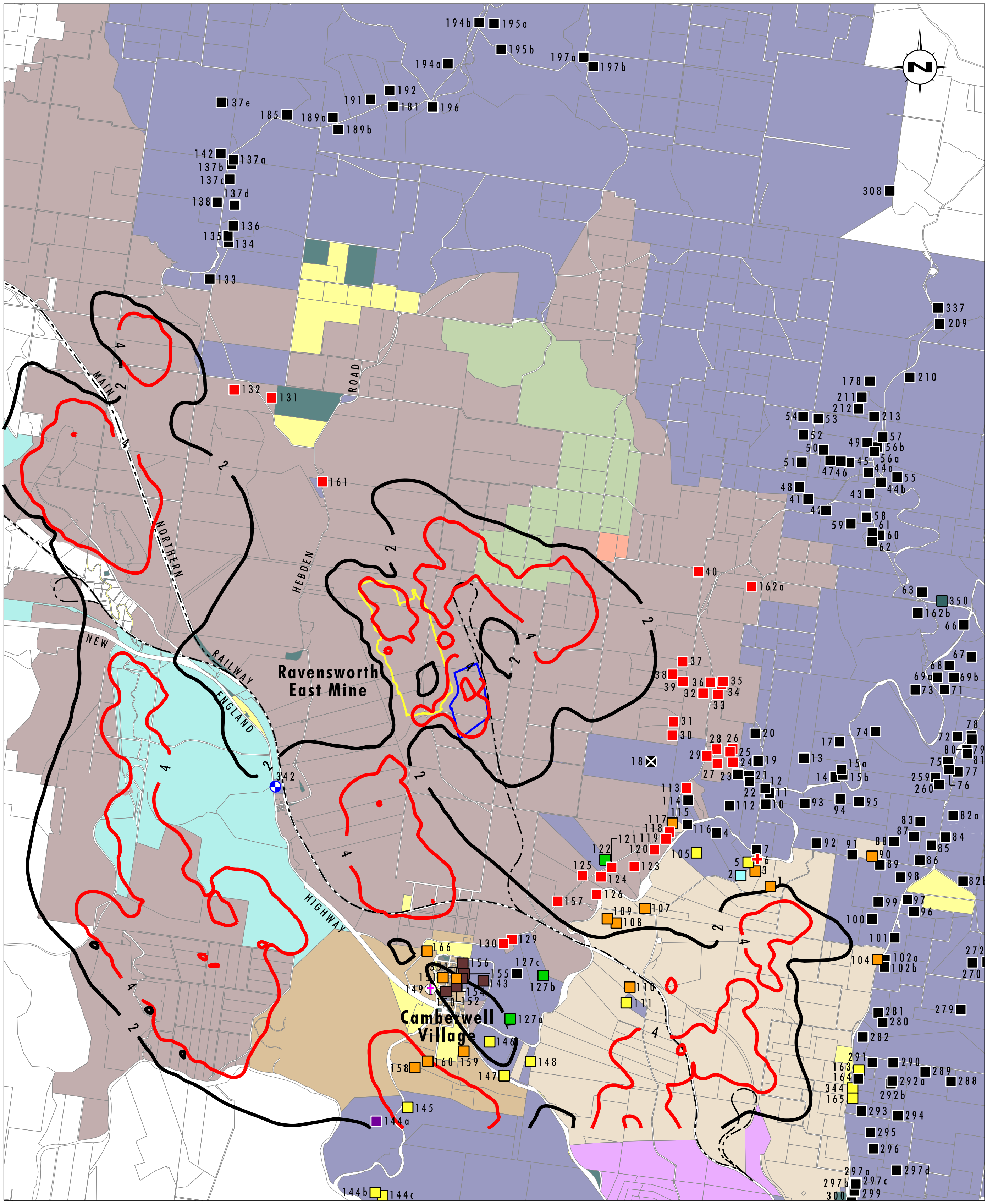
Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mt Pleasant Primary School
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Predicted Annual Average Cumulative TSP Contour
- 90 $\mu g/m^3$ Criteria Contour

FIGURE 6.7

Predicted Annual Average Cumulative TSP Concentrations (conceptual mine plan 2016) (Year 4)

File Name (A4): R01/3081_039.dgn
20121218 16.56



Source: Mount Owen (2012) PAE Holmes (2012)

0 1.0 2.5 5.0km
1:100 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Ashton Coal
- Crown Land
- Crown Land TSR
- Government Authority
- Integra Coal
- Macquarie Generation
- Xstrata
- Private
- Rixs Creek Mine
- State Forest
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mt Pleasant Primary School
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Predicted Annual Average Cumulative Dust Deposition Contour
- 4 g/m²/month Criteria Contour

FIGURE 6.8

Predicted Annual Average Cumulative Dust Deposition (conceptual mine plan 2016) (year 4)

File Name (A4): R01/3081_040.dgn
20121218 16.57

The simulation assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given 'modelled day'. Through sufficient repetitions, this yields a statistical estimate of the combined and independent effects of varying background and the contributions from the proposed modification to total PM_{10}.

From this analysis it was determined that the probability of cumulative 24-hour PM_{10} concentrations exceeding the criteria of 50 $\mu g/m^3$ is increased on average by approximately 2 per cent at the nearest residences. The proposed modification is therefore not considered a significant contributor to PM_{10} levels at receptors within the vicinity.

6.4.7 Air Quality Management and Monitoring Commitments

XMO will continue to manage air quality impacts at Ravensworth East Mine in accordance with the *Mount Owen Complex Air Quality and Greenhouse Gas Management Plan*. This plan implements a number of procedures to control dust emissions which may be generated from trafficable areas, coal preparation and handling, pre-strip operations, blasting, drilling and stemming. The existing air quality management measures include:

- Routine review of meteorological and dust risk forecast from the Hunter Valley Modelling system which includes two day forecasts of:
  - dust risk index;
  - dust transport (dusk risk contour plots); and
  - meteorological conditions (wind roses).
- watering or the application of chemical suppressants to active mining areas, and active haul roads that are subject to frequent vehicle movements;
- all drill rigs being equipped with dust control systems that are regularly maintained for effective use, and may include a combination of dust extractors, dust curtains, water injection systems and extraction systems;
- automatic sprays fitted to the dump hopper and crushing plant to minimise dust from coal processing activities;
- restricting or ceasing dust-generating activities during adverse meteorological conditions;
- minimising the area of disturbance by restricting vegetation clearing ahead of mining operations and rehabilitating mine spoil dumps as soon as practicable after mining; and
- restricting blasting activities to acceptable wind speed and direction periods such that impacts of dust and fume from blasting activities on private residences is minimised.

6.5 Groundwater Impact Assessment

A groundwater impact assessment has been undertaken by Sinclair Knight Merz (SKM) for the proposed modification, and is presented in full in **Appendix 5**.

6.5.1 Existing Groundwater Environment

There are two geological units which form the main aquifers surrounding the Ravensworth East Mine including:

- the alluvial aquifers associated with the drainages of the Hunter River and its tributaries including Bowman and Glennies Creeks; and
- the Wittingham Coal Measures coal seams.

The Hunter River alluvium is generally deeper and more transmissive than the alluvium of the smaller tributaries such as Bowmans or Glennies Creeks. The nearest creek to the RERR mining area is Swamp Creek and its associated colluvial and alluvial deposits. Much of these colluvial and alluvial deposits have been removed as part of the existing approved mining operations and the creek has previously been diverted. The basal coarse grained unit of the alluvial sequence forms the main aquifer of the alluvium in these systems and in places may be confined by the overlying fine grained terrace deposits. Hydraulic conductivity is known to vary significantly in each of these units of the alluvium, which appears to have been caused by palaeo-geomorphology and drainage conditions during deposition.

The hardrock aquifer associated with coal measures exhibit varying levels of groundwater storage and transmissivity. Within the coal measures, the most permeable horizons are the coal seams. Non-coal interburden strata generally exhibit permeability's which are one to two orders of magnitude less than that of the coal seams. Mining operations associated with the proposed modification will target the shallow coal seams of the Burnamwood formation.

Water quality (salinity) trends for the majority of the bores within the Mount Owen monitoring network (refer to **Figure 2.3**) show a stable trend based on the readings over the last five years with the exception of bores NPz1, NPz8, North, East and South located to the east of the Mount Owen Complex which show either increasing or decreasing trends. However bore NPz10 which is located in close proximity to the Ravensworth East Mine exhibits a flat trend, which indicates there has been no impact on groundwater quality from the existing Ravensworth East Operations. Monitoring results indicate that groundwater salinity ranges from 2,000 to 22,000 EC and pH is slightly alkaline however these are typical values for groundwater within the coal measures.

Searches of the NOW database of registered bores and wells undertaken as part of previous investigations at the Mount Owen Complex (MER 2008 and MER 2011), shows that there have been only three registered bores or wells drilled within the predicted zones of mining impacts which are not mine owned, most of which were in the alluvial aquifer. These registered bores or wells are located greater than 4 kilometres east of the Ravensworth East Mine and are sited within the shallow alluvium associated with Glennies Creek. The bores within the Ravensworth East Mine are owned by Xstrata and the majority of the registered bores within the surrounding area are now owned by Xstrata or other coal companies.

No groundwater dependant ecosystems have been identified in the RERR mining area or the West Pit Overburden Emplacement Area.

The Mount Owen Complex groundwater monitoring network consists of piezometers that have been installed at various depths in coal seams, interburden strata and the alluvial aquifers associated with Bowmans Creek and Glennies Creek (and their tributaries).

6.5.2 Numerical Groundwater Model

A regional numerical groundwater flow model has been developed as part of a broader investigation of groundwater impacts associated with Liddell Coal Operations, Ravensworth Surface and Underground Operations and the Mount Owen Complex. This model was developed to further understand the environmental impacts associated with the future development of the operations outlined above and to provide estimates of the changes in groundwater heads that will occur as a result of mine dewatering operations and changes to baseflow in the local creeks draining to the Hunter River.

This regional model was used to assess the impact of the proposed modification on the surrounding area including the predicted drawdown and associated impacts as a result of the proposed modification at various times during the future mining operations in addition to the estimated inflows to the RERR mining area. A summary of the regional model development is provided in **Appendix 5**.

6.5.3 Groundwater Impact Assessment Results

The coal measures in the vicinity of Ravensworth East Mine are partially depressurised as a result of mining activities across the region, particularly through mining activities at the Mount Owen Complex and Integra Underground Mine.

The groundwater impact assessment included the investigation of any potential for further impact as a result of the proposed modification in relation to aquifer pressure, loss of yield at existing water bore locations, leakage of shallow aquifer waters to deeper coal measures and any reduction of groundwater quality.

6.5.3.1 Loss of Groundwater Yield at Bore Locations

The groundwater modelling results provided in **Appendix 5** indicate that there will be negligible impact to any existing bores in the immediate vicinity of the RERR mining area as a result of the proposed modification as all identified bores are located greater than 4 kilometres east of the RERR Mining Area and are sited within shallow alluvium associated with Glennies Creek.

6.5.3.2 Leakage of Shallow Alluvial Aquifer Waters to Deeper Coal Measures

The nearest creek to the RERR mining area is Swamp Creek and its associated colluvial and alluvial deposits. Much of the colluvial and alluvial deposits have been removed as part of the existing approved mining operations and the creek has been previously diverted.

The underlying coal measures comprise layered strata of differing permeability. The presence of these layers naturally impedes leakage of groundwater from the overlying shallow sediments associated with the remnant alluvial deposits of Swamp Creek. While there is potential for leakage to occur along occasional joint and fracture zones, these zones are typically orientated parallel to local fold axes and therefore are unlikely to provide conduit pathways to the RERR mining area. Leakage through the interburden will also be negligible due to the very low hydraulic conductivity of sandstones, siltstones and shales, and the eastward dip (increasing depth) of sediments. Therefore, the opportunity for downward leakage as a result of the proposed modification is generally minimal.

The modelling results predict that groundwater inflows to the RERR mining area over the life of the proposed modification of up to approximately 1 ML/day. This rate is similar to the inflow rate for current operation in the West Pit. The current groundwater licences held by the Mount Owen Complex (refer to **Section 2.7.3**) will allow for the estimated inflow rates.

6.5.3.3 Groundwater Quality

The RERR mining operations are predicted to have minimal impact on groundwater quality. Monitoring results indicate that there has been no change to water quality as a result of the existing Ravensworth East operations (refer to **Section 6.5.1**) to date and this along with minimal leakage predicted, strongly suggests that future impacts to groundwater quality will also be negligible for the proposed modification.

One void will remain at the completion of mining and will be retained to provide for long term tailings emplacement associated with future mining operations within the Mount Owen Complex. The mixing of groundwater as the void or the emplaced tailings re-saturate is unlikely to impact the regional groundwater quality. Additionally, as part of the long term tailings strategy, this tailings emplacement area would be capped and rehabilitated once tailings emplacement is completed.

6.5.3.4 Groundwater Impacts on Ecology

The quality of the groundwater within the coal measures is considered to be poor and no obvious ecological system, with a particular dependency on groundwater within the coal measures has been identified.

6.5.3.5 Cumulative Impacts

The cumulative impacts from the existing mining operations surrounding and including the Ravensworth East Mine have contributed to the overall impact on the alluvial system baseflow, though the modelling results indicate that Ravensworth East has had minimal contribution to this existing impact. The numerical groundwater modelling indicates that the proposed modification will have negligible additional impact to the existing groundwater system. Additionally, the estimates of groundwater inflow to the RERR mining area is similar to the previous estimates based on the existing mining sequence included in the *Mount Owen Complex Water Management Plan* (XMO 2011), reflecting the small footprint of the mine with little impact on regional groundwater flows, refer to **Appendix 5**.

6.5.4 Summary of Potential Groundwater Impacts and Management Measures

The groundwater impact assessment has identified that the proposed modification will have minimal impact on groundwater yield, leakage, quality and groundwater dependant ecology. The modelled results are considered to be less than the Level 1 minimal impacts in accordance with the Aquifer Interference Policy and therefore additional management measures are not required as a result of the proposed modification.

XMO currently manage groundwater impacts at the Mount Owen Complex in accordance with the *Mount Owen Water Management* (XMO 2011), which incorporates the Mount Owen Complex Groundwater Monitoring Program, the Surface Water and Groundwater Response Plan and the Erosion and Sediment Control Plan.

A full review of the existing *Mount Owen Complex Water Management Plan* (XMO, November 2011) was undertaken and concluded that mining activities associated with the proposed modification can be appropriately managed in accordance with these existing management plans. As a result of the groundwater impact assessment the *Mount Owen Water Management Plan* (XMO November 2011) would also be updated to reflect the updated groundwater inflows associated with the RERR mining area.

Additionally, there has been a number of groundwater monitoring bores installed throughout 2012. The ongoing monitoring of these bores will be included in the *Mount Owen Complex Water Management Plan*.

6.6 Surface Water Assessment

6.6.1 Surface Water Context

The Mount Owen Complex water management system is integrated across the Ravensworth East, Mount Owen and Glendell mining operations and associated infrastructure. The Mount Owen Complex water management system also forms part of the Greater Ravensworth Water Sharing Scheme (GRWSS) which enables water transfers between the Mount Owen Complex, Liddell, Narama, Ravensworth North and Cumnock mining operations.

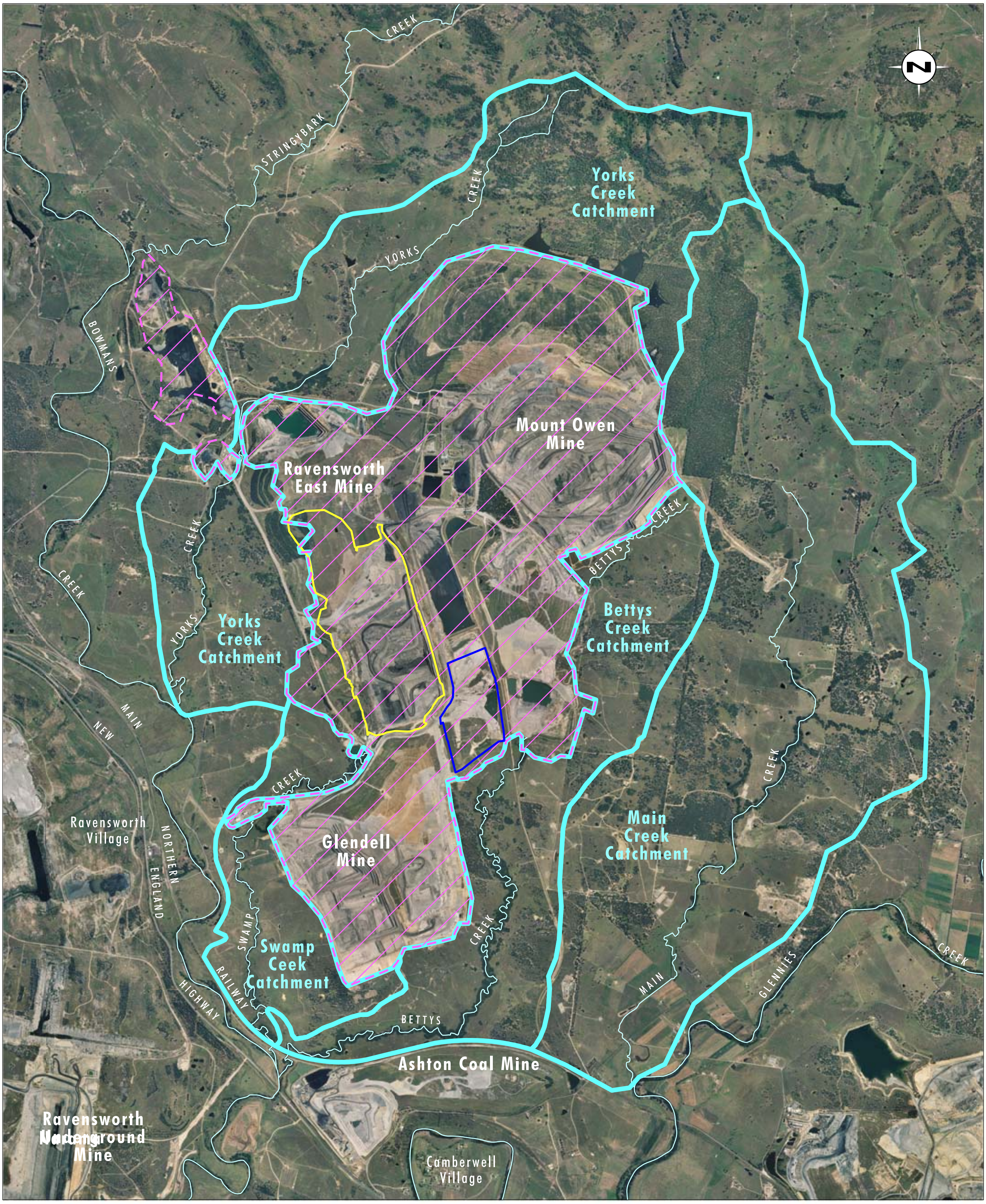
The GRWSS facilitates effective management of water across the participating sites, the segregation of water of different quality, enables the sharing and beneficial use of water between operations and helps to reduce the potential impacts associated with saline mine water discharge into the Hunter River system by reducing the amount of discharge required.

The RERR mining area and West Pit Overburden Emplacement Area is located within the Mount Owen Complex water management system and the catchment area of Bowmans Creek. Major tributaries of Bowmans Creek within the vicinity of the RERR mining area and the West Pit Overburden Emplacement Area include Yorks Creek, Swamp Creek and Bettys Creek. Catchments and sub-catchments for these waterways are illustrated on **Figure 6.9**. These catchment areas will not be modified during the life of the mining within the RERR mining area, with the exception of a minor change in the Yorks Creek catchment and associated minor change on the wider catchment of Bowmans Creek (refer to **Section 6.6.4**). A description of each watercourse is provided below:

- **Bowmans Creek** is a sixth order (Schedule 3)[1] watercourse and flows in a southerly direction to the Hunter River. Bowmans Creek is located on the western side of Hebden Road approximately 1.3 kilometres west of Ravensworth East Mine (refer to **Figure 6.9**). The natural catchment of Bowmans Creek has been reduced by mining operations. Although disturbed by agriculture and mining activities, Bowmans Creek has a sufficient contributing catchment to maintain flows under most climatic conditions.

- **Yorks Creek** is a third order (Schedule 2)[1] watercourse and flows in a south-west direction to Bowmans Creek. Yorks Creek is located to the north of Ravensworth East Mine (refer to **Figure 6.9**). The Yorks Creek catchment north and west of the Mount Owen Complex is mostly cleared and utilised for agricultural purposes. As Yorks Creek flows past Ravensworth East Mine it collects runoff from rehabilitated areas to the north-west of the current operations in the West Pit. Yorks Creek is an ephemeral watercourse, and is frequently dry. Yorks Creek currently flows past the Stage 2 Swamp Creek mine void to the west, the Stage 3 Ravensworth East void to the east and the former Ravensworth East workshop/ROM dump area (refer to **Figure 6.9**).

[1] Strahler ordering system, as described in *NSW Government Gazette no. 37* on 24 March 2006.



Source: Mount Owen (2012)

0 1.0 2.0 3.0km
1:60 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Mount Owen Complex Water Management System Catchment
- Creek Catchment
- Drainage Line

FIGURE 6.9

Catchment Boundaries

- **Swamp Creek** is a fourth order (Schedule 2)[1] watercourse and flows in a southerly direction to Bowmans Creek (refer to **Figure 6.9**). Swamp Creek is an ephemeral watercourse, and is frequently dry. A small residual catchment of Swamp Creek remains upslope of the Ravensworth East Mine and clean water from this residual catchment is directed through Ravensworth East Mine via a clean water diversion drain to the clean downstream catchment of Swamp Creek. Downstream of Ravensworth East Mine the Swamp Creek catchment is mostly cleared and utilised for agricultural purposes.

- **Bettys Creek** is a fourth order (Schedule 2)[1] watercourse located to the south-east of Ravensworth East Mine (refer to **Figure 6.9**) and flows in a south then westerly direction to Bowmans Creek. Bettys Creek catchment has been largely modified and incorporated into the Mount Owen Complex water management system. Approximately the upper third of the original Bettys creek catchment has been diverted east to Main Creek. The remaining catchment area of Bettys Creek is grazing land. Bettys Creek is an ephemeral watercourse, and flows only during storm events or after prolonged periods of rain.

6.6.2 Site Water Management Plan

The RERR mining area and the West Pit Overburden Emplacement Area is located within the Mount Owen Complex water management system. XMO propose to manage the proposed modification within the Mount Owen Complex water management system. The water management system objectives and monitoring and management methods are outlined in the current *Mount Owen Complex Water Management Plan* (WMP) (XMO 2011) which includes the following components:

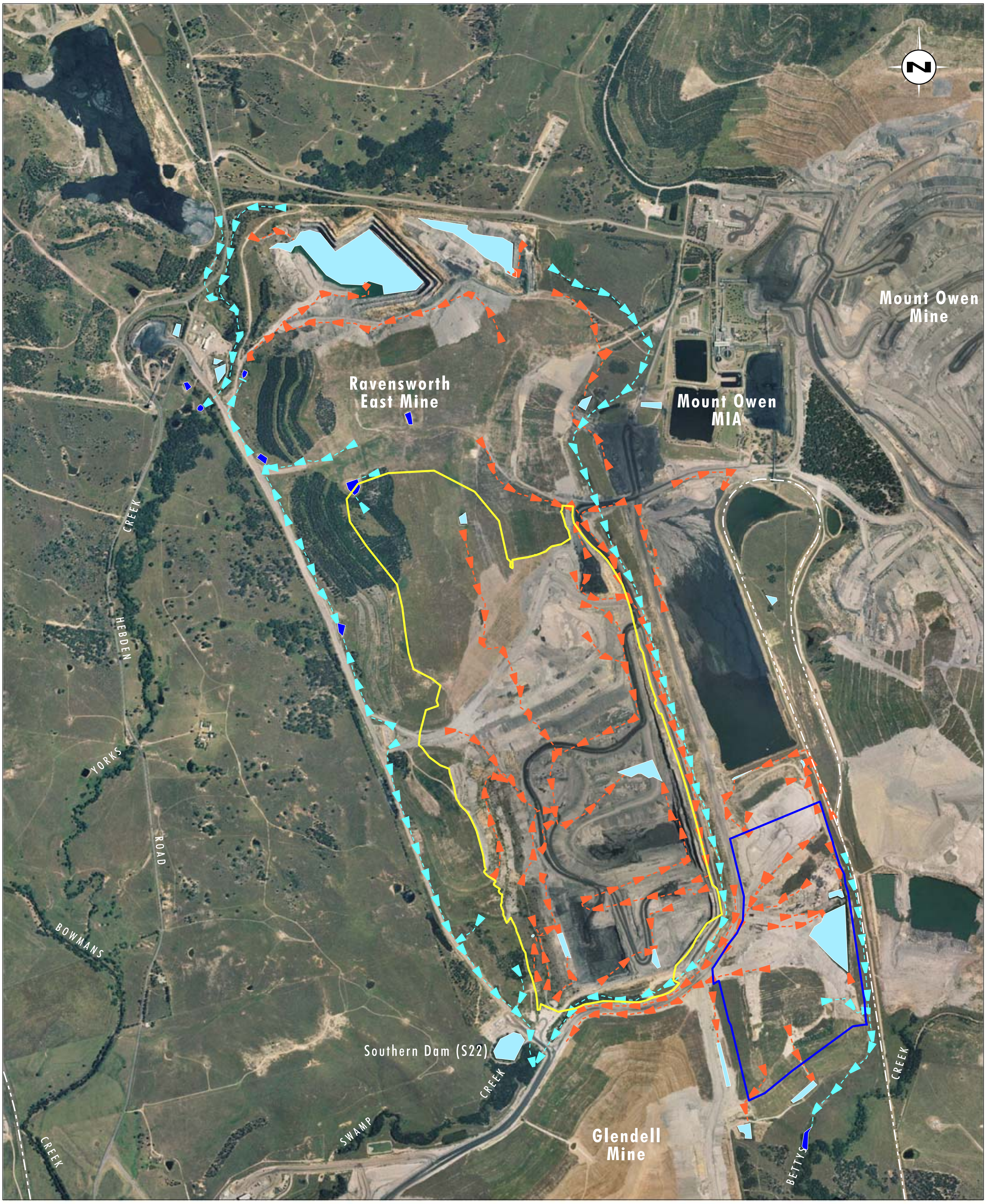
- Site Water Balance;
- Surface Water Monitoring Plan;
- Groundwater Monitoring Plan;
- Surface and Groundwater Response Plan; and
- Erosion and Sediment Control Plan.

The key components of the Mount Owen Complex water management system as it relates to Ravensworth East Mine are illustrated on **Figure 6.10**.

The overarching objectives of the Mount Owen Complex water management system included in the water management plan are as follows:

- prevent the contamination of clean water by mining activities;
- segregate clean waters away from active mining areas to reduce the volume of mine affected water requiring subsequent storage and treatment;
- minimise the discharge of pollutants from mining affected areas into the environment;
- manage approved water discharges to meet licence conditions;
- minimise adverse effects of mining activities on the surrounding areas;
- quantify the water used, stored and imported/exported;
- minimise the demand for high quality water in mining operations (including water sourced from Glennies Creek);

Umwelt
Environmental Consultants



Source: Mount Owen (2012)

0 0.5 1 1.25km
1:25 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Clean Water Dam
- Dirty Water Dam
- Clean Water Drain
- Dirty Water Drain

FIGURE 6.10

Existing Water Management System

File Name (A4): R01/3081_028.dgn
20120914 10.50

- minimise inflow into the pit void from the alluvium of Swamp and Bettys Creeks;
- maximise recycling and water sharing opportunities; and
- minimise discharges under Hunter River Salinity Trading Scheme (HRSTS).

6.6.3 Erosion and Sediment Controls

Erosion and sediment control measures currently implemented at Ravensworth East Mine are outlined in the existing *Mount Owen Complex Erosion and Sediment Control Plan* (ESCP) (XMO 2011) in accordance with the XCN standard (XCN SD ANN 0077 Erosion and Sediment Control Management), and follow the relevant guidelines for erosion and sediment control including:

- Managing Urban Stormwater Soils and Construction (the Blue Book) Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DCCEE 2008); and
- Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields (DIPNR undated).

The existing strategies and measures outlined in the Mount Owen Complex ESCP that will continue to be applied during the life of the proposed modification include clean diversion drains and banks, catch drains, silt fences, hydrocarbon oil booms, and sediment dams to manage and minimise potential impacts on site water quality and surrounding waterways.

6.6.4 Impacts on Surface Water Management

The potential impacts of the proposed modification on surface water resources have been assessed and compared to the surface water assessment presented in the *Ravensworth East Mine EIS* (ERM 1999) and the predicted site water balance has been compared to the water balance presented in the Water Management Plan.

The following potential surface water management impacts, as a result of the proposed modification, were identified as requiring assessment:

- changes to the mine plan requiring the potential relocation of components of the current surface water management system, including the clean and dirty water controls (refer to **Section 6.6.4.1**);
- possible changes to the site water balance (refer to **Section 6.6.4.2**);
- changes to the existing approved impacts on downstream surface water systems (refer to **Section 6.6.4.3**); and
- potential changes to water management within the proposed conceptual mine plan 2017 (Year 5) landform (refer to **Section 6.6.4.1**).

The assessment also considered any potential statutory and licensing changes resulting from the proposed modification (refer to **Section 6.6.4.4**).

6.6.4.1 Water Management System

All of the existing water management strategies for the Mount Owen Complex water management system will be maintained as part of the proposed modification.

As mining associated with the proposed modification progresses, the surface water drainage from the active mining area will be captured and managed within the existing Mount Owen Complex water management system. The West Pit Overburden Emplacement Area will increase in height and will be progressively rehabilitated, with all runoff captured and managed within the existing Mount Owen Complex water management system. When the rehabilitated West Pit Overburden Emplacement Area is sufficiently stabilised, it will be returned to the clean water catchment.

There are no significant changes proposed to key water management infrastructure currently utilised at Ravensworth East Mine. The key components of the water management system for the conceptual mine plan 2013 (year 1) and 2017 (year 5) are illustrated on **Figures 6.11** and **6.12** respectively.

There will be an increase in the Mount Owen Complex water management system catchment area of approximately 3.2 hectares associated with the proposed changes to the West Pit Overburden Emplacement Area. This increase in the extent of the Mount Owen Complex water management system will reduce the catchment area of Yorks Creek by approximately 3.2 hectares or 0.2 per cent. This increase in the catchment area of the Mount Owen Complex water management system will only occur whilst the 3.2 hectare area of the West Pit Overburden Emplacement Area is active. Clean water runoff will be returned progressively to the downstream catchment areas when the West Pit Overburden Emplacement Area has established rehabilitation (refer to **Section 6.10**).

XMO proposes to continue to manage surface water runoff by re-use of water within the mine water management system with excess water being treated and discharged as required in accordance with the Hunter River Salinity Trading Scheme (HRSTS) and site EPL, issued under the *POEO Act 1997*. Existing approval for licensed extraction from Glennies Creek and transfers within the GRWSS will also be utilised as required. XMO also proposes to continue to review the performance of the mine water management system throughout the life of the mine in accordance with the current Water Management Plan.

The erosion and sediment control measures required for the proposed modification to control the quality of runoff will be consistent with the existing controls as outlined in the currently approved *Mount Owen Complex Erosion and Sediment Control Plan*, as discussed in **Section 6.6.3** above.

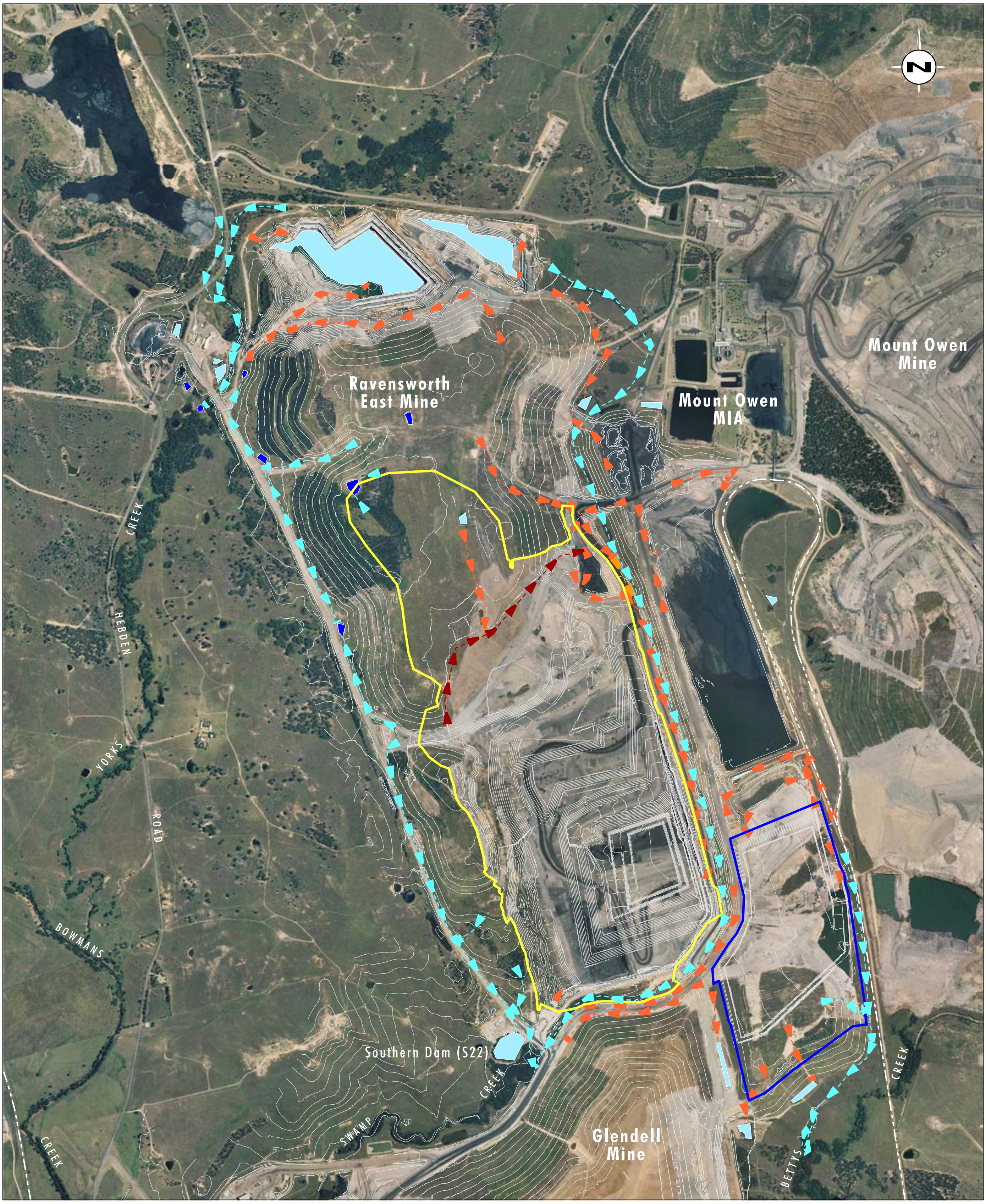
6.6.4.2 Water Balance

A water balance assessment has been undertaken by Gilberts and Associates Pty Ltd for the proposed modification, and is presented in full in **Appendix 6**.

Current Water Balance

The inflows to the Mount Owen Complex water balance (including Ravensworth East Mine) include rainfall, runoff, groundwater inflow, licensed extraction (Glennies Creek) and transfers from the Greater Ravensworth Water Sharing Scheme (GRWSS). Water is also recovered from tailings water bleed and re-used in the Mount Owen Complex mine water management system.

Umwelt
Environmental Consultants



Source: Mount Owen (2012)
Note: WMS only shown within Project Area
Contour Interval 5m

0 0.5 1 1.25km
1:25 000

Legend

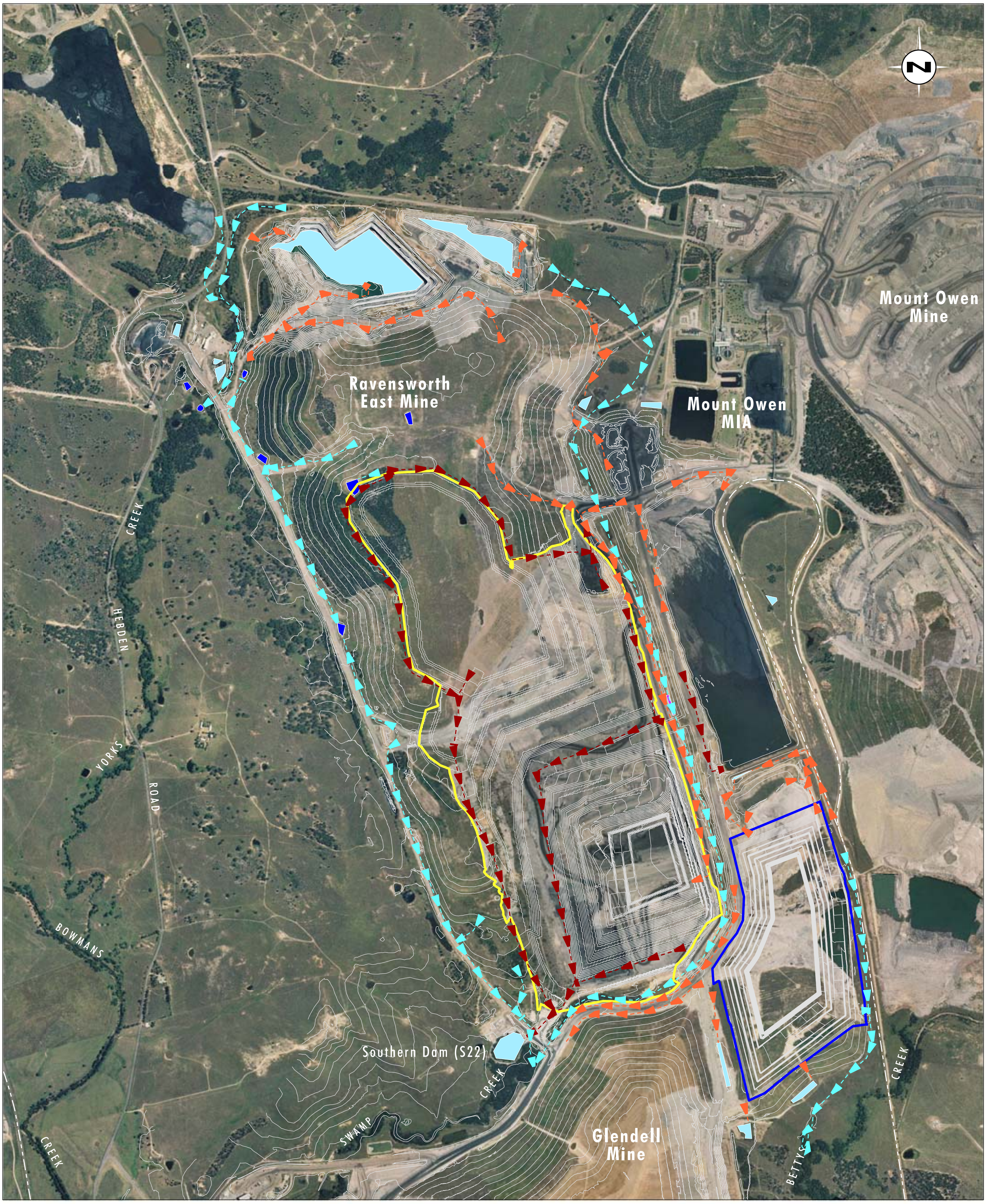
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Clean Water Dam
- Dirty Water Dam
- Clean Water Drain
- Dirty Water Drain (existing)
- Dirty Water Drain (proposed)

FIGURE 6.11

Conceptual Mine Plan 2013 (Year 1) Proposed Water Management System

File Name (A4): R01/3081_026.dgn
20120920 13.24

Umwelt
Environmental Consultants



Source: Mount Owen (2012)
Note: WMS only shown within Project Area
Contour Interval 5m

0 0.5 1 1.25km
1:25 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Clean Water Dam
- Dirty Water Dam
- Clean Water Drain
- Dirty Water Drain (existing)
- Dirty Water Drain (proposed)

FIGURE 6.12

Conceptual Mine Plan 2017 (Year 5)
Proposed Water Management System

File Name (A4): R01/3081_027.dgn
20120920 13.27

Water outflows from the water balance include CHPP use, haul road dust suppression, evaporation from storage dams and transfers to the Greater Ravensworth Water Sharing Scheme (during wet periods). XMO also discharge surplus water when required in accordance with the Mount Owen EPL 4460 via the HRSTS.

The Mount Owen Complex currently operates with a gross water deficit with water sourced from Glennies Creek and the Greater Ravensworth Water Sharing Scheme to meet water deficits.

A water balance for the Mount Owen Complex water management system was presented in the *Mount Owen Complex Water Management Plan (XMO 2011)*. Since the preparation of the WMP additional improvements and updates have been made to the water balance model.

Water Balance Modelling Results

The water balance model operates on a daily time step and simulates the remaining mine life using the full period of available climatic data for the region. The model includes 115 possible climatic "realisations" which are simulated using climatic records to generate the average ML/year system inflows and outflows and are summarised in **Table 6.16**. The Water Balance Report (Gilbert & Associates 2012) is included as **Appendix 6**.

The results in **Table 6.16** indicate that the proposed modification will have negligible impact on the overall site water balance.

Table 6.16 – Modelled Average System Inflows and Outflows

Inflows	**Average Volume (ML) Without RERR**	**Average Volume (ML) With RERR**
Inflows		
Runoff	2414	2529
Tailings Water Bleed	2596	2774
Groundwater	537	584
Total Inflows	**5547**	**5887**
Outflows		
Evaporation	917	950
CHPP Supply	4703	5023
Haul Road Supply	832	830
Total Outflows	**6452**	**6803**
Gross Water Balance[1]	**-905**	**-916**
Water Sourcing and Discharges		
Greater Ravensworth Water Sharing Scheme (sourced from)[2]	1812	1766
Greater Ravensworth Water Sharing Scheme (exported to)[2]	1714	1857
Glennies Creek	147	214
Spill[3]	28	31

Note 1: With no water sourcing or discharges from the WMS.
Note 2: Transfers to and from the WMS via the GRWSS occur to meet daily/monthly fluctuations in water supply and demand across the Mount Owen Complex.
Note 3: Refers to spills during major or prolonged storm events, for example during a repeat of the June 2007 storm event (approximately 1 in 80 year event at Mount Owen) and is equivalent to average spills over the mine life for the 115 possible climatic "realisations".

The modelled average system inflows show that runoff and tailings water contributes to the majority of inflows to the water management system and CHPP use makes up approximately 58 per cent of the outflows, with and without the proposed modification. The modelling results also indicate that the inflows and outflows are approximately balanced from the Greater Ravensworth Water Sharing Scheme. It should be noted that in dry periods the Greater Ravensworth Water Sharing Scheme provides an important inflow source, while in wet periods, also provides an option to transfer water as an alternative to HRSTS discharge and is only a small outflow component on average.

In terms of potential impacts on the Mount Owen Complex water balance associated with the project the Mount Owen Complex mine water management system area is largely unaffected by the proposed modification in terms of catchment size, with only a slight change in the north-west corner of the operational surface water management system boundary (refer to **Section 6.6.4.1**). In addition, it should be noted that:

- the increase in the mine water management system area is approximately 3.2 hectares and is equivalent to approximately 2 ML/year based on average regional runoff rates;
- there is predicted groundwater inflows to the RERR mining area over the life of the proposed modification of up to approximately 1 ML/day; and
- the production associated with the proposed modification of typically 1.3 Mtpa but ranging up to 2.5 Mtpa will result in additional water being used in the CHPP and as lost to product and tailings of up to approximately 400 ML/year (as a result of mining the additional 6 Mt).

The predicted changes to the Mount Owen Complex water balance with the proposed modification will result in a slight increase in inflows (runoff, tailings water bleed and groundwater) and a slight increase in outflows (evaporation, spill and CHPP supply). These changes are considered to be within the expected margin of error of the water balance (refer to **Table 6.16**).

Therefore the proposed modification is expected to have negligible impact on the predicted Mount Owen Complex water balance, with the potential impacts within the current fluctuations of the existing approved water balance (refer to **Table 6.16**).

6.6.4.3 Downstream Surface Water Environment

Annual Flow Volumes

The catchment area of the Mount Owen Complex water management system will increase by approximately 3.2 hectares associated with the proposed modification to the West Pit Overburden Emplacement Area. This increase in the extent of the Mount Owen Complex water management system would reduce the catchment area of Yorks Creek by approximately 3.2 hectares. The current catchment area of Yorks Creek is approximately 1430 hectares. As such the predicted decrease in catchment area is approximately 0.2 per cent. The proposed modification is expected to have negligible impacts on annual flow volumes in the downstream environment and on potential water users. In addition, it is considered that the proposed modification will result in no changes to the approved impacts as discussed in the *Ravensworth East Mine EIS* (ERM 1999).

Flooding

The majority of the proposed modification is located within the existing Mount Owen Complex water management system. The key change associated with the proposed modification will be a reduction in the catchment area of Yorks Creek by approximately 3.2 hectares or 0.2 per cent with runoff from this area being captured within the Mount Owen Complex water management system. This could potentially translate to a minor reduction in flooding impacts in Yorks Creek, but due to the minor change in total catchment, it is considered that the proposed modification will have a negligible impact on flooding in Yorks Creek and downstream creek systems. In addition, it is considered that the proposed modification will result in no changes to the approved impacts as discussed in the *Ravensworth East Mine EIS* (ERM 1999).

Water Quality

As the majority of the area associated with the proposed modification is located within the boundary of the current Mount Owen Complex water management system and all operations are proposed to be consistent with the existing *Mount Owen Complex Water Management Plan* and associated *Mount Owen Complex Erosion and Sediment Control Plan,* it is considered that there will be negligible change to the impact on water quality in downstream surface water systems. As such it is considered that the proposed modification will result in no changes to the approved impacts as discussed in the *Ravensworth East Mine EIS* (ERM 1999) and provided for by the existing *Mount Owen Complex Water Management Plan*.

6.6.4.4 Statutory Requirements, Guidelines and Licences

The *Water Management Act 2000* regulates the use and interference with surface water and groundwater in NSW. The *Water Management Act 2000* applies to water sources which are governed by an operational Water Sharing Plan. Under Part 3 of the *Water Management Act 2000*, a Water Sharing Plan may be prepared for the management of water resources in a specified area. Where a Water Sharing Plan is not in place, the *Water Act 1912* is still applicable.

The surface waters and the associated alluvial aquifers of Yorks Creek, Swamp Creek and Bettys Creek catchment areas are included in the Jerrys Water Source within the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (2009) and consequently are governed by the *Water Management Act 2000*, while the groundwater associated with the hard rock aquifers; that is, hard rock overlying and underlying the coal seams and the coal seams themselves, is governed by the *Water Act 1912*.

The existing Water Sharing Plan and Hunter River Salinity Trading Scheme is not affected by extraction of water from, or the discharge of water to the Hunter River by the proposed modification. In addition, there are expected to be negligible changes to the site water balance as a result of the proposed modification. XMO will continue to operate within the existing statutory requirements, guidelines and licensing for surface water extraction and discharges.

As discussed in **Section 2.7.3** a range of surface and groundwater licences for Ravensworth East have been issued to XMO by New South Wales Office of Water (NOW). None of these licences will be affected by the proposed modification. In addition, the proposed modification is not expected to require any additional water access licences or modifications to existing licences. As such, the proposed modification will comply with the rules of Jerrys Water Source within the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (2009).

6.6.5 Summary of Potential Surface Water Impacts and Management Methods

The surface water assessment for the proposed modification indicates that:

- changes to the mine plan, including pit and overburden emplacement area and associated water management controls, can be managed in accordance with the current existing site water management strategies;
- the proposed modification will result in negligible changes to the site water balance;
- there will be no impacts on flood flows in Bowmans Creek as a result of the proposed modification;
- there will be no changes to water quality in Bowmans Creek as a result of the proposed modification;
- the proposed modification will have negligible impacts on annual flow volumes in downstream watercourses compared to the approved impacts; and
- Ravensworth East Mine will continue to operate in accordance with the relevant water planning policies/plans and legislation, including relevant licensing requirements under the *PoEO Act 1997*, *Water Act 1912* and the *Water Management Act 2000*.

Based on the conclusions of the assessment, XMO proposes to continue to manage surface water for the proposed modification in accordance with the currently approved *Mount Owen Complex Water Management Plan* as follows:

- all of the existing water management strategies for the Mount Owen Complex water management system will be maintained as part of the proposed modification;
- XMO proposes to continue to manage surface water runoff by re-use of water within the Mount Owen Complex mine water management system;
- the key water management system infrastructure currently utilised within Ravensworth East Mine will continue to be used; and
- the erosion and sediment control measures required for the proposed modification to control the quality of runoff will be consistent with the existing controls and performance review measures as outlined in the *Mount Owen Complex Erosion and Sediment Control Plan* (XMO 2011).

6.7 Ecology

A comprehensive ecological assessment has been undertaken to assess the impacts of the proposed modification on ecological values. The ecological survey and assessment has been undertaken in accordance with the requirements of the *Threatened Species Conservation Act 1995* (TSC Act), the *Environmental Planning and Assessment Act 1979* (EP&A Act), the *Fisheries Management Act 1994* (FM Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

6.7.1 Background and Ecological Context

Significant ecological survey and assessment has been undertaken at the Mount Owen Complex for previous development approvals and as part of the site's annual fauna monitoring program (Forest Fauna Surveys et al. 2011; Umwelt 2003; Umwelt 2007; Umwelt 2009). Fauna monitoring for the Mount Owen Complex has identified a total of 259 fauna species comprising 164 birds, 52 mammals, 16 frogs and 27 reptiles, of which 28 are listed as threatened species. Based on vegetation mapping undertaken for the *Biodiversity and Land Management Plan* (Umwelt 2009) and preliminary vegetation mapping within Mount Owen Complex, 10 vegetation communities have been previously mapped of which two are non-native communities (rehabilitation and planted areas) and three are listed under the TSC Act as Endangered Ecological Communities (EECs). Vegetation communities known to occur in Mount Owen Complex (Umwelt 2009) include:

- Central Hunter Box – Ironbark Woodland EEC;
- Central Hunter Bulloak Forest Regeneration;
- Central Hunter Ironbark – Spotted Gum – Grey Box Forest EEC;
- Central Hunter Ironbark – Spotted Gum – Grey Box Forest (planted);
- Central Hunter Swamp Oak Forest;
- Hunter Lowlands Red Gum Forest EEC;
- Hunter Valley River Oak Forest;
- Planted areas;
- Rehabilitation; and
- Derived grassland.

The results of these substantive ecological surveys have been used to inform this ecological assessment, including the impact assessment. A site inspection was also undertaken to provide information relating specifically to the RERR mining area and the West Pit Overburden Emplacement Area (ecological study area).

The ecological study area for the environmental assessment includes the RERR mining area and the West Pit Overburden Emplacement Area, as shown on **Figure 6.13**, and entirely comprises previously disturbed land. The ecological study area does not include native vegetation or native fauna habitats.

6.7.2 Flora Surveys and Fauna Habitat Assessment Methodology

In order to identify all potential threatened species, endangered populations and Threatened Ecological Communities (TECs) with the potential to occur in the ecological study area, an assessment of relevant ecological databases was completed. These database sources comprised:

- a 10 kilometre radius search from the centre of the ecological study area of the Office of Environment and Heritage (OEH) Atlas of NSW Wildlife (May 2012); and

Umwelt
Environmental Consultants

Source: Mount Owen (2011)

0 250 500 750m
1:15 000

Legend

- West Pit Overburden Emplacement Area
- RERR Mining Area
- Habitat Assessment
- Green and Golden Bell Frog Habitat Assessment

FIGURE 6.13

Ecological Site Inspections

- a 10 kilometre radius search from the centre of the ecological study area of the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) Protected Matters Search Tool (May 2012).

Records from these database searches were combined with records derived through literature reviews and professional opinion to identify the range of potentially occurring threatened species. The identification of potentially occurring threatened species was then used to assist in the development of appropriate survey methods. The results of the database searches are compiled in Tables 1 and 2 of **Appendix 7**.

6.7.2.1 Flora Survey Methodology

An assessment of the vegetation communities occurring in the ecological study area (299 hectares) was undertaken on 23 May 2012. Habitat assessments were undertaken by two ecologists to determine the floristic composition of the communities. The location of habitat assessments completed within the ecological study area is provided on **Figure 6.13**. As outlined in **Section 3.4.3**, the proposed RERR mining area was re-located to the north and as such one green and golden bell frog habitat assessment and one fauna habitat assessment site now occur outside of the ecological study area. The information gathered from these assessments is considered to be representative of the habitats and communities identified within the ecological study area and data collected at these locations has been included in this assessment.

Habitat assessments were used primarily to assist in the delineation and refinement of vegetation mapping due to the highly disturbed nature of the ecological study area. Dominant, common and some uncommon plant taxa were recorded within each vegetation community along meandering transects, carried out at each location. Threatened flora species known to occur in the local area were also targeted during habitat assessments.

The habitat assessments utilised a qualitative sampling approach, as this method was designed to allow rapid collection of non-quantitative species dominance data across the ecological study area. A meandering technique was selected over the plot-based method since the amount of replicate plots that could have been sampled within each vegetation unit was not considered necessary due to the lack of native vegetation communities.

6.7.2.2 Fauna Habitat Assessment

As native vegetation communities and native fauna habitats were not identified in the ecological study area, opportunistic fauna observations were undertaken to identify bird, mammal, reptile and amphibian species that occur within and surrounding the ecological study area. Signs of faunal activity such as diggings, tracks, nests, dreys, feathers, hairs and scats were also recorded.

A general habitat assessment was also undertaken to assess valuable features of habitat such as the presence of hollow bearing trees, logs and the potential for suitable habitat to provide breeding, nesting, feeding and roosting resources for native species, including threatened species. The location of fauna habitat assessments undertaken in the ecological study area is shown on **Figure 6.13**.

6.7.2.3 Biases and Limitations

The survey was influenced by limitations in time and by seasonal factors as the survey was conducted during autumn and over a one day period. The use of consistent surveyors for the sampling effort helped to minimise observer bias which may occur when surveys are conducted by more than one surveyor.

For herbaceous and graminoid species, such as those belonging to the families Asteraceae and Poaceae, the allocation of specimens to sub-specific levels was affected by the availability of adequate flowering of fruiting material.

Despite the inherent bias and limitations of ecological surveys, sufficient survey and assessment was conducted as part of the proposed modification in order to accurately document the ecological features and values of the ecological study area and to determine the likely presence of threatened species, endangered populations and EECs that may require assessment as part of the proposed modification.

6.7.3 Flora Species and Vegetation Communities

A total of 21 plant species were recorded within the ecological study area comprising 7 native species and 14 introduced species. One aquatic species, cumbungi (*Typha orientalis*), was recorded in the ecological study area, associated with two sediment and erosion control dams. A list of all plant species recorded is provided in **Appendix 7**. No threatened flora species were recorded in the ecological study area and due to the highly disturbed nature of the site, none are expected to occur.

6.7.3.1 Vegetation Communities

Rehabilitation (Grassland Complex)

This vegetation community occurred across the majority of the rehabilitated portions of the ecological study area containing a low diversity of grass and shrub species (refer to **Figure 6.14**). The shrub cover was sparse and dominated by scattered juvenile sickle wattle (*Acacia falcata*) and other planted *Acacia* sp. The dense ground cover is largely dominated by exotic grasses including Rhodes grass (*Chloris gayana*) kikuyu (*Pennisetum clandestinum*) and other weeds including purpletop (*Verbena bonariensis*) and cobblers pegs (*Bidens pilosa*). An example of the Rehabilitation (Grassland Complex) is shown on **Plate 1**.

Rehabilitation (Forest Complex)

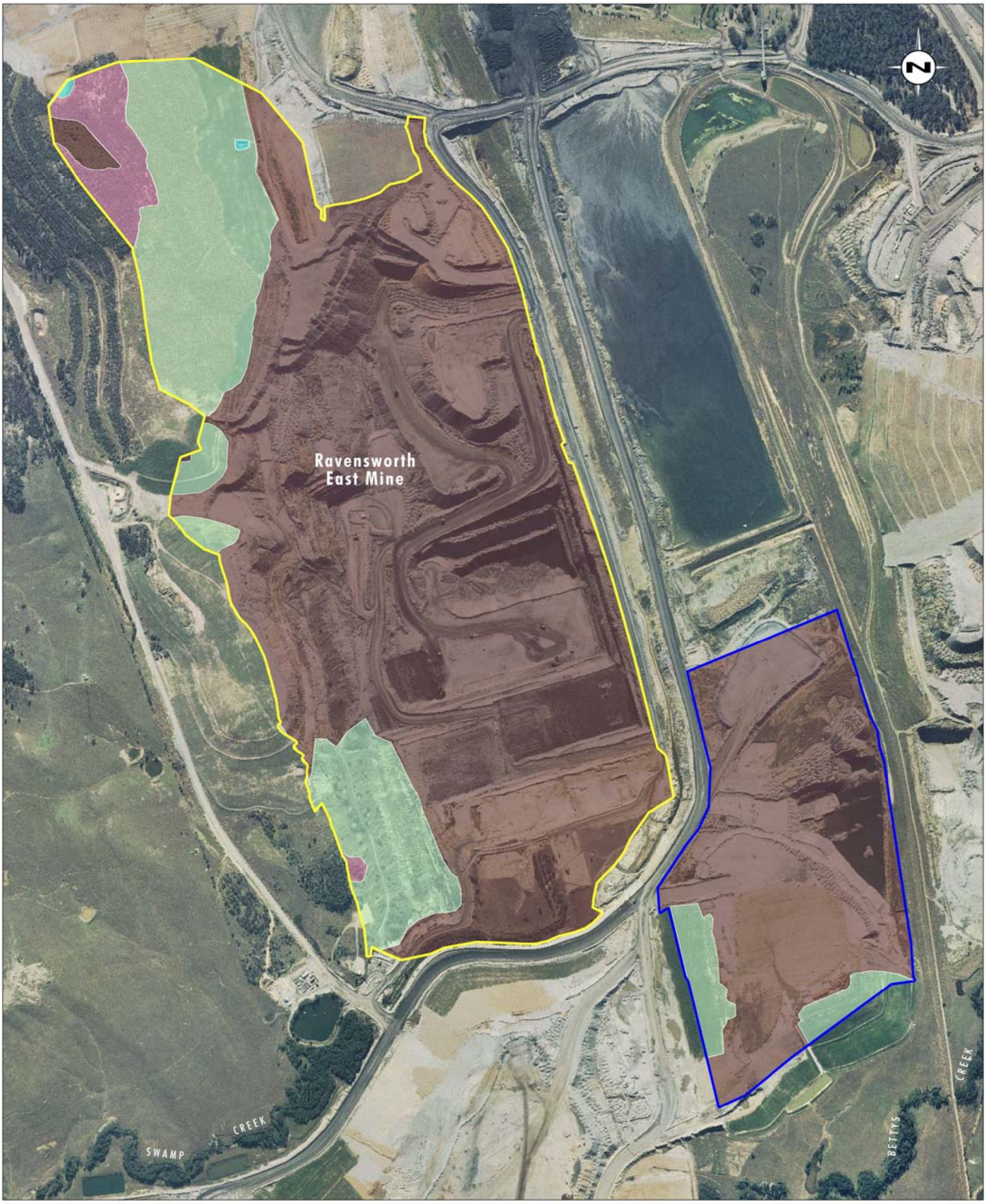
Immature rehabilitation (Forest Complex) was recorded on a ridgeline to the north-west of the current West Pit where efforts have been made to create a native forest vegetation community. The tree species occurring within this community included spotted gum (*Corymbia maculata*) and narrow-leaved ironbark (*Eucalyptus crebra*).

Given the relatively young age of this rehabilitation, no natural thinning had taken place in the canopy and therefore the shrub layer and understorey structure and diversity was considered poor. The shrub layer consisted of the occasional *Acacia* species however these scattered individuals were defoliating under stress due to being shaded out by taller eucalypts.

Bare soil was common under the areas of complete canopy shading while the edges and cleared areas within the immature Rehabilitation (Forest Complex) contained a similar understorey composition to that of adjacent Rehabilitation (Grassland Complex) including Rhodes grass (*Chloris gayana*) and kikuyu (*Pennisetum clandestinum*). The immature Rehabilitation (Forest Complex) is shown on **Plate 2**.

6.7.3.2 Fauna Habitat Description

The ecological study area contains low quality fauna habitat and is not expected to provide an important area of habitat for native fauna species.



Source: Mount Owen (2011)

0 250 500 750m
1:15 000

Legend
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Rehabilitation Grassland Complex
- Rehabilitation Forest Complex
- Dam
- Disturbed Land

FIGURE 6.14

Vegetation Communities

PLATE 1
Rehabilitation (Grassland Complex)

PLATE 2
Rehabilitation (Forest Complex)

Rehabilitation (Forest Complex) Habitat

The immature rehabilitation (Forest Complex) habitat was recorded across 7.3 hectares of the ecological study area (refer to **Figure 6.14**). The relatively young age of the rehabilitation (Forest Complex) and resultant lack of natural thinning has resulted in limited habitat structure and diversity. This limits the potential for native fauna species to occur and a lack of tree hollow development prevents hollow dependent species from occurring as residents.

The eucalypt species present within the immature rehabilitation (Forest Complex) habitat may provide a seasonal foraging resource for a number of nectarivorous bird species, as well as insectivorous birds. The value of the habitat is limited however by the isolated nature of the habitat, with expanses of disturbed land; including actively mined areas in close proximity (refer to **Figure 6.14**).

The immature Rehabilitation (Forest Complex) also lacks a diversity of habitat features in the ground layer with scattered logs and rocks or other ground layer habitat not recorded during the site inspection. Similarly, permanent water sources were not identified which limits the potential for a range of reptile and amphibian species to occur.

Rehabilitation (Grassland Complex) Habitat

Grassland habitat has been constructed within the ecological study area through rehabilitation activities. Approximately 53.1 hectares of grassland habitat was identified in the ecological study area which is expected to provide limited habitat to native fauna species (refer to **Figure 6.14**). The grassland habitat was established from the 1990s generally occurs on shaped overburden and is dominated by introduced species. The grassland habitat lacks natural habitat complexity by way of leaf litter, debris such as fallen trees, logs and rocks or rocky outcrops. The areas of grassland may provide a marginal foraging resource for macropods and some species of micro-bats suited to foraging over open areas. Small mammals are considered unlikely to occur due to the highly disturbed nature of the habitat.

Aquatic Habitat

Two dams were recorded in the ecological study area which form part of the site water management system and have been constructed by the mine for sediment control purposes. The dams were found to be highly turbid, and generally lacked significant aquatic and semi aquatic fringing vegetation and surrounding native terrestrial vegetation which decreases the value of the habitat of these dams for native species. The habitat associated with the dams is shown on **Plates 3** and **4**. Water management practices require these dams to be cleaned out or pumped out as required and any habitat value is intermittent or temporary.

6.7.3.3 Fauna Species

A total of 259 fauna species have been identified within the Mount Owen Complex (Murray and Clulow 2010), however only seven fauna species were recorded opportunistically in the ecological study area, including:

- Australian magpie (*Gymnorhina tibicen*);
- willie wagtail (*Rhipidura leucophrys*);
- black-shouldered kite (*Elanus notatus*);
- Australian raven (*Corvus coronoides*);

PLATE 3
Western Dam

PLATE 4
Eastern Dam

- nankeen kestrel (*Falco cenchroides*);
- masked lapwing (*Vanellus miles*); and
- common eastern froglet (*Crinia signifera*).

In addition, the eastern grey kangaroo (*Macropus giganteus*) was recorded in proximity to the ecological study area.

6.7.3.4 Threatened Fauna Species

No threatened fauna species were recorded in the ecological study area during the site inspection and threatened species habitat is considered marginal.

None of the threatened fauna species known to occur at Mount Owen Complex were recorded in the ecological study area. Fauna monitoring undertaken at two rehabilitation sites in the northern rehabilitation area of Mount Owen Mine approximately four kilometres from the ecological study area (Mahony and Clulow 2011) were examined to determine the range of threatened fauna species that have been previously identified occurring in mine rehabilitation at Mount Owen Complex. Of the threatened species known, or expected to occur in the vicinity of the ecological study area (refer to **Appendix 7**), the speckled warbler (*Chthonicola saggitata*, hooded robin (*Melanodryas cucullata cucullata*), diamond firetail (*Stagonopleura guttata*), greater broad-nosed bat (*Scoteanax rueppellii*) and spotted-tailed quoll (*Dasyurus maculatus*) have all been recorded in a rehabilitation monitoring site at Mount Owen Mine. This site is located adjacent to intact native vegetation of Ravensworth State Forest and it is expected that these species are using the rehabilitation site as part of a broader foraging/home range that is centred on native woodland/forest habitat. Threatened species recorded using mine rehabilitation habitat that is isolated from adjoining intact vegetation includes three highly mobile bat species including the eastern bent-wing bat (*Miniopterus schriebersii oceanensis*) and eastern freetail bat (*Mormopterus norfolkensis*), both of which are recorded frequently across a range of habitats within Mount Owen Complex; and the yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*) which has been tentatively recorded.

Based on these monitoring results, it is considered unlikely that the fauna habitats identified in the ecological study area will provide habitat for woodland bird species known to occur in the Mount Owen Complex, due to the isolated nature of the habitats in relation to the more natural habitats associated with native woodland and forest communities that occur within the Mount Owen Complex. Highly mobile threatened bat species are considered moderately likely to forage within the ecological study area, although roosting habitat in the form of tree hollows or man-made roosting structures such as buildings or bridges were not identified. An assessment of significance in accordance with the TSC Act and EPBC Act is included in **Appendix 7**, and the results of the assessment are discussed below.

6.7.4 Ecological Impact Assessment

The proposed modification, as described in **Section 3.0** will result in the loss of approximately 60.4 hectares of mine rehabilitation, including 7.3 hectares of immature Rehabilitation (Forest Complex), 53.1 hectares of Rehabilitation (Grassland Complex) and two sediment and erosion control dams and associated fauna habitats. The impact of the proposed modification on ecological features and values identified in the ecological study area are discussed in the following sections.

6.7.4.1 Impact on Flora Species

A total of 21 flora species were recorded in the ecological study area, of which 67 per cent are not native to the area. The diversity of species recorded in the ecological study area is considered likely to be lower than in surrounding areas of intact vegetation due to the extent of disturbance within the ecological study area and the immature and man-made nature of the rehabilitation communities.

The proposed modification is not expected to result in a substantial loss of flora species diversity from the Mount Owen Complex or the local area and vegetation communities will be reinstated in the final landform resulting in no net loss of native flora species.

6.7.4.2 Impact on Vegetation Communities

The proposed modification will result in the clearing of approximately 53.1 hectares Rehabilitation (Grassland Complex) and 7.3 hectares immature Rehabilitation (Forest Complex)) that is floristically and structurally simple. Native vegetation communities occurring in the broader Mount Owen Complex will not be impacted as a result of the proposed modification and therefore, the proposed modification is not expected to result in a loss of native vegetation communities.

The proposed modification includes a commitment to the rehabilitation of the final landform. Rehabilitation will include native tree species, and pasture species commensurate with the floristic composition of vegetation communities' characteristic of the Mount Owen Complex and surrounding areas.

6.7.4.3 Impact on Fauna Species

The proposed modification is not considered likely to result in a substantial loss of fauna habitat from the local area and region. A total of 60.4 hectares of fauna habitat will be removed from the ecological study area, comprising 53.1 hectares of immature Rehabilitation (Forest Complex), 7.3 hectares Rehabilitation (Grassland Complex) and two dams comprising 0.2 hectares. The habitat to be removed is highly modified and disturbed as a result of previous and ongoing mine activities and is not expected to comprise an important area of habitat for locally occurring species. The removal of the highly modified habitat will not result in the isolation of proximate habitats.

The proposed modification includes a commitment to the rehabilitation of the final landform. Rehabilitation will include native species commensurate with the floristic composition of vegetation communities' characteristic of the Mount Owen Complex thereby providing potential fauna habitat for the range of fauna species known to occur.

6.7.4.4 Impact on Threatened Species, Populations and Ecological Communities

Threatened Species Conservation Act 1995

Appendix 7 lists the threatened flora and fauna species known, or considered likely to occur, within a 10 kilometre radius of the ecological study area. Each threatened species, endangered population or EEC identified was considered in an assessment of the impact of the proposed modification. Tables 1 and 2 in **Appendix 7** assess the likely impact of the proposed modification on each species, endangered population and EEC and identify the need or otherwise for additional assessment in accordance with Section 5A of the EP&A Act or the EPBC Act.

The proposed modification is not expected to result in a significant impact on any potentially occurring threatened flora or fauna species, endangered populations or EECs occurring in the ecological study area, wider Mount Owen Complex or local area.

State Environmental Planning Policy (SEPP) 44 (Koala Habitat) Assessment

A development application which relates to a site occurring within an LGA specified under State Environmental Planning Policy 44 (SEPP 44) – Koala Habitat Protection, affecting an area of one hectare or greater, must be assessed under SEPP 44. The ecological study area is located within Singleton LGA and accordingly an assessment has been completed.

Assessment under SEPP 44 is based on an initial determination of whether the land constitutes potential koala (*Phascolarctos cinereus*) habitat. This is determined by assessing whether the eucalypt species present in Schedule 2 of SEPP 44 (refer to **Table 6.17**) constitute 15 per cent or more of the total number of trees in the upper or lower strata of the tree component.

Table 6.17 – Eucalypt Species Listed Under Schedule 2 of SEPP 44

Scientific Name	Common Name	Proportion of Species in Tree Canopy (%)
Eucalyptus tereticornis	forest red gum	0
Eucalyptus microcorys	tallowwood	0
Eucalyptus punctata	grey gum	10
Eucalyptus viminalis	ribbon or manna gum	0
Eucalyptus camaldulensis	river red gum	0
Eucalyptus haemastoma	broad-leaved scribbly gum	0
Eucalyptus signata	scribbly gum	0
Eucalyptus albens	white box	0
Eucalyptus populnea	bimble box or poplar box	0
Eucalyptus robusta	swamp mahogany	0

An assessment of the presence of trees listed on Schedule 2 of SEPP 44 was undertaken at each of the habitat assessment sites, identified in **Figure 6.14**. A number of juvenile trees (less than 4 metres in height and diameter at breast height of less than 10 centimetres) were recorded in the immature rehabilitation (Forest Complex) community that may comprise grey gum (*Eucalyptus punctata*), however as no fruiting material was identified a positive identification could not be made[2]. The potential grey gums were found to constitute less than 15 per cent of the trees recorded. The habitat assessments undertaken in the ecological study area included searches for signs of fauna presence such as scats and no evidence of koala faecal pellets was recorded during walking transects in the ecological study area.

The ecological study area is therefore not considered to comprise potential koala habitat, as described under SEPP 44 and further assessment is not required.

[2] With young eucalypts it is difficult to identify to species level as the diagnostic characteristics are very different in juvenile trees (as they do not have sufficient diagnostic material such as fruits/flowers/seeds and many species do not flower/fruit every year) compared to mature trees.

Matters of National Environmental Significance

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister for DSEWPC is required for any action that may have a significant impact on Matters of National Environmental Significance (MNES). These matters are:

- Listed threatened species and communities;
- Migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties;
- National Heritage places; and
- Nuclear actions.

The EPBC Act lists criteria which are used to determine whether an action is likely to have a significant impact on MNES. These criteria are addressed in the Assessment of Significance provided in **Appendix 7**.

No threatened or migratory species were recorded or are considered likely to occur in the ecological study area and the proposed modification is not expected to significantly impact MNES. Therefore, the proposed modification does not require approval from DSEWPC.

6.7.5 Proposed Management and Mitigation Measures

The proposed modification includes a commitment to the rehabilitation of the final landform. Rehabilitation will include native tree species commensurate with the floristic composition of vegetation communities characteristic of the Mount Owen Complex, thereby providing potential fauna habitat for the range of species known to occur and no net loss of diversity in the ecological study area.

6.8 Greenhouse Gas and Energy Assessment

A greenhouse gas and energy assessment (GHGEA) has been prepared by Umwelt to evaluate the greenhouse gas and energy use implications of the proposed modification and is included in full in **Appendix 8**.

The proposed modification will not change many ancillary aspects of the current Ravensworth East Mine operations. Accordingly a number of emission sources were excluded from the GHGEA as the proposed modification will not change the activities currently approved, that generate the excluded emission sources.

The calculations used for the GHGEA are based on activity data projections developed by XMO and estimated from other Xstrata Coal operations. Diesel use activity data has been estimated based on the proposed modification conceptual mine plans and comparable diesel burn rates (litres/hr) for similar equipment estimated at another Xstrata Coal site.

6.8.1 Assessment Methodology

The GHGEA is based on the methodologies and emission factors contained in the *National Greenhouse Accounts (NGA) Factors* (Department of Climate Change and Energy Efficiency (DCCEE) 2011).

Scope 1 and 2 emissions were calculated based on the methodologies and emission factors contained in the *NGA Factors 2011* (DCCEE 2011). Fugitive emissions from the proposed open cut operation have been calculated using a state based emission factor (i.e. using the Method 1 approach as described by the *NGA Factors 2011)*.

Scope 3 emissions associated with product transport were calculated based on emission factors contained in the National Greenhouse Gas Inventory: Analysis of Recent Trends and Greenhouse Gas Indicators (Australian Greenhouse Office 2007). Other Scope 3 emissions were calculated using methodologies and emission factors contained in the *NGA Factors 2011* (DCCEE 2011).

The scope 1, 2 and 3 emission calculations for the GHGEA for the proposed modification were based on the following:

- Scope 1 (diesel use and fugitive emissions);
- Scope 2 (electricity use); and
- Scope 3 (product use, product transportation by rail and ship and diesel and electricity consumed associated with coal extraction, production and transportation).

6.8.2 Greenhouse Gas and Energy Assessment Results

The results of the GHGEA calculations identified that over a six year period (including the removal of overburden from the RERR mining area) based on the extraction of approximately 6 million tonnes of ROM coal, the proposed modification is forecast to be associated with the following annual emissions:

- approximately 64,000 t CO_2-e Scope 1 emissions per annum;
- approximately 2,750 t CO_2-e Scope 2 emissions per annum; and
- approximately 1,650,000 t CO_2-e Scope 3 emissions per annum.

The GHGEA indicates the proposed modification is expected to generate approximately 66,750 t CO_2-e of Scope 1 and 2 emissions per annum. Given the relatively small scale of the proposed modification (that is, approximately 6 million tonnes of ROM coal) these emissions are considered to be relatively low when compared with typical mining projects. Scope 1 emissions forecast for the proposed modification are expected to vary significantly between statutory GHG reporting periods due to normal variations in mining activities that occur from year to year. Scope 3 emissions will be generated by third parties during product transport and consumption activities (e.g. electricity generators). Approximately 96 per cent of the total greenhouse gas emissions (scope 3 emissions) will occur downstream of the operations (i.e. by third parties), and beyond the operational control of XMO.

The proposed modification will be required to comply with national greenhouse and energy use legislation, as the proposed modification is part of a facility that triggers the NGERS reporting thresholds.

6.8.3 Greenhouse Gas Management and Monitoring Commitments

The results of the GHGEA indicate that the proposed modification is a relatively small coal project that will produce valuable energy commodities over the six year timeframe (including the removal of overburden from the RERR mining area). The proposed modification's forecast energy use intensity is considered to fall within the normal range when compared with similar operations across Australia.

Therefore the proposed modification is unlikely to impact national greenhouse gas policy objectives due to the relatively small contribution the proposed modification will make to national emissions and is unlikely to impact on National and International greenhouse gas policy objectives due to the relatively small contribution it will make to national and international emissions.

XMO adheres to all legal requirements to manage greenhouse gas emissions and energy use. The *Energy Efficiency Opportunities Act 2006* and the *Energy and Utilities Administration Act 1987* require XMO to participate in the Energy Efficiency Opportunities (EEO) and Energy Savings Action Plan (ESAP) Programs respectively. Full details regarding these plans and programs are included in the GHGEA report, see **Appendix 8**.

XMO will continue to address Scope 1 and 2 emissions through energy efficiency initiatives which are driven by energy use and productivity. Through continuation of the implementation of its *Air Quality and Greenhouse Gas Management Plan* (XMO 2011) XMO will manage energy efficiency through the following initiatives:

- optimising the design of haul roads to minimise the distance travelled between the pit and the ROM stockpiles and overburden dumping locations;
- minimising the re-handling of material (i.e. coal, overburden and topsoil);
- managing truck payloads to utilise the tray space without overloading; and
- maintaining the mine fleet in good operating order.

XMO will continue to participate in the EEO and ESAP Programs.

XMO is not in a position to manage Scope 3 emissions directly as they relate to the end use of the coal, however, Xstrata Coal manages a significant product stewardship and market development program which aims to mitigate the downstream impacts of its products.

6.9 Visual Amenity Assessment

6.9.1 Visual Landscape

The general landscape between Singleton and Muswellbrook presents a combination of mining, agricultural and natural landscapes. Existing mining operations are visually dominant particularly the associated infrastructure and overburden emplacement/rehabilitation areas.

The topography of the area surrounding the Mount Owen Complex is characterised by undulating hilly landscape with a ridgeline extending north to south to the east of the Mount Owen Complex. This ridgeline is a dominant topographic feature and extends to a height of approximately 360 m AHD. Another ridgeline also runs in an east to west direction to the south of the Mount Owen Complex with an elevation of approximately 115 m AHD.

As described in **Section 1.3**, 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 influenced by the existing mining operations. The broader visual environment of the Mount Owen Complex includes the Ravensworth State Forest to the north-east and rural, agricultural and rural residential views being prevalent in the Falbrook, Middle Falbrook and Camberwell areas. The overburden emplacement areas associated with the Ravensworth East Mine are the most visible feature of the existing Ravensworth East operations from public view points. Views of the Ravensworth East Mine from surrounding private residential properties located to the south-east and east are long range (in excess of 4 kilometres) and are predominately restricted by the existing Ashton Mine overburden emplacement areas and by the north-south ridgeline to the east of the Mount Owen Complex. Current views of the Ravensworth East Mine operations from the south on the New England Highway are restricted by the existing Ashton Mine Operations, however views of the Ravensworth East Mine particularly overburden emplacement areas, are prominent from the west further along the New England Highway.

6.9.2 Visual Assessment

The visual assessment included an assessment of the visibility of the existing mining operations compared with the addition of the RERR mining area and increase in height (by 20 metres) of the West Pit Overburden Emplacement Area using a radial analysis method. A radial analysis is developed using 3D topographic information, aerial photographs and landform data relating to site operations (e.g. overburden emplacement areas, pits, site infrastructure and other infrastructure surrounding the mine site). The radial analysis illustrates what is visible from a height of 1.7 metres (i.e. from eye height) at the highest point of the proposed West Pit Overburden Emplacement Area which is the most visible feature associated with the proposed modification. As mining progresses within the RERR mining area, overburden emplacement will continue within the existing West Pit Overburden Emplacement Area to a height of approximately RL 180 m, an increase of 20 metres in height from the currently approved RL 160 m.

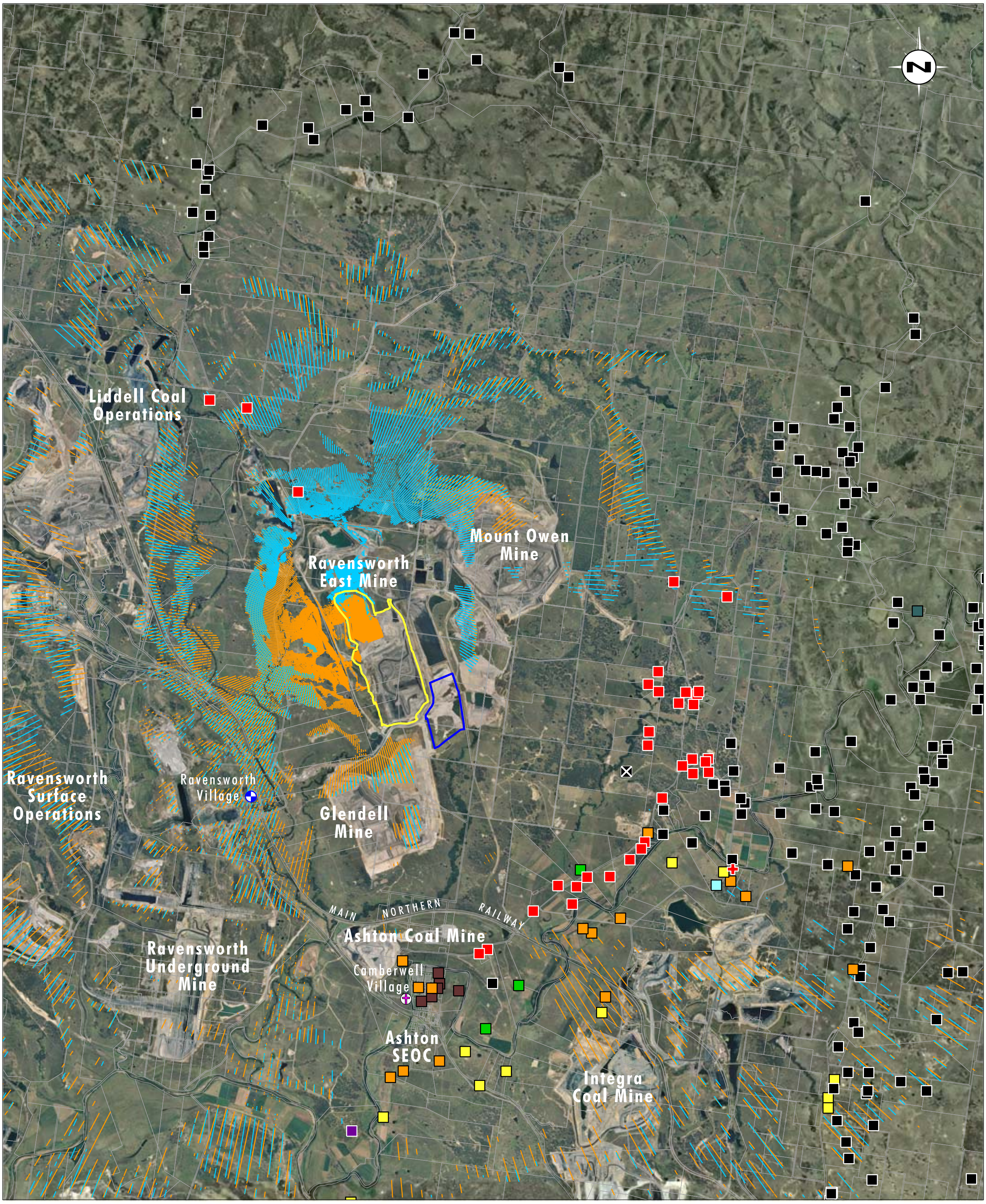
The results of the radial analysis are illustrated on **Figure 6.15**.

6.9.3 Visual Assessment Results

Based on the results of the radial analysis (refer to **Figure 6.15**) there will be minimal change to the existing level of visibility of the West Pit Overburden Emplacement Area as a result of the increase in height of RL 20 m. Views of the Ravensworth East Mine from the New England Highway will increase marginally and views from the residences located to the east and south-east will remain unchanged.

Although the West Pit Overburden Emplacement Area is considered the visually dominant aspect of the Ravensworth East Mine, the West Pit Overburden Emplacement Area is viewed from the New England Highway and private residences within the context of the existing Glendell, Ashton and Mount Owen emplacement areas, with the Mount Owen Western out-of–pit dump having a maximum height of RL 190 m. The existing ridgelines which surround the Mount Owen Complex to the east also contribute to the integration of the increased overburden height into the existing landscape and provide a level of shielding to residents in the Falbrook and Middle Falbrook area. Progressive rehabilitation works will also be undertaken as mining progresses to enable the integration of the West Pit Overburden Emplacement Area with the surrounding environment and reducing the visual impact of the proposed modification.

The current management measures implemented at Ravensworth East Mine will be retained in order to ensure light pollution is minimised. Accordingly the proposed modification is not



Source: Mount Owen (2012)

Legend
- West Pit Overburden Emplacement Area
- RERR Mining Area
- Private Residence
- Church
- Daracon Site Office
- Glennies Creek Fire Brigade
- Community Hall
- Mt Pleasant Primary School
- Mine Owned Residence - Xstrata
- Mine Owned Residence - Other Mine
- Currently Subject to Acquisition Rights - Xstrata (no dwelling)
- Currently Subject to Acquisition Rights - Xstrata
- Currently Subject to Acquisition Rights - Other Mines
- Currently Subject to Acquisition Rights - Dairy
- Currently Subject to Acquisition Rights - Ashton SEOC Noise Trigger
- Visible Terrain Proposed (Proposed RL 180m)
- Visible Terrain Existing (Existing RL 165m)

FIGURE 6.15

Radial Analysis Conceptual Mine Plan (Year 2017)

File Name (A4): R01/3081_019.dgn
20121218 16.58

predicted to result in any significant changes to visual amenity compared to that currently approved.

6.9.4 Management of Visual Impacts

In accordance with the existing requirements of DA 52-03-99 and the Mount Owen Environmental Management System, XMO will continue to implement the following visual controls at Ravensworth East to reduce the visual impact of mining operations:

- active rehabilitation of the proposed overburden emplacement areas as mining progresses including shaping and re-vegetation;
- take all practicable measures to mitigate off-site lighting impacts from mining operations; and
- design of lighting to minimise excessive night glow in accordance *Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting*.

6.10 Mine Rehabilitation

6.10.1 Xstrata Coal NSW Mine Closure Planning Process

Xstrata Coal NSW (XCN) has implemented a proactive approach to rehabilitation and mine closure by developing a range of standards that are to be implemented across its business units. These standards provide that the planning for closure is an integrated part of the life of mine planning process. Specific guidance is provided for developing, implementing and reviewing mine closure plans taking into consideration economic, social and environmental factors so that each of XCN's operations meet statutory requirements and achieve a sustainable post-closure land use.

As part of the ongoing operations at the Mount Owen Complex, the existing XMO Conceptual Closure Plan will continue to be reviewed and updated to reflect changes to the mining operations. As such, this plan will be updated in consideration of the commitments outlined in this EA and will include details regarding final land use objectives and closure criteria, rehabilitation and final void management strategies as well as the process for engaging relevant stakeholders in the closure planning process to be adopted throughout the mine life. It is the intention that the Conceptual Closure Plan will form the basis of the Final Closure Plan, which is to be developed following the completion of the detailed mine closure planning process and submitted to the relevant government authorities at least two years prior to the planned closure date.

6.10.2 Proposed Post Mining Land Use

The proposed post mining land use for Ravensworth East Mine, will provide the basis for the design of mine closure and rehabilitative activities which will primarily involve the establishment of pasture with corridors comprised of native ecosystems (consistent with the currently approved post mining land use) as shown in **Figure 3.4**. The process for ongoing management of the post mining land use will be determined through the detailed mine closure planning process (refer to **Section 6.10.1**).

The proposed land use has been developed in consideration of a number of factors including existing strategic land use objectives as well as site opportunities and constraints as discussed below. However, in recognition of the likely five year operational life of the proposed modification, the potential for other sustainable and economically productive post-closure land uses will be investigated in light of the local and regional government land use strategies that may have further evolved towards the end of the mine life. This process will be undertaken as part of the Xstrata detailed mine closure process (refer to **Section 6.10.1**) and in consultation with the relevant government and community stakeholders. Any alternative land use options will need to be consistent with both local and regional land use plans and may require development approval before proceeding.

It will be the intent that rehabilitation and closure activities for the Mount Owen Complex that are implemented progressively throughout the life of mine will be designed to maximise opportunities for the development of other potential viable land use options. These options may include use of the final voids for further mining activities such a coal washery rejects or tailings emplacement.

The vision for final land use is to achieve a combination of rehabilitated pasture and native trees and shrubs consistent with the broader integrated strategic rehabilitation objective across Xstrata's Mount Owen and Ravensworth complexes. As such, the closure objectives and criteria at Ravensworth East Mine (refer to **Sections 6.10.3** and **6.10.4** respectively), have been developed to guide rehabilitation and decommissioning activities to attain this final land use.

6.10.3 Rehabilitation Principles and Objectives

In consideration of the proposed final land use option as outlined in **Section 6.10.2**, the primary rehabilitation objectives for Ravensworth East Mine include the following:

- use of the West Pit and proposed RERR mining area voids for tailings emplacement, followed by capping and rehabilitation works;
- creating a safe and stable final landform with acceptable post mining land capabilities;
- returning the land affected by the operations to pasture and in some areas native forest/woodland, to allow for the future connection with the Southern Remnant of the Ravensworth State Forest following the cessation and removal of existing infrastructure at the Mount Owen Mine (DA 52-03-99 Schedule 4 Condition 31); and
- providing for the safety of employees and the public during and following the closure of the mining operations.

The end land use and landscape design for Ravensworth East Mine is intended to be compatible with adjoining lands and the DRE's '*Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW*'.

6.10.4 Closure and Rehabilitation Criteria

Completion criteria, determined in consultation with the relevant agencies, will be utilised to demonstrate achievement of the rehabilitation objectives. The attainment of the completion criteria will be monitored and reported within relevant internal and external reports including the Annual Environment Management Report (AEMR). XMO is committed to the achievement of relevant closure criteria.

The preliminary closure and rehabilitation criteria are outlined in **Table 6.18**. These have been adopted from the currently approved Landscape Management Plan and prepared in consideration of XCN's standards as well as some example criteria as outlined in *Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment on the Coal Mines in the Hunter Valley* 2005 (ACARP).

Table 6.18 – Ravensworth East Preliminary Closure and Rehabilitation Criteria

Aspect	Preliminary Closure Criteria
Landform	Rehabilitated slopes are generally less than 10 degrees with a maximum of 14 degrees (subject to approval) No significant erosion is present that would constitute a safety hazard or compromise the capability of supporting the end land use Contour banks are stable and there is no evidence of overtopping, tunnelling or significant scouring as a result of runoff Surface layer to be free of any hazardous materials Final void has been assessed to validate that it is stable and does not pose a safety risk
Soil	Topsoil or a suitable alternative has been spread uniformly over the rehabilitation surface Monitoring demonstrates soil profile development in native rehabilitated areas (e.g. development of organic layer) Need for ongoing soil amelioration for pasture areas is consistent with general agricultural management practices (e.g. re-fertilising)
Water	Runoff water quality from rehabilitation areas is within the range of water quality data recorded from analogue sites and does not pose a threat to downstream water quality
Vegetation	At least 30 per cent of the site is to be returned to native trees or shrubs to provide habitat for native fauna and corridors to link reforested areas on the Mount Owen Mine site Native corridors contain flora species assemblages characteristic of the desired native vegetation community More than 75 per cent of trees are healthy and growing as indicated by long term monitoring Second generation tree seedlings are present or likely to be, based on monitoring in comparable older rehabilitation sites Pasture species to consist of grasses and legumes appropriate for grazing Pasture areas can be demonstrated to have a suitable carrying capacity of a specified head of stock Weed species to be controlled such that pasture cover is not significantly impaired
Fauna	Rehabilitated corridor areas provide a range of vegetation structural habitats (e.g. eucalypts, shrubs, ground cover, developing litter layer etc.)
Bushfire Hazard	Appropriate bushfire hazard controls have been implemented
Heritage	Potential items of European or Aboriginal Heritage will be managed in accordance with the approved heritage management plans for the Mount Owen Complex

The preliminary closure criteria will be reviewed and revised throughout the mine life and used as the basis for further refinement following the commencement of rehabilitation activities; consideration of the results of rehabilitation monitoring programs and research trials; and consideration of stakeholder feedback. It is envisaged that this process will occur as part of the development of the *Rehabilitation Environmental Management Plan* (REMP) and subsequent Annual Reviews that are submitted to DP&I, DRE, Singleton Shire Council and other key agencies.

Proposed rehabilitation monitoring is discussed in **Section 6.10.10**.

6.10.5 Proposed Post Mining Landform

The conceptual final landform for the Mount Owen Complex has been designed to maintain consistency with the local area and will predominantly consist of an undulating landform reflecting the dominant features of the existing environment. Key features of the final landform relating to the proposed modification are discussed below.

Once mining operations are complete within the West Pit at Ravensworth East Mine, the mining fleet and employees will move to the proposed RERR mining area. The West Pit void will then be used for tailings emplacement (as is currently approved). Following the completion of mining activities associated with this proposed modification (i.e. in approximately 2019), the West Pit tailings emplacement area and the RERR void would be retained in order to continue to be utilised for the emplacement of tailings from future XMO operations.

6.10.5.1 Proposed Void and Highwall

As outlined in **Section 6.10.5** the intention is to utilise the voids at Ravensworth East Mine for the emplacement of tailings from future XMO operations. However, for completeness, the management measures associated with final voids are included below should this intended use (ongoing tailings emplacement) not be realised. Key features and processes associated with the final void are outlined below:

- the highwall of the void will be stabilised in accordance with DRE requirements;
- the lowwall will be reshaped from 10 to 14 degrees and revegetated consistent with the *Rehabilitation Environmental Management Plan*; and
- a surface drainage network will be established to divert the bulk of surface water away from the final void so as to maximise replenishment of the local catchment areas.

Details regarding final void management will be finalised as part of the detailed Final Closure Plan, which will be prepared within two years of projected mine closure in accordance with relevant development consent conditions and Xstrata Standards. Final void management will include:

- identification of possible beneficial uses for the final void (that is, potential future mining activities including tailings emplacement);
- a review of modelling predictions of final void water quality and level;
- an assessment of the integrity of void slopes;
- waste characterisation and drainage patterns with regards to runoff into the receiving environment and final void and potential environmental impacts;

- safety and regulatory requirements;
- long term management, monitoring and mitigation measures; and
- void stability and safety.

As outlined in **Section 6.10.1**, the Final Closure Plan will be submitted to the appropriate regulatory authorities for approval two years prior to cessation of mining. Monitoring of the final void would be undertaken as part of ongoing monitoring during the care and maintenance period until it can be demonstrated that rehabilitation has satisfied the closure criteria.

6.10.6 Tailings Emplacement Areas

The tailings emplacement areas on site will be filled and shaped to the agreed final landform and subsequently capped in accordance with a design that is developed in consultation with DRE. Following capping, these areas will be revegetated in accordance with the rehabilitation strategy as outlined in **Section 6.10.9**.

To promote the geotechnical stability of these areas and avoid the potential sterilisation of land in the post-mining landform, dewatering strategies will be incorporated into the design of the tailings dam. The aim of the strategy will be to progressively dewater the tailings dams and promote the consolidation of material throughout the tailings profile. Water extracted from the process will be re-utilised for on-site purposes such as the processing of coal or for dust suppression. Dewatering of the tailings dam will be managed to enable finalisation following the cessation of active mining.

6.10.7 Overburden Emplacement Areas

In the final post mining landform all slopes will be battered to an average of 10 degrees with a maximum slope of 14 degrees to minimise erosion risk. Elements such as drainage paths, contour drains, ridgelines, and overburden emplacement areas are shaped into undulating informal profiles in keeping with natural landforms of the surrounding environment.

The top surface of overburden dumps will be constructed with adequate drainage to control over-topping and to form a profile that is commensurate with the natural local topography. The maximum height of the proposed overburden emplacement area will be approximately RL 180 with undulations in areas to ensure that a more natural profile can be achieved.

6.10.8 Rehabilitation Strategy

Rehabilitation will be undertaken in accordance with the REMP as required by the *Mining Act 1992*. The REMP will detail performance measures and criteria for specific rehabilitation domains, to be used as benchmarks and provide detail against which to measure the performance of the rehabilitation strategy. The monitoring of rehabilitation performance will be reported annually, as required of the REMP.

A key aspect of the closure strategy for the proposed modification requires the progressive rehabilitation of disturbed areas as soon as practicable over the life of the mine. The indicative sequence for progressive rehabilitation is shown in **Figures 3.2** to **3.4**, however, it is the intention that the schedule will be progressively updated as part of the REMP review process. Whilst it is the objective to maximise opportunities for progressive rehabilitation and reduce the disturbance footprint, potential deviations from the schedule may be incurred due to the following scenarios:

- delays in the mining schedule; and
- postponement of rehabilitation activities to avoid revegetating in un-seasonal conditions. The aim being to minimise factors (that is, excessive heat, low moisture content and so on), which may lead to poor quality rehabilitation or failure.

Where rehabilitation is delayed due to the above scenarios, overburden areas will be shaped to final landform as close as reasonably practical behind the active mining operation and suitable erosion controls (for example, cover crop) applied on exposed areas. The rehabilitation will subsequently be formally rescheduled in consultation with the DRE.

Similarly, temporary revegetation will be undertaken on unshaped overburden dumps that are planned to be inactive for more than 12 months, which will provide improvements in both visual amenity and the control of dust emissions.

At least 30 per cent of the rehabilitation areas are to be returned to native trees or shrubs to provide habitat for native fauna. These areas will form corridors to link areas of remnant native vegetation and reforested areas on the Mount Owen Mine site and surrounding areas.

6.10.9 Scope of Mine Closure Decommissioning Works

At the end of the proposed operational life of the Mount Owen Complex, with the exception of that which is required as part of the final land use, XMO proposes to decommission all on site infrastructure and associated facilities as part of the mine closure process. Closure monitoring and maintenance works would continue after mine closure activities are complete until it can be demonstrated that the criteria have been met in accordance with the Mount Owen Complex Closure Plan.

6.10.10 Proposed Rehabilitation Monitoring

XMO will continue to undertake a rehabilitation monitoring program in accordance with XCN standards. The objectives of the program will be to:

- assess the long term stability and functioning of re-established ecosystems on mine affected land;
- provide the scientific basis for assessing rehabilitation performance against objectives and closure criteria; and
- facilitate continuous improvement in rehabilitation practices.

The monitoring program will be continued within rehabilitated as well as non-mined areas until it can be demonstrated that rehabilitation has satisfied the closure criteria. Information from this monitoring program will also be used to refine closure criteria as required.

6.10.11 Proposed Rehabilitation Sign-Off Process

Based on the outcomes of the rehabilitation monitoring programs and in consultation with the relevant government agencies, progressive sign-off of rehabilitation areas will be sought once the closure and rehabilitation sign-off process has been met. The aim of this process will be to achieve consensus on the quality of final rehabilitation required as a benchmark for future rehabilitation activities.

7.0 Statement of Commitments

XMO will amend the relevant environmental management plans for the Mount Owen Complex to reflect the modified operations at Ravensworth East Mine. Except as outlined in the following commitments, the updates to the relevant management plans will be undertaken as part of the review process defined under the existing consents.

The following commitments outline those management requirements identified as a result of this EA. These commitments would be incorporated into amended management plans.

Table 7.1 – Summary of Commitments

Aspect	EA Section	Commitment
Noise	6.2	XMO will continue to manage the noise performance of Ravensworth East Mine in accordance with the *Mount Owen Complex Noise Monitoring Program* (Xstrata Coal NSW - Mount Owen Complex, 2011).
Blasting	6.3	XMO will commit to meeting the relevant blasting criteria by implementing the following management measures: • implementation of additional blast management measures when undertaking blasting at the maximum bench size of 26 metres within a 100 metre radius of the of the northern area of the RERR pit adjacent to the TP1 dam wall; and • XMO will undertake an additional blasting assessment as mining develops to confirm the proposed vibration limits, ensuring blasting impacts in relation to Integra can be managed and revise the BMP to re-establish the Personnel Withdrawal Protocol, in consultation with Integra.
Air Quality	**6.4**	XMO will continue to manage air quality impacts at the Mount Owen Complex in accordance with the Air Quality and Greenhouse Gas Management Plan.
Groundwater	6.5	XMO will continue to manage groundwater impacts in accordance with the Mount Owen Water Management Plan. As a result of the groundwater impact assessment the Water Management Plan would also be updated to reflect the updated groundwater inflows associated with the RERR mining area.
Surface Water	6.6	XMO will continue to manage surface water for the proposed modification in accordance with the currently approved *Mount Owen Complex Water Management Plan*.
Ecology	6.7	XMO will continue rehabilitation works in accordance with the existing rehabilitation requirements for the Ravensworth East Mine.

Table 7.1 – Summary of Commitments (cont)

Aspect	EA Section	Commitment
Greenhouse Gas and Energy	6.8	XMO will continue to participate in the EEO and ESAP Programs and manage energy efficiency through the continued implementation of its *Air Quality and Greenhouse Gas Management Plan* (Xstrata Coal 2011).
Visual Amenity	6.9	• XMO will continue implement the following visual controls at Ravensworth East Mine in accordance with the existing requirements of DA 52-03-99 and the Mount Owen Environmental Management System • active rehabilitation of the proposed overburden emplacement areas as mining progresses including shaping and re-vegetation • take all practicable measures to mitigate off-site lighting impacts from mining operations; and • lighting will be designed to minimise excessive night glow in accordance with *Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting*.
Rehabilitation and Mine Closure	6.10	XMO will continue rehabilitation works will be undertaken in accordance with the *Rehabilitation Environmental Management Plan* as required by the *Mining Act 1992.*

8.0 Conclusion, Justification for the Proposed Modification and Ecologically Sustainable Development

8.1 Conclusion

As discussed in **Section 6.0**, potential environmental impacts associated with the proposed modification have been identified and where relevant, been the subject of detailed environmental assessment. Each impact assessment has included:

- a review of site characteristics;
- a review of existing Ravensworth East operation's against the proposed modification;
- consultation with relevant government agencies and the local community;
- expert technical assessment; and
- application of the principles of ecologically sustainable development, including the precautionary principle, inter-generational equity, conservation of biological diversity and ecological integrity, and valuation and pricing of resources.

Detailed assessment of key issues is contained in **Section 6.0**. As noted in **Section 6.1**, detailed assessments were deemed to not be required for land capability and agricultural stability, land use, public infrastructure and traffic, Aboriginal archaeology and cultural heritage and historical heritage.

8.2 Justification

Ravensworth East Mine has provided substantial economic benefits at the Federal, State and local level as part of its ongoing operations. The proposed modification would allow for the ongoing use of the workforce currently operating in the West Pit following completion of mining in the West Pit approximately quarter three 2013. The proposed modification would allow for extraction of additional coal resources, continuation of mining operations and employment at the Ravensworth East Mine for an additional six years.

The proposed modification will provide the following key benefits:

- maximising the coal resource recovery from an area previously disturbed by approved mining operations, thus minimising environmental impact;
- recovery of approximately 6 million tonnes of ROM coal;
- continued employment of the existing workforce;
- maintain efficient use of existing infrastructure for mining, processing and transportation of coal;
- payment of royalties to the State of NSW; and
- export earnings for Australia.

XMO is committed to the ongoing effective management of the Ravensworth East Mine to minimise the environmental and community impacts of the proposed mining operations.

8.3 Ecologically Sustainable Development

The EP&A Act aims to encourage Ecologically Sustainable Development (ESD) within NSW. As outlined in **Section 5.0**, the proposed modification requires approval from the Minister for Planning and Infrastructure under Section 75W of the EP&A Act. As such, the Minister needs to be satisfied that the proposed modification is consistent with the principles of ESD. This section provides an assessment of the proposed modification in relation to the principles of ESD.

To justify the proposed modification with regard to the ESD principles, the benefits in an environmental and socio-economic context should outweigh any negative impacts. The ESD principles, as outlined in Section 6 of the *Protection of the Environment Administration Act 1991* encompass the following:

- the precautionary principle;
- inter-generational equity;
- conservation of biological diversity; and
- valuation and pricing of resources.

8.3.1 The Precautionary Principle

The EP&A Regulation defines the precautionary principle as:

> Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
>
> In the application of the precautionary principle, public and private decisions should be guided by:
>
> (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and
> (ii) an assessment of the risk-weighted consequences of various options.

In order to achieve a level of scientific certainty relating to potential impacts associated with the proposed modification, this EA has undertaken an extensive evaluation of all the key components of the proposed modification. Detailed assessment of all key issues and necessary management measures has been conducted and is comprehensively documented in this EA.

The assessment process has involved a detailed study of the existing environment and the assessment and determination of potential impacts of the proposed modification using engineering and scientific modelling (refer to **Section 6.0**). To this end, there has been careful evaluation to avoid, where possible, any irreversible damage to the environment.

The decision making process for the design, environmental assessment and development of management processes has been transparent in the following respects:

- Government authorities and landholders potentially affected by the proposed modification were consulted during EA preparation (refer to **Section 4.0**). This enabled comment and discussion regarding potential environmental impacts and proposed environmental management procedures.

- XMO has designed and implemented a comprehensive Environmental Management System (EMS), and related environmental management plans, that seek to implement best practice management across the Mount Owen Complex. The proposed modification will incorporate the practices implemented and demonstrated to be effective at the Mount Owen Complex and the existing EMS will be revised to incorporate any additional controls outlined in this EA.

- The EA has been undertaken on the basis of the best available scientific information for the area subject to the proposed modification. Where uncertainty in the data used in the assessment has been identified, a conservative worst-case analysis has been undertaken and contingency measures have been identified to manage that uncertainty.

8.3.2 Intergenerational Equity

The EP&A Regulation defines intergenerational equity as:

> Intergenerational equity namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

Social equity involves concepts of justice and fairness so that the basic needs of all sectors of society are met and there is a fairer distribution of costs and benefits to improve the well being and welfare of the community, population or society (DUAP 1997).

Intergenerational equity refers to equality between generations. It requires that the needs and requirements of today's generations do not compromise the needs and requirements of future generations in terms of health, biodiversity and productivity.

The objective of the proposed modification is to allow for the recovery of available resources in a manner that achieves the best practicable safety, environmental, social and economic outcomes while also aiming to minimise any associated environmental impacts. The environmental management measures discussed in **Section 7.0** have been developed to minimise the impact on the environment to the greatest extent reasonably possible.

The management of environmental issues as outlined in this EA will maintain the health, diversity and productivity of the environment for future generations. The proposed modification would also contribute to maintaining services in the community through the direct and flow on effects of employee and operational expenditure.

8.3.3 Conservation of Biological Diversity

The conservation of biological diversity refers to the maintenance of species richness, ecosystem diversity and health and the links and processes between them. Environmental components, ecosystems and habitat values potentially affected by the proposed modification are described in the EA (**Section 6.0**). Potential impacts and measures to ameliorate any negative impact are outlined in the Statement of Commitments (refer to **Section 7.0**).

The environmental impact of the proposed modification has been minimised by limiting the extent of the open cut mine plan and emplacement area to within an area of the Ravensworth East Mine previously disturbed by approved mining operations. Potential impacts and mitigation measures associated with the proposed modification are summarised in **Section 7**.

8.3.4 Valuation and Pricing of Resources

The principle of improved valuation and pricing refers to the need to determine proper values of services provided by the natural environment. The objective is to apply economic terms and values to the elements of the natural environment. This is a difficult task largely due to the intangible comparisons that need to be drawn in order to apply the values.

The proposed modification represents a continuation of the existing operations which provides for the extraction of additional coal resources and the continued employment of the existing workforce. The proposed modification appropriately values the environmental resources by designing the proposed mining operations to avoid and minimise potential environmental impacts as much as possible including the efficient use of existing infrastructure (MIA, CHPP, Rail loop). Where residual impacts remain, mitigation measures (refer to **Section 6.0** and **7.0**) are proposed to further reduce potential impacts on the environment.

9.0 References

Australian Coal Association Research Program (ACARP). (2005). *Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment on the Coal Mines in the Hunter Valley.*

Australian and New Zealand Environment Conservation Council (ANZECC). (1990). *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibrations*.

Australian Standard AS4282 (INT) (1995) – *Control of Obtrusive Effects of Outdoor Lighting*.

Australian Standard AS2187-2. (2006). *Explosives Storage and Use – Part 2: Use of Explosives' and Australian Coal Association Research Program Guidelines.*

Coakes Consulting (2012). *Social Impact and Opportunities Assessment – Ravensworth East Resource Recovery Project – Mount Owen Complex.*

Department of Climate Change and Energy Efficiency (DCCEE) (2008). *Managing Urban Stormwater – Soils and Construction – Volume 2E Mines and Quarries.*

Department of Climate Change and Energy Efficiency (DCCEE) (2011). *National Greenhouse Accounts (NGA) Factors.*

Department of Environment and Conservation NSW (DEC) (2005). *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW.*

DIPNR (undated). *Draft Guidelines for the Design of Stable Drainage Lines on Rehabilitated Minesites in the Hunter Coalfields.*

ERM (1999). *Ravensworth East Mine Environmental Impact Statement*.

Gilberts & Associates (2012). *Mount Owen Complex, Ravensworth East Resource Recovery Project Water Balance.*

Landcom (2004). *The Blue Book – Managing Urban Stormwater and Construction Volume 1*. NSW DEC (2005) 'Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW', August 2005.

Murray M and Clulow J, (2011). Mt Owen Complex fauna Monitoring 2011 Annual Report – *Forest Fauna Surveys Pty Ltd.*

NSW Department of Mineral Resources (1999). *Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW.*

NSW Environment Protection Authority (EPA) (2000). *NSW Industrial Noise Policy (INP)*.

NSW Environment Protection Authority (EPA) (2012). *Application Notes – NSW Industrial Noise Policy.*

PAE Holmes (2012). *Ravensworth East Resource Recovery Project, Air Quality Impact Assessment.*

Sinclair Knight Merz (SKM) (2012). *Ravensworth East Resource Recovery (RERR) Project Groundwater Impact Assessment.*

Umwelt (Australia) Pty Limited (2003). *Environmental Impact Statement – Mount Owen Operations*.

Umwelt (Australia) Pty Limited (2007). *Environmental Assessment for the Modification of Glendell Mine Operations*.

Umwelt (Australia) Pty Limited (2009). *Biodiversity and Land Management Plan.*

XMO (2011). *Mount Owen Complex Air Quality and Greenhouse Gas Management Plan.*

XMO (2011). *Mount Owen Complex Erosion and Sediment Control Plan.*

XMO (2011). *Mount Owen Complex Landscape Management Plan (Including Rehabilitation and Offset Management Plan, Mine Closure Plan and Final Void Management Plan).*

XMO (2011). *Mount Owen Complex Water Management Plan.*

XMO (2011). *Mount Owen Complex Noise Monitoring Program*.

XMO (2012). *Mount Owen Blast Management Plan (BMP).*

XMO (undated). *Mount Owen Tailings Management Strategy.*

10.0 List of Abbreviations and Glossary of Technical Terms

AEMR	Annual Environmental Management Report
AHD	Australian Height Datum
AIS	Agricultural Impact Statement
ANFO	ammonium nitrate/fuel oil
BMP	Blast Management Plan
BoM	Bureau of Meteorology
CHPP	Coal Handling and Preparation Plant
dB	Decibel
DECCW	Department of Environment, Climate Change and Water now referred to as OEH
DGRs	Director-General's Requirements
DP&I	Department of Planning and Infrastructure (NSW)
DSC	Dam Safety Committee
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
DTIRIS	Department of Trade & Investment, Regional Infrastructure & Services
EA	Environmental Assessment
EECs	Endangered Ecological Communities
EEO	Energy Efficiency Opportunities
e.g.	'exempli gratia' meaning 'for the sake of example'
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENM	Environmental Noise Model
EPA	Environmental Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EPBC	Environment Protection and Biodiversity Conservation

EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EPL	Environmental Protection Licence
ERP	Eastern Rail Pit
ESAP	Energy Savings Action Plan
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development
FM Act	*Fisheries Management Act 1994*
GHG	Greenhouse Gas
GRWSS	Greater Ravensworth Water Sharing Scheme
ha	Hectares
HMA	Habitat Management Area
HRSTS	Hunter River Salinity Trading Scheme
HVAS	High Volume Air Samplers
i.e.	'id est' meaning 'that is'
INP	Industrial Noise Policy
IUM	Integra Underground Mine
km	Kilometres
LA_{eq}	Equivalent continuous A-weighted sound pressure level
LEP	Local Environmental Plan
LGA	Local Government Area
m	metres
MIA	Mining Infrastructure Area
Mining SEPP	State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007
ML	Megalitres
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
NGA	National Greenhouse Accounts

NPW Act	*National Parks and Wildlife Act 1974* (NSW)
NOW	NSW Office of Water (NSW)
NSW	New South Wales
OEH	Office of Environment and Heritage
PAC	Planning Assessment Commission
PM_1	Particle Matter less than 1 micron
$PM_{2.5}$	Particle Matter less than 2.5 microns
PM_{10}	Particle Matter less than 10 microns
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
PSNL	Project Specific Noise Level
RBL	Rating Background Level
Rd	Road
RERR	Ravensworth East Resource Recovery Project
ROM	Run of Mine
RMS	Roads and Maritime Services (NSW)
SEPP	State Environmental Planning Policy
SIOA	Social Impact and Opportunities Assessment
SWL	Sound Power Level
TECs	Threatened Ecological Communities
TEOMs	Tapered Element Oscillating Microbalance instruments
TP1	Tailings Pit 1
TP2	Tailings Pit 2
TSC Act	*Threatened Species Conservation Act 1995* (NSW)
TSP	Total Suspended Particulate Matter
Umwelt	Umwelt (Australia) Pty Limited
WMP	Water Management Plan
XCN	Xstrata Coal NSW
XMO	Xstrata Mount Owen Pty Limited

APPENDIX 1

EA Statement of Authorship, Schedule of Lands and Project Team

STATEMENT OF AUTHORSHIP

EA prepared by	
Name:	Michelle Kirkman
Qualifications:	B Env Sc, Grad Dip Policy Studies
Address:	Umwelt (Australia) Pty Limited PO Box 3024 Teralba NSW 2284
In respect of:	Proposed Modification for the Ravensworth East Resource Recovery (RERR) Project at Ravensworth East Mine as described in the accompanying Environmental Assessment
Applicant Name:	Xstrata Mount Owen Pty Limited
Applicant Address:	PO Box 320, Singleton NSW 2330
Land to be developed:	See Schedule of Lands attached.
Proposed Development:	Ravensworth East Resource Recovery Project (proposed modification) as described in the accompanying Environmental Assessment.
Environmental Assessment	An Environmental Assessment is attached.
Certification	I certify that I have prepared the contents of this environmental assessment and to the best of my knowledge: • it is in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*, and • it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.
Signature	
Name:	Michelle Kirkman
Date:	20 December 2012

SCHEDULE OF LANDS

Lot	DP
1	925901
1	135026
1	380676
1	48490
1	865784
2	549723
2	233019
2	859544
2	823167
2	730978
2	1072124
2	865784
3	859544
3	1072124
4	1072124
4	859544
5	859544
6	255403
6	859544
7	859544
8	859544
9	6842
11	6842
11	592404
13	665120
13	247945
15	247945
17	6830
20	841165
21	841165
21	6830
22	841165
23	841165
24	841165
24	6830
25	841160
26	841160
32	545601
32	535087
123	752462
180	858299
232	752470
311	848411
352	867083
353	867083
354	867083
355	867083
356	867083
921	844642
922	844642
923	844642
924	862883
925	862883
1221	709371

Project Team

Umwelt (Australia) Pty Limited – EA Preparation

Michelle Kirkman, Manager Environmental Assessment and Management/Associate B Env Sc, Grad Dip Policy Studies	Project Director, strategic direction and Environmental Assessment review
Tim Browne, Senior Consultant BSc (Earth & Environmental), Master Environmental Management	Project Manager, client, sub-consultant coordination and government and community liaison, Environmental Assessment preparation and review
Penelope Williams, Environmental Scientist BSc	Project Coordinator, client and sub-consultant coordination, Environmental Assessment preparation.
Susan Shield, Technical Engineering Manager/Associate B E (Hons), M E (Water),	Surface Water Assessment
Anna Milner, Water Resources Engineer, B E (environmental) (Hons)	Surface Water Assessment
Malcolm Sedgwick, Senior Energy & Greenhouse Specialist B Sc, MBA	Greenhouse Gas and Energy Assessment
Matthew Newton, Associate B Env Sc (Hons)	Rehabilitation and Closure
Tim Proctor, Engineering Services/Associate B Eng (Hons) Chem	Noise Assessment
Anthony Van der Horst, Process Engineer B Eng (Hons) Chem	Noise Assessment
Alison Riley, Senior Ecologist Bsc	Ecological Assessment
Ian Kennedy, Drafting Coordinator	Drafting and Graphic Design
Kerrie Hine	Report formatting, quality control and compilation

Other Specialist Investigations

Gilbert and Associates Tony Marszalek Dayjil Fincham	Water Balance
Pacific Environment Jane Barnett Judith Cox	Air Quality Assessment
Sinclair Knight Merz (SKM) Dr Richard Cresswell John Wall	Groundwater Assessment
Coakes Consulting Dr Louise Askew Ashlee Cook Dr Sheridan Coakes	Social Impact Assessment
Enviro-Strata Consulting Thomas Lewandowski	Blasting Assessment

Xstrata Coal NSW

The assistance of the following Xstrata personnel during the preparation of this EA is gratefully acknowledged. In addition, personnel from Xstrata provided details regarding the project.

Vicki McBride	Approvals Manager, Projects
Aislinn Farnon	Approvals Coordinator
Shane Scott	Infrastructure Superintendent, XCN Projects
Shane Holmes	Technical Services Manager

APPENDIX 2

Social Impact and Opportunities Assessment

Social Impact and Opportunities Assessment (SIOA)

Ravensworth East Resource Recovery Proposed Modification – Mt Owen Complex

Prepared for

Xstrata Coal NSW

September, 2012

Sheridan Coakes Consulting Pty Ltd

WA
Suite 6, 315 Railway Road,
Shenton Park WA 6008

Tel: 08 9226 5388 • Fax: 08 93813140

NSW
Suite 6, 500 High Street,
Maitland NSW 2320

Tel: 02 4933 2188 • Fax: 02 4933 2588

Email: scoakes@coakesconsulting.com

Website: www.coakesconsulting.com

ABN: 29 085 257 709

Table of Contents

List of Figures

List of Tables

Glossary

EA	Environmental Assessment
IAIA	International Association of Impact Assessment
LGA	Local Government Area
RERR	Ravensworth East Resource Recovery (proposed modification)
SIOA	Social Impact and Opportunities Assessment
SRLUP	Strategic Regional Land Use Plan
XMO	Xstrata Mt Owen

1.0 Introduction

This report documents the outcomes of a *Social Impact and Opportunities Assessment* (SIOA) undertaken by Coakes Consulting on behalf of Xstrata Coal NSW as part of an Environmental Assessment (EA) for the Ravensworth East Resource Recovery (RERR) proposed modification (hereafter referred to as RERR or the proposed modification) at its Ravensworth East Mine within the Mt Owen Mine Complex.

The proposed modification aims to allow operations at the Ravensworth East Mine to extract coal resources from deeper seams in an area previously subject to disturbance associate with approved mining activities. RERR is a small scale operation, within existing mining leases and development approval area and involves no change to the approved mining extraction rates, mining methods, mining equipment, employment or operating hours. The proposed modification is aimed at maximising resource utilisation within a currently disturbed area.

The SIOA program has been designed to identify, consider and manage potential impacts of the proposed modification on local communities, and more specifically to:

- **Identify potential social impacts and opportunities**, including potential cumulative impacts
- **Identify relevant management and enhancement strategies** to address relevant social impacts
- **Ensure effective integration of study outputs** with other environmental assessment studies to inform project planning.

1.1 SIOA Report Structure

The SIOA report is divided into several sections. First, the **SIOA methodology** (Section 2.0) is outlined to detail each phase of the SIOA, including key aims and methods.

Second, a **project overview** (Section 3.0) is provided to define the RERR proposed modification and outline the operational context of the Mt Owen Complex.

Third, a **socio-economic profile** (Section 4.0) is developed for the identified communities of interest surrounding the operation. This includes an overview of: the geography of the area; key socio-economic characteristics (community profiles) of surrounding local and regional areas; relevant governance details; and current regional issues.

Fourth, an analysis of **perceived issues and opportunities** (Section 5.0) in relation to the proposed modification are presented based on outcomes of consultation undertaken with key stakeholders, namely neighbouring landholders.

Fifth, an overall **assessment of social impacts and opportunities** (Section 6.0) is provided and relevant **management, enhancement and monitoring strategies** are explored to address social impacts and enhance opportunities.

2.0 SIOA Methodology

SIOA is an approach of assessing and predicting the likely consequences and opportunities of a proposed project in social terms. This involves understanding impacts and opportunities from the perspectives of those involved in a personal, community, social or cultural sense (see IAIA, 2003; Vanclay, 2008). Social assessment processes work together to provide a complete picture of potential impacts / opportunities and their context and meaning.

2.1 SIOA Methodology: RERR Project

The International Association for Impact Assessment (IAIA, 2003) guidelines have been addressed as part of this SIOA throughout each phase of the process. Table 2.1 provides a summary of the SIOA phases and the assessment and consultation mechanisms utilised during each phase.

It should be noted that Xstrata Coal NSW (XCN) has also commissioned a series of social studies conducted by Coakes Consulting throughout 2011-2012. These studies sit alongside XCN projects in the Hunter Region (including this proposed modification) and focus on: regional issues associated with mining in the Singleton LGA and needs and opportunities for the regional Aboriginal community (see Coakes Consulting, 2012a, b). Key relevant outcomes of this work have been utilised in various sections of this assessment.

Table 2.1 Summary of SIOA phases and activities

Phase / Activities	Description
Phase 1	**Program Planning**
Development of Stakeholder Engagement Strategy	Development of a tailored stakeholder engagement strategy for the Mt Owen Complex. The strategy was informed by previous consultation activities, existing data on perceived issues and opportunities and preliminary social impact risk rankings undertaken in the pre-feasibility phase.
Phase 2	**Community Profiling**
Community Capitals Analysis (socio-demographic analysis)	Assessment and analysis of ABS Census data and other relevant social and community datasets to develop a detailed social profile of the communities of interest. Areas of resilience and vulnerability in the community are identified.
Regional issues and media analysis	Review and analysis of planning documents, strategies and media for the region to understand historical and emerging issues / opportunities within the community.
Phase 3	**Scoping of Issues and Opportunities**
Personal interviews	Personal interviews to obtain information on existing and perceived issues and opportunities in relation to RERR.
Phase 4	**Assessment of impacts and opportunities**
Risk Ranking	Ranking of perceived stakeholder issues and opportunities by relative frequency and assessment (i.e. high, medium, low) of perceived stakeholder risks (identified in the SIOA) against technical risks (identified in the EA).
Phase 5	**Prediction of impact and strategy development**
Social Impact Management	Identification and development of appropriate strategies to specifically address predicted impacts with the aim of minimising high and medium risk ranking through commitment to relevant strategies.

The SIOA phases undertaken for the proposed modification reflect a participatory approach to social assessment involving local landholders / residents. A number of consultation methods were used as part of the SIOA process and are outlined in more detail in Table 2.2. Further discussion of the stakeholders involved in the consultation is provided in the following section.

Table 2.2 Consultation methods

Consultation and Communications Methods	Description
Stakeholder/meetings	Personal meetings with stakeholders to explain proposed modification aspects and receive feedback on issues / opportunities.
Government briefings and consultation	Briefing of government representatives (local, state and federal) on relevant proposed modification aspects.
Community Feedback	Community feedback provided to near neighbours explaining the EA findings, RERR aspects / updates, and feedback from consultation.
Newsletter	Publication of relevant RERR information in the Mt Owen Mine newsletter.

Source: Coakes Consulting (2012)

2.1.1 SIOA Participants / Stakeholders

Social impact assessment 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
- Have an interest in the proposed action or change
- Use or value a resource
- Are interested in its use, and/or
- Are forced to relocate.

Table 2.3 provides an overview of the stakeholders consulted as a part of the SIOA and EA process, including consultation undertaken as part of the broader regional XCN studies (see Coakes Consulting, 2012a; b).

Table 2.3 RERR SIOA consultation summary

Stakeholder / Category	Number of Participants
Near Neighbours	29
Government agencies – local and state (RERR Project Team consultation)	4
Regional Stakeholders (XCN Regional Issues Assessment; XCN Aboriginal Needs and Opportunities Assessment) (see description in Section 2.1)	60
Total	93

Source: Coakes Consulting (2012)

The RERR Project Team has also undertaken additional consultation activities regarding the Project with local mines in proximity to Mt Owen (N=2) as well as local landholders (N=42). However, this SIOA primarily reports on the outcomes of the near neighbour stakeholder consultation phase (N=29) and references key findings from regional studies (see Coakes Consulting, 2012a; 2012b).

3.0 Project Context and Overview

The RERR proposed modification is part of the Mt Owen Complex and is located within the Singleton Local Government Area (LGA) of the Hunter Region, New South Wales (NSW). The Mt Owen Complex consists of Mt Owen, Glendell and Ravensworth East open cut coal mines and is managed by Xstrata Mt Owen Pty Limited (XMO) on behalf of Xstrata Coal Australia Pty Limited (Xstrata) (see Figure 3.1).

Operations at Mt Owen Mine are managed by Xstrata Mt Owen (XMO) and operated by Thiess Pty Limited (Thiess). Glendell operates under the management of Xstrata Glendell Pty Limited managing Glendell and Ravensworth East mining areas. All mining activities are conducted by Xstrata (XCN, 2012).

Overall, the Mt Owen Complex has current approval to extract and process up to 15Mtpa of Run of Mine (ROM) coal. These high quality export thermal and semi-soft coking coals are predominantly exported to South-East Asia for domestic power generation and use in steel production.

The Ravensworth East Mine, formerly known as Swamp Creek Mine, was originally mined by Hebden Mining Company. Mining ceased at Swamp Creek Mine in April 1991 following the completion of contracted coal supplies. Prior to its reopening, the site was under a care and maintenance contract. Development Consent for Ravensworth East Mine was obtained in March 2000, approving the Mine to produce up to 4Mt of ROM coal per annum. Ravensworth East Mine was purchased by Xstrata Coal in 2002 and was integrated into the Mt Owen Complex in 2004. Ravensworth East Mine now operates under the management of Xstrata Glendell within the greater Mt Owen Complex (XCN, 2012).

The Ravensworth East Resource Recovery (RERR) proposed modification aims to allow operations at Ravensworth East Mine to extract coal resources from deeper seams within an area that has been previously disturbed, associated with approved mining activities (see full Project details below in Section 3.1).

3.1 Project Details

The proposed modification presents a continuation of operations within an already disturbed area of the existing Ravensworth East Mine (see Figure 3.1). The proposed modification requires no change to the approved mining extraction rates; mining methods; mining equipment; employment or operating hours. RERR is aimed at maximising resource utilisation within currently disturbed areas and retaining and continuing employment at the Ravensworth East Mine.

Figure 3.1 Map of Mt Owen Complex and surrounding area

Source: Umwelt 2012

4.0 Socio-Economic Profile

A baseline socio-economic profile provides a review of key primary and secondary data to gain an understanding of the existing social environment in which a proposed project is located (see IAIA, 2003). For the purposes of this assessment, the following components have been assessed in the development of the social profile for RERR, namely:

- Geographic and development context – identification of the communities of interest relevant to the current assessment
- Community capitals / assets – assessment of areas of vulnerability and resilience across the communities of interest
- Governance – structures of governance at local, state and federal levels
- Key regional issues– documentation of current community issues for the Singleton LGA as identified in key planning documents, regional studies and the media.

The following sections provide a brief summary of the assessment across these four components.

4.1 Geographic and Development Context

The Mt Owen Complex is located in the Singleton Local Government Area (LGA), in the Hunter Region, NSW (see previous Figure 3.1). The complex is located approximately 25 kilometres north-west of the Singleton township, and Camberwell is the largest neighbouring village.

The main areas of interest, defined for the purpose of the SIOA, include the Hunter Statistical Region (SR) / State Electoral District (SED)[1], Singleton Local Government Area (LGA), and Camberwell State Suburb (SS).

4.2 Community Capitals

In developing a community profile, it is important to identify those key community assets which are fundamental to ensuring community resilience over time. It is also important to address how community capacity can be enhanced to enable a community to develop adaptive capacities against sudden changes or threats to community way of life.

According to key sustainable society theorists (e.g. DFID, 1999; Hart, 1999; Ellis, 2000; Beckley et al., 2008; Coakes & Sadler, 2011) there are five capital areas that should be assessed to define levels of community resilience: human (e.g. education, demographics), social (e.g. crime, mobility), economic (e.g. income, employment), built/physical (e.g. utilities /services, infrastructure/housing) and natural (e.g. resources, forests, lakes), as shown in Figure 4.1. Data from the ABS Census and other key sources has been obtained and analysed for the state (NSW), region (Hunter Region), local community (Singleton LGA) and neighbouring communities (Camberwell) of the Mt Owen Complex to develop a comparative profile for each of these capitals (see Appendix 9.19.1 for key census indicators).

[1] ABS boundaries for the Hunter Region changed slightly between 2006 and 2011. To ensure the most accurate analysis, this report has used Hunter SR data for 2006 and Hunter SED data for 2011. The different data sources will be referred to as the “Hunter Region” throughout the report.

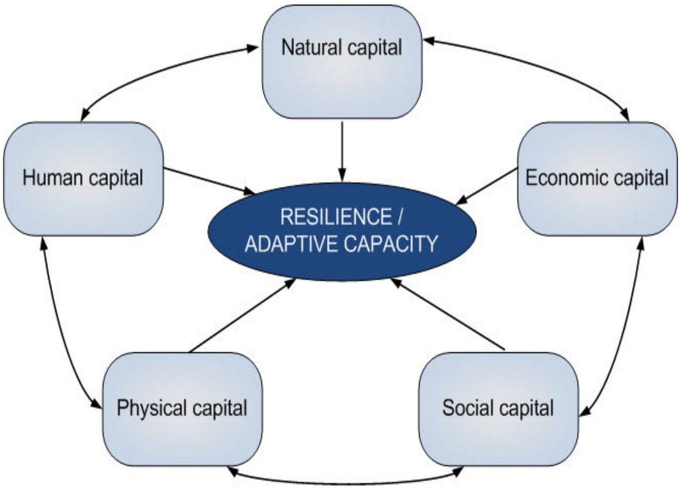


Figure 4.1: Community Capitals framework©

Source: Coakes and Sadler (2011)

The following Table 4.1 summarises the findings of the capitals assessment which shows the strengths and vulnerabilities of the local communities of Camberwell and Singleton.

Table 4.1 Community capitals assessment summary - Camberwell and Singleton

Capital Area	Camberwell		Singleton LGA	
	Strengths	Vulnerabilities	Strengths	Vulnerabilities
Natural	Diversity of natural resources	Potential for land use conflict	Diversity of natural resources	Potential for land use conflict
Economic	Mining is key industry of employment High employment participation rates Low levels of unemployment Higher than average household incomes	Dependency on mining – key industry of employment Higher than average home loan payments High levels of part time employment	Mining is key industry of employment High employment participation rates Low levels of unemployment Higher than average household incomes	Dependency on mining – key industry of employment Increasing home loan / rental cost High levels of part time employment
Human		Population decreased significantly Family households decreased significantly Lower than average schooling / post-school education	Population increasing Good performance against key health indicators Relatively good access to health services High levels of private health insurance	Family households have decreased significantly Lower than average schooling and post-school education levels
Physical	Access to primary school Access to local hall facility Nearby access to Singleton LGA services and infrastructure	Dependence on private road transport Poor condition of local roads High and increasing proportion of rental properties Declining home ownership	Provision of utilities Provision of telecommunications (although access does vary in more remote areas of the LGA)	Reliance on private car transport with limited public transport, rail etc Cumulative impacts on accessibility and affordability of services, housing etc

Capital Area	Camberwell		Singleton LGA	
	Strengths	Vulnerabilities	Strengths	Vulnerabilities
Social		Declining community participation and involvement (volunteerism) High and increasing proportion of single parent families with young children	High and increasing rates of community participation and involvement (volunteerism)	Presence of relatively few at risk groups High and increasing proportion of single parent families with young children High rates of mobility and generally increasing key crime offenses

Sources: ABS (2006a, b, c, d); CSER (2009); ABS (2011a, b ,c, d); AIHW (2011); BOCSAR (2011); Country Transport (2011); PHIDU (2011); Visit NSW (2011); Coakes Consulting (2012c); DoPI (2012); Singleton Council (2012a, b)

Note: strengths and vulnerabilities for Camberwell have only been highlighted where there is supporting data specifically relating to Camberwell. Health statistics for Camberwell are not available. Several sections of the 2011 Census are yet to be released, therefore some indicators are based on 2006 Census data.

Overall, the region is generally growing and offers significant opportunities for employment and the benefits of higher incomes associated with the mining industry. There are relatively good levels of infrastructure and service provision for a rural/regional area, and there is an abundance of diverse natural resources. Key challenges for the region include servicing and housing a growing population and changing demographic structure indicated by increasing cohorts of younger age groups, increasing single and group households and single parent families, and a highly mobile population.

Camberwell, while benefiting from the high levels of employment and associated incomes evident in the region, does show some signs of vulnerability including a declining population, a high and increasing proportion of rental properties, single and group households and conversely a decline in family households and home ownership in the area.

4.3 Governance

Local Government

The Project area lies within the Singleton Local Government Area (LGA). Singleton Council recently changed its council structure for the 2012 election in September, switching from three four-person wards to an elected Mayor plus nine councillors elected at large. The interim results of the election are detailed below (yet to be finalised) which resulted in the appointment of a new mayor – John Martin (Ind).

In January 2012, Singleton Council released a long term Community Strategic Plan: '*Our Place: A Blue Print for 2022'*. The plan involved consultation with over 800 community residents across the LGA during 2011. The plan seeks focuses on four key areas: community, places, environment and leadership through which to deliver a range of visions (discussed further in Section **Error! Reference source not found.** and detailed in Appendix 9.2).

To date, Singleton Council has had varying involvement with the mining industry in the Singleton LGA. Issues commonly identified by Council in relation to the presence of mining include: housing and accommodation; increased cost of living; presence of a drive-in / drive-out workforce; health / community impacts of mining shift work; loss of community / demise of villages; and stress on infrastructure and services. These issues closely reflect the regional issues outlined in Section 4.4 and some of the key near neighbour issues identified later in Section 5.0.

State Government

The Singleton LGA is part of the Upper Hunter State Electorate which has been represented by National Party Member George Souris since 1998.

Key NSW State Government policies which are of relevance to the region include:

- Strategic Regional Land Use Policy (2012): Upper Hunter Regional Land Use Plan (outlined in Section 4.4)
- A New Planning System for NSW: Green Paper (2012)
- Aquifer Interference Policy (2012)
- Environmental Planning and Assessment Amendment (Part 3A Repeal) Bill 2011
- Upper Hunter Economic Diversification Project (2011) and Lower Hunter Regional Strategy (2006)

Federal Government

The Singleton region is represented by Joel Fitzgibbon (Australian Labor Party) in the Federal seat of the Hunter. The Federal Labor party is currently in minority government with the support of key independent and minority party members.

There are several key pieces of current federal legislation that may have an influence on social perceptions of the RERR Project due to their current prominence in the media, namely the Carbon Pricing Scheme and the Minerals Resource Rent Tax.

4.4 Regional Issues

An analysis of key regional planning documents (see ACCSR, 2011; Coakes Consulting, 2012a; 2012c; DoPI, 2012; Singleton Council, 2012a; Appendix 9.2) and media (see Appendix 9.3) highlights some central challenges and opportunities that can be identified for Singleton LGA and the Hunter Region for the future . Many of these issues align with indicators of strength and vulnerability highlighted in the community profile above. Some of the key challenges for the region include:

- Balancing the impacts and economic benefits of mining for the region in the long-term
- Addressing land use conflicts more effectively and developing coordinated approaches to land management and rehabilitation
- Enhancing infrastructure, housing and service provision and improving planning for these for a growing region (e.g. roads / transport; housing accessibility, affordability and mix; health services)
- Addressing community sustainability and protecting core community values
- Addressing mining-related health concerns (e.g. air quality and dust, health research and assessments)
- Ensuring employment and training opportunities for local people
- Protecting the environment and natural capital of the area
- Improving information sharing with the community from government and industry.

4.5 Profile Summary

Data collected from a variety of different primary and secondary data sources has provided a sound foundation and understanding of the social context in which the RERR Project is located. Table 4.2 provides a summary of the key challenges and opportunities that can be drawn from the profile to inform the broader SIOA program.

Table 4.2 Socio-economic profile summary

Capital	Challenges	Opportunities
Natural	• Conflicting land uses – CSG, mining, agricultural, viticulture, tourism • Perceived lack of leadership from key government and industry on land use planning • Community concerns around impacts on natural areas/ecosystems, rehabilitation	• Strong natural capital in the locality • Implementation of NSW Strategic Regional Land Use Strategy Plan and Singleton Community Strategic Plan
Economic	• Increasing dependency on mining • High levels of part-time employment • Non-mining businesses reporting high turnover, skills shortages • Increased housing costs	• Overall economic strength evidenced through low unemployment, high workforce participation rates and growing local and regional investment • Mining is a key industry of employment
Human	• Increasing population in Singleton and decreasing population in more rural localities such as Camberwell • Lower than average levels of schooling and post-school education • Changing household structures – decreasing family households and growing single / group households	• Increasing levels of skilled employment and training • Youthful and generally increasing population
Physical	• Decreasing housing affordability, availability and diversity • Provision of needed services e.g. childcare and youth services • Management of increased traffic and associated road conditions / safety • Ongoing funding of key infrastructure	• Comparatively good infrastructure and service provision for a regional locality • Government, industry and community attempts to address the housing / accommodation issues • High levels of capacity for improved infrastructure / service provision in the region
Social	• Singleton LGA has lower levels of access to GPs than NSW averages • Management of perceptions and/or impacts relating to sense of community and community wellbeing from mining • Addressing perceptions of health and well-being impacts from mining	• High levels of community health and wellbeing within the LGA • Strong sense of culture, heritage and identity • Singleton air quality monitoring network

Source: Coakes Consulting (2012)

5.0 Perceived Issues and Opportunities

A key component of the SIOA is the process of understanding, from a community perspective, the perceived impacts and opportunities associated with RERR specifically and the broader operational context. The aim of this section is to provide a description of community views on the proposed modification from the perspectives of those interviewed, in a personal, community, social and cultural sense.

This phase of the SIOA program has three main objectives:

- To identify perceived issues / impacts associated with RERR (Section 5.1)
- To identify perceived existing issues / impacts associated with the Mt Owen Complex and cumulative mining development in the region (Section 5.2)
- To identify any opportunities associated with the proposed modification or Mt Owen Complex (Section 5.3).

These objectives were achieved through consultation with landholders residing in proximity to the Mt Owen Complex (N=29) and a review of the existing Mt Owen stakeholder databases and engagement outputs. Local landholders were drawn from the key localities surrounding the Mt Owen Complex (see Figure 5.1) including: Camberwell Village; Middle Falbrook Rd; Falbrook Rd; Goorangoola Rd; Glennies Creek Rd; and Hebden Rd.

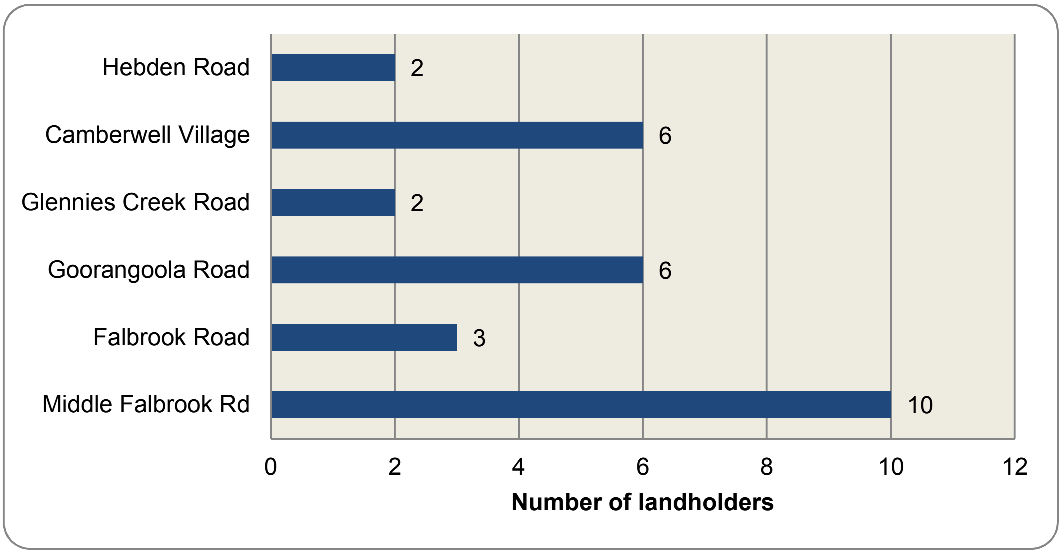


Figure 5.1 Number of landholders consulted by location

5.1 Specific Issues: RERR

Only a very limited number of the perceived issues / impacts identified by neighbouring landholders were specifically associated with RERR. In fact most landholders stated they had *no concerns* about the proposed modification (see Figure 5.2). The small number of landholders who identified RERR-specific impacts believed that existing impacts from the Mt Owen Complex may be exacerbated by the proposed modification including impacts of noise, dust and blasting. They also identified concerns regarding mining methods and operations (although the proposed modification does not alter existing mining methods or operations) and the perceived proximity to neighbouring landholders (although the proposed modification sits within the existing Mt Owen Complex). There are a series of landholder quotes listed below that illustrate these key concerns although minor.

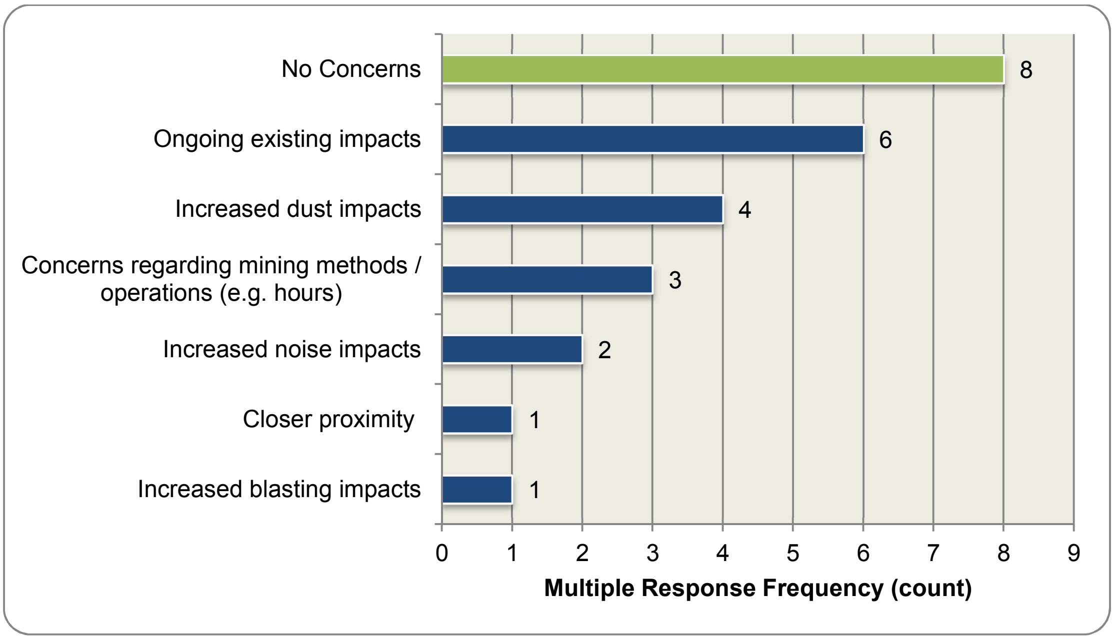


Figure 5.2 Perceived issues / impacts associated with the RERR Project specifically, identified by neighbouring landholders

Note: Any positive impacts or opportunities are colour coded in green to distinguish from other perceived negative impacts. All response frequency counts are multiple response frequencies as each respondent may identify more than one issue / impact.

Neighbouring Landholder Quotes:

"What mining methods will you be using?"

"If it is over a long period of time it should be fine…won't know till the blasting starts"

"It is within the existing footprint, just going deeper? It wouldn't really concern us unless you are coming this way."

"Will it produce more dust?"

The following section outlines each of the key themes identified by neighbouring landholders in relation to the Mt Owen Complex more broadly and cumulative issues associated with mining in the region. From a community perspective, concerns around impacts such as noise and dust are often not attributed to specific areas or projects within the mine but are seen as impacts generated by the Mt Owen Complex as a whole (e.g. noise) or indeed mining across the region (e.g. dust).

5.2 Existing and Cumulative Issues

Overall as shown in Figure 5.3, there were a range of perceived existing and cumulative issues identified by landholders relating to Mt Owen Complex and mining more generally. Landholders were asked to identify the issues / impacts associated with mining that were of most concern to them. The perceived issue / impact themes identified most frequently by landholders were noise (19%), followed by a historical lack of consultation / communication with the community (17%), dust (14%) and community and environmental impacts (12%). Issues less frequently raised included those relating to; economic impacts, traffic, decline in property values, community investment, blasting, visual and Aboriginal Cultural Heritage.

It is important to reiterate here that these are the key themes raised by landholders relating to the Mt Owen Complex as a whole and cumulative impacts of mining in the region, as well as positive impacts associated with the proposed modification and mining more generally.

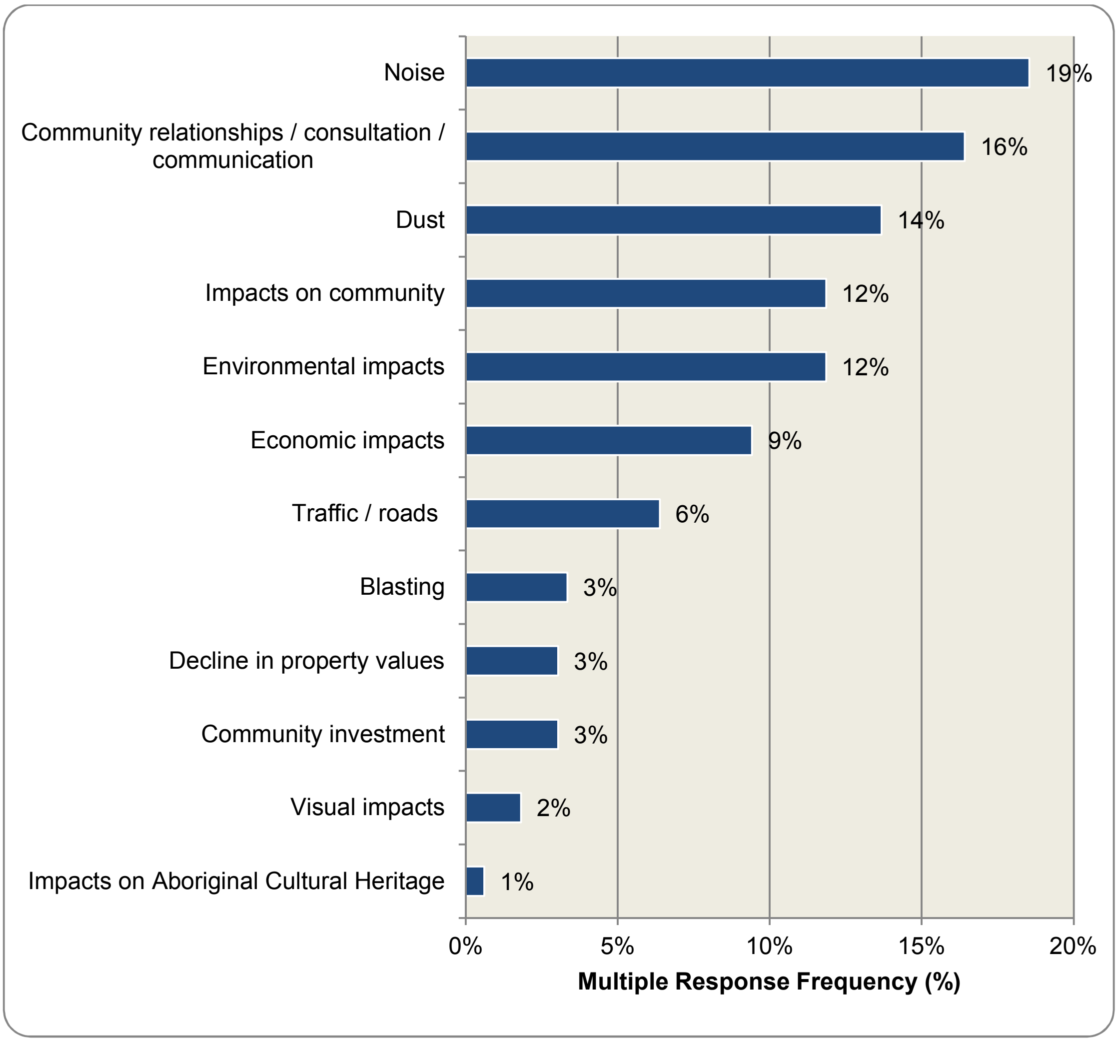


Figure 5.3 Key issue themes raised by neighbouring landholders

Note: All response frequency counts are multiple response frequencies as each respondent may identify more than one issue / impact.

The following Table 5.1 provides further detail on each of these key perceived impact / issue themes. Each theme area (e.g. noise) is further detailed with the specific perceived impacts identified by landholders (e.g. night time noise) which are listed in order of the frequency with which they were identified. This summary includes positive impacts as identified by landholders (shown in italics). A range of landholder quotes are also provided to further illustrate concerns where relevant.

Table 5.1 Summary of existing and cumulative issues / impacts identified by landholders

Impact Themes	Perceived Impacts (in order of frequency)	Examples of Landholder Quotes
Noise	• Noise from general mining operations (e.g. trucks) • Noise impacts exacerbated by weather conditions • Night time noise • Noise from trains • Increasing noise impacts • Noise from traffic • Noise from blasting • Poor management of mine noise	"Noise is the number one issue … We have to wear ear plugs to bed." "Night time noise is terrible – it's a humming." "Can hear Mt Owen trucks and reversing alarms. Overcast days are worse." "I can hear the trucks and the banging of rocks…the bulldozer goes clack, clack, clack. Mt Owen is noisier at the moment and the traffic noise is terrible… for the first time in 70 years I had to close my bedroom window because of the noise." "We hear noise … but it doesn't worry us at the moment."
Community Consultation / Communication	• Lack of consultation by Mt Owen Complex • *Good communication with mining companies* • Ineffective complaints process – Mt Owen • Need for greater transparency in mine companies' activities • Mistrust of mining companies • *Improved consultation with Mt Owen Complex*	"[They should] improve hotlines for complaints. We have stopped writing them down and stopped ringing up as they don't do anything." "[You] have to complain a lot to get anything done." "[We are] extremely dissatisfied with the Mt Owen complaints process." *"We have a good relationship – no problems at all."*
Dust	• Reduced amenity due to dust impacts • General impacts of dust on air quality / health • Impacts of dust on water quality (e.g. tank water) • Dust impacts exacerbated by weather conditions • Poor management / increasing dust impacts	"Dust is the biggest issue! [It] impacts our tank water … we need more recognition of health concerns." "Respiratory issues are a cost of mining. We would like to know more about health risks associated with mining dust." "Once you get past the range the air quality is different. There is black soot in the gutters."
Impacts on Community	• Concerns about scale of mining / expansions and impacts on community • Negative impacts on sense of place / community • Negative impacts of property acquisition (e.g. loss of community) • Decreased accessibility and affordability of housing • *Positive impacts of population growth and sustainability* • Division between mining / non-mining community • Negative impacts of mining work on family life • Increasing cumulative impacts of mining on community	"The community spirit is gone. We don't know our neighbours..." "Not many benefits for Singleton … Singleton people are scruffy in their work gear around town." "Neighbours turn on one another – the acquisitioned land was all kept so secretive, when the word got out, people were jealous of what one another had been offered." "There needs to be more responsibility for the impacts that are being caused. We have seen marriages breakdown as one can't handle the impacts and wants out and the other doesn't."
Environmental Impacts	• Negative impacts on water quality and quantity • Poor management of mine owned land (e.g. increased pests and weeds) • Poor rehabilitation practices	"Coal activity and rehab would be the best thing to happen to this land." "I do not like the screening type of plantation or the fake hills. [The rehabilitation] needs to be more natural." "We worry about the impacts on the environment and the animals. [There

Impact Themes	Perceived Impacts (in order of frequency)	Examples of Landholder Quotes
	• *Good rehabilitation practices* • Impacts of mining on wildlife • Concerns about extent / amount of mine-owned land • General environmental impacts of mining	are] increased pests and weeds." *"Coal activity and rehab would be the best thing to happen to this land."*
Economic Impacts	• *Benefits of employment* • Higher costs of living • Negative impacts on other industries (e.g. dairy, agriculture) • *Positive economic impacts from mining generally* • Employment is not local (i.e. no benefits locally)	"I wouldn't be employed without the mines. Neither would my children." "The cost of living here is expensive. I hope they are employing locals." "Locals are not being employed in the mining industry. It's unfair." *"There is a [positive] flow on effect caused by mining investment … income for local businesses."*
Traffic / Roads	• Increased traffic congestion • Increased mine-related traffic (e.g. employees, mine equipment) • Impacts on road conditions / safety from increased traffic • Impacts on road traffic from train movements (i.e. closed rail crossings)	"Trucks are damaging the local roads – [they're] not supposed to be on these roads. Local roads need maintenance." "Mines should supply buses for employees so it will decrease traffic." "The traffic is caused by all the drive in-drive out workforce."
Blasting	• Vibration impacts • Structural damage to property • Air quality concerns (i.e. blast plumes)	"The vibrations from the blasts are cracking the roof." "The orange clouds worry me."
Decline in Property Values	• Perceived decline in property values as a result of mining	"We would like to get away from the area… but we can't sell our house as it's not worth anything."
Community Investment	• *Positive impacts of community investment by mining companies*	*"We have found the mining industry very family-orientated and make a lot of good investments…"*
Visual Impacts	• Lighting impacts • Decreased visual amenity from mining • Decreased visual amenity – Mt Owen	"You can see the lights from Mt Owen … [it has] impacts when you're driving on the local roads." "Something needs to be done about visual amenity – we need a divider."
Impacts on Aboriginal Cultural Heritage	• Negative impacts on Aboriginal Cultural Heritage	"We have concerns regarding Aboriginal heritage. So much has been wrecked in the Valley and we cannot replace it."

Note: Positive impacts are in italics. Mt Owen Complex is noted where it has been mentioned specifically by landholders. Otherwise impacts are identified by stakeholders in a broad sense as impacts from mining generally.

5.3 Perceived Opportunities

Due to the small nature of the project, the consultation for RERR was focused predominantly on concerns of local and neighbouring residents, however in the course of interviewing these community members, a number of key opportunities to address concerns and/or enhance community well-being were suggested by landholders. Table 5.2 provides a summary of these identified opportunities.

Table 5.2 Summary of key landholder-identified opportunities

Theme	Identified opportunities
Impact Management	Investigate best practice dust and noise management practices Investigate opportunities for improved operational planning under certain weather conditions to decrease dust and noise impacts
Community Engagement	Development of an ongoing community consultation program Keep the community engagement approach personal and regular Improve accessibility, transparency and effectiveness of complaints mechanism
Lifestyle and Community Sustainability	Invest in community programs that help to retain the 'sense of community'
General Environment/ Land Use	Research additional impacts of weather on mine-related issues such as dust and noise Implement programs to reduce pests and weeds on mine land Address rehabilitation practices to promote more natural landforms
Community Health	Recognition of community health concerns and communication with the community regarding any environmental/health monitoring e.g. dust and air/water quality

5.4 Summary of Perceived Issues and Opportunities

Through consultation with neighbouring landholders, it is evident that issues / impacts specifically associated with RERR are minimal.

Of most concern to the local community are the issues / impacts associated with the Mt Owen Complex as a whole and the cumulative issues associated with mining in the region generally. The most commonly identified issue was noise from the complex as a whole. Another common concern amongst those interviewed was a historical lack of communication and genuine community engagement by XMO, exacerbated by a community complaints mechanism that was perceived to be unresponsive. Longer-term issues including a loss of sense of community, and the ongoing sustainability of small localities (e.g. sustained local employment and housing) were also key concerns for landholders. Issues relating to air quality/ health, surface and ground water, roads and transport, general environmental issues, visual amenity and blasting were also discussed, but to a lesser extent.

Having identified the perceptions of key stakeholders as part of the assessment, the proceeding sections of this SIOA report involve further technical social assessment of these perceived issues, prediction of the likely social impacts that may occur as a result of the proposed modification and documentation of the strategies that may be implemented to mitigate any potential negative impacts and where possible enhance positive impacts.

6.0 Issues, Opportunities and Management Strategies

6.1 Assessment of Issues and Opportunities

The scope of the social impact assessment is to assess the proposed *change* to the current baseline social environment (in which RERR is proposed), as a result of the RERR proceeding. This approach acknowledges that, from a social perspective, the proposed modification will be viewed as part of the existing mining operations.

In order to understand the potential social impacts presented by RERR, a risk-based approach has been applied. The risk ranking process used by Coakes Consulting for RERR has been developed from literature review, previous SIOA work and specialist experience and knowledge. The approach is consistent with Sandman's risk equation (Risk = Hazard + Outrage) (Sandman 1993), and reflects an integration of expert and local knowledge. The integration of the outcomes of the technical (environmental and social) risk assessment, undertaken by specialists/ technical experts, with community perceptions of risk affords a more integrated, and socially responsive risk assessment approach.

First, the unmitigated impacts of the proposed modification are assessed in terms of technical risk (i.e. high, medium or low), determined through direct reference to the environmental and social impact assessment studies conducted as part of the EA. Second, the stakeholder perceived impact risk is assessed (i.e. high, medium or low) based on findings from consultation undertaken as part of the SIOA. This impact assessment exercise then allows impacts requiring management to be prioritised – i.e. impacts to be addressed as a priority include those that are ranked as high perceived community risk and/or high technical risk.

The following Table 6.1 summarises the technical and stakeholder-perceived social risks in relation to the following impact categories:

- population change
- community impacts
- social amenity impacts
- economic impacts
- environmental impacts.

The summary outlines the identified impacts / issues, likely impact time frame, geographic scope and stakeholders that may be likely to experience social impacts, together with the unmitigated technical and stakeholder perceived risk rankings. **As can be seen, most of the impacts associated with RERR are ranked as low technical and stakeholder perceived risks.**

The following section (Section 6.2**Error! Reference source not found.**) goes on to outline the management, mitigation and enhancement strategies associated with RERR, although most strategies are part of ongoing and existing operations due to the low risks posed by the proposed modification specifically.

Table 6.1 Summary of impacts and opportunities

Impacts / issues / opportunities	Time	Geographic scope	Stakeholders impacted	Unmitigated technical risk	Perceived risk
Population Change Impacts					
Ongoing operational workforce	*Life of mine*	*Hunter Region*	*Wider community*	*Medium (positive)*	*Medium (positive)*
Construction workforce	Construction	Singleton LGA	Wider community	Low	Low
Land acquisition (population change)	Construction	Neighbouring villages	Local landholders	Low	Low
Community Impacts					
Decline in property values	Life of mine	Neighbouring villages	Neighbouring landholders	Low	Medium
Housing accessibility and affordability	Life of mine	Singleton LGA	Wider community	Low	Medium
Increased costs of living	Life of mine	Singleton LGA	Wider community	Low	Medium
Mining / XMO investment in community	*Life of mine*	*Hunter Region*	*Wider community*	*High (positive)*	*Medium (positive)*
Sense of community	Life of mine	Neighbouring villages and Singleton LGA	Neighbouring landholders and wider community	Low	High
Cultural heritage	Construction and operation	Singleton LGA	Aboriginal community	Low	Low
Land use conflict	Construction and operation	Neighbouring villages	Other land users	Low	Low
Lack of community consultation and engagement	Initial phases	Neighbouring villages	Neighbouring landholders	Medium	High
Social Amenity Impacts					
Noise	Construction and Operation	Neighbouring villages	Neighbouring landholders	Low	High
Dust	Construction and Operation	Neighbouring villages and Singleton LGA	Wider community	Low	Medium
Traffic	Construction and Operation	Neighbouring villages and Singleton LGA	Wider community	Low	Medium
Blasting	Operation	Neighbouring villages	Neighbouring landholders	Low	Low
Visual	Construction and Operation	Neighbouring villages	Neighbouring landholders	Low	Low

Impacts / issues / opportunities	Time	Geographic scope	Stakeholders impacted	Unmitigated technical risk	Perceived risk
Economic Impacts					
Economic benefits	*Life of mine*	*Hunter Region, NSW, Australia*	*Wider community*	*High (positive)*	*High (positive)*
Lack of local employment	Construction and Operation	Singleton LGA	Neighbouring landholders and wider community	Low	Low
Impacts on other industries	Operation	Singleton LGA	Wider community	Low	Low
Environmental Impacts					
Water impacts	Construction / Operation	Neighbouring villages and Singleton LGA	Wider community	Low	Medium
Land management impacts	Operation	Neighbouring villages and Singleton LGA	Wider community	Low	Medium
Ecological impacts	Construction / Operation	Local area	Neighbouring landholders	Low	Low
Greenhouse gases	Life of mine and beyond	National	Wider community	Low	Low

Source: Coakes Consulting (2012). Note: Wider Community is defined as all people who may reside, work, govern or have connection to the locality. Negative risks are written in normal font, positive opportunities in italics.

6.2 Management, Enhancement and Monitoring Strategies

Having identified and assessed the social impacts relating to RERR, this section outlines appropriate management and enhancement strategies. Clearly, many of these impacts do not require direct management / enhancement actions as part of RERR specifically, due to their inherently cumulative and/or positive nature.

Many of the key issues identified above can be addressed through progression and continuation of communication and relationship-building with the local community. There was strong positive feedback on the RERR consultation process, with many community members suggesting that this type of communication needed to continue in order to further develop relationships between the mine and local community. As such, the strategies outlined below focus on continuing and in some cases enhancing existing community engagement, communication strategies, impact management/monitoring and social investment as part of the ongoing Mt Owen Complex operations. It is proposed that this approach to further develop existing communication and engagement with the community will also lead to ongoing and improved understanding and monitoring of social impacts over time.

The following Table 6.2 summarises the key mitigation, enhancement and monitoring measures for consideration in the management of predicted social impacts. Again, it is important to note that the strategies proposed for RERR are largely existing and ongoing programs for the Mt Owen Complex as a whole, rather than targeted to RERR specifically. The enhancement of existing strategies reflects the overall small scale of the proposed modification and predicted social impacts.

Table 6.2 RERR management and enhancement strategies

Category	Management and enhancement strategies
Communication	**Feedback to the community** regarding the outcomes of the EA for the RERR Project **Regular updates to the community** regarding operations at the Mt Owen Complex **Ongoing distribution of bi-annual Community Newsletter** detailing Mt Owen Complex programs, events and activities **Continuation of the 24-hour Community Response Hotline** to provide the public with a means of raising and registering concerns and issues
Engagement / Relationships	**Continuation of Mt Owen Complex Community Consultative Committee (CCC) meetings** **Continuation of household near neighbour visits** on request by community **Continuation of periodic Mt Owen Open Day** to include near neighbours, employees and their families **Maintain relationship with the local Mt Pleasant Public School** by building on existing relationships and support of the local school **Continuation of existing local employment / training programs**
Impact Management / Monitoring	**Implementation of technical strategies** as outlined within this EA as part of ongoing operational guidelines for the Mt Owen Complex **Continuation of ongoing social impact monitoring** in accordance with the XMO Social Involvement Plan (SIP)
Investment	**Continual improvement and update of the XMO Social Involvement Plan (SIP)** **Continue to actively pursue ongoing opportunities to use and invest in local facilities** where appropriate and in accordance with XMO Social Involvement Plan.

Source: Coakes Consulting (2012)

7.0 Conclusion

The RERR proposed modification presents a small-scale resource recovery project in an already disturbed area of the Ravensworth East Mine. It presents an opportunity to recover coal resources within existing mining operations and to continue employment. Together with the implementation of recommended management strategies, the proposed modification is unlikely to have any significant negative social impacts.

The SIOA has involved a series of phases including: profiling, scoping of issues and opportunities, assessment of impacts and opportunities; strategy development to mitigate and/or enhance social impacts; and finally, reporting and development of an ongoing monitoring framework. Throughout this SIOA process the assessment of impacts has involved the integration of community and technical knowledge.

As part of the SIOA, a number of social impacts have been identified that XMO will need to manage / enhance as part of their ongoing operations, namely: a perceived lack of community consultation and engagement, perceived noise impacts, perceived (cumulative) impacts on sense of community; positive impacts from mining / XMO community investment and economic benefits to the region.

A range of initiatives, strategies and programs are currently utilised by XMO to assist with this management including regular community newsletters, open days and ongoing social investment. There are also a range of methods for ongoing management and monitoring of social impacts adopted by XMO/XCN. Together these strategies help to manage and monitor social impacts and promote more communication and collaboration between community and industry, leading to a net social benefit from the proposed modification.

8.0 References

Australian Bureau of Statistics (ABS) (2006a). *Basic Community Profile,* Camberwell, NSW (State Suburb), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2006b). *Basic Community Profile,* Singleton, NSW (Local Government Area), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2006c). *Basic Community Profile,* Hunter Region, NSW (State Region), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2006d). *Basic Community Profile,* NSW (State), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2011a). *Basic Community Profile,* Camberwell, NSW (State Suburb), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2011b). *Basic Community Profile,* Singleton, NSW (Local Government Area), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2011c). *Basic Community Profile,* Hunter Region, NSW (State Electoral District), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Bureau of Statistics (ABS) (2011d). *Basic Community Profile,* NSW (State), cat. No. 2001.0. ABS: Canberra, ACT.

Australian Centre for Corporate Social Responsibility (ACCSR) (2011). Upper Hunter Mining Dialogue. Prepared for the NSW Minerals Council.

Australian Institute of Health and Welfare (AIHW) (2011). *Singleton Hospital.* Available online at: http://www.myhospitals.gov.au/hospital/singleton-hospital

Beckley, T.M., Martz, D., Nadeau, S., Wall, E. and Reimer, B. (2008). Multiple capacities, multiple outcomes: Delving deeper into the meaning of community capacity. *Journal of Rural and Community Development* 3(3): 56-75.

Burdge, Rabel J. (2004). *A Community Guide to Social Impact Assessment*. Third ed. Middleton, Wisconsin: Social Ecology Press.

Centre for Sustainable Ecosystem Restoration (CSER) (2009). *Ravensworth State Forest Vegetation Complex – Model Site for the Restoration and Reconstruction of Forest and Woodland.* The University of Newcastle, Australia.

Coakes Consulting (2012a) *Aboriginal Needs and Opportunities Assessment (ANOA): the Hunter Region*. Report prepared for Xstrata Coal NSW.

Coakes Consulting (2012b) *Regional Issues Assessment: Singleton LGA*. Report prepared for Xstrata Coal NSW.

Coakes, S. and Sadler, A. (2011). *Utilizing a sustainable livelihoods approach to inform a social impact assessment practice*. In Vanclay, F. and Esteves, A.M. (Eds.) New Directions in Social Impact Assessment. Edward Elgar, UK.

Country Transport (2011). *Town Services – Singleton.* Available online at: http://www.countrytransport.131500.com.au/index.asp?InfoMode=TownServices&Town=singleton&ServiceType=Community

Department for International Development (DfID) (1999), *Sustainable Livelihoods Guidance Sheets*. London: Department for International Development.

Department of Planning and Infrastructure (DoPI) (2012) *Strategic Regional Land Use Plan: Upper Hunter*. NSW Government.

Ellis, F. (2000). *Rural Development and Diversity in Developing Countries*. Oxford University Press: Oxford, UK.

Hart, M. (1999). Guide to Sustainable Community Indicators, Ipswich, MA: QLF/Atlantic Centre for the Environment. Available online at: http://www.sustainablemeasures.com

Hunter Valley Coal Chain Coordinator (HVCCC) (2011). *About the HVCC*. Available online at: http://www.hvccc.com.au/

International Association of Impact Assessment (IAIA) (2003). *Social Impact Assessment: International Principles.* Available online at: http://www.iaia.org/publicdocuments/special-publications/SP2.pdf

NSW Bureau of Crime Statistics and Research (BOCSAR) (2011) *Ranking of NSW LGAs*, Available online at: http://www.bocsar.nsw.gov.au/lawlink/bocsar/ll_bocsar.nsf/pages/bocsar_research

NSW Government (2012). A New Planning System for NSW: A Green Paper. NSW Government, July.

Public Health Information Development Unit (PHIDU) (2011). *A Social Health Atlas of Australia*. The University of Adelaide.

Sandman, P.M. (1993) *Responding to Community Outrage: Strategies for Effective Risk Communication*. American Industrial Hygiene Association, Fairfax VA.

Singleton Argus (2011). *Singleton District Guide*, Available online at: http://magresources.f2.com.au/sdg/2011/sdg/pageflip.html

Singleton Council (2012a). *Our Place a Blueprint 2022: Singleton Community Strategic Plan*, January.

Singleton Council (2012b). *Singleton Council: Services and Facilities* Available on line at: http://www.singleton.nsw.gov.au/templates/singleton_content_2.aspx?edit=false&pageID=110

Vanclay, F (2008). Place Matters. In F. Vanclay, M. Higgins and A. Blackshaw (eds) *Making sense of place: Exploring concepts and expressions of place through different senses and lenses*. National Museum of Australia Press, Canberra, Australia.

Visit New South Wales (2011) *Destination NSW - Hunter Valley Singleton*. Available online at: http://www.visitnsw.com/destinations/hunter/hunter-valley/singleton

Xstrata Coal NSW (XCN) (2012). *Mt Owen Complex.* Available online at: http://www.mtowencomplex.com.au/EN/Pages/default.aspx

9.0 Appendices

9.1 Key Socio-Economic Indicators

	Camberwell SS			Singleton LGA			Hunter Region			NSW		
	2006	2011	↑↓	2006	2011	↑↓	2006	2011	↑↓	2006	2011	↑↓
Economic Capital												
Employed full-time	66%	–	–	63%	–	–	71%	–	–	72%	–	–
Employed part-time	26%	–	–	27%	–	–	16%	–	–	16%	–	–
Unemployed	5%	–	–	4%	–	–	7%	–	–	6%	–	–
Top Industry of Employment	21.2% Mining	–	–	19.9% Mining	–	–	15.7% Manufact.	–	–	12.9% Manufact.	–	–
Median household income ($/weekly)	$1153	$1607	↑	$1258	$1692	↑	$888	$1196	↑	$1036	$1237	↑
Median rent ($/weekly)	$100	$160	↑	$180	$260	↑	$180	$200	↑	$210	$300	↑
Median mortgage repayment ($/month)	$1213	$2400	↑	$1408	$2000	↑	$1300	$1733	↑	$1517	$1993	↑
Human Capital												
Population size (persons)	378	181	↓	21939	22694	↑	589238	72463	↑	6549178	6917658	↑
Indigenous population (%)	5%	6%	↑	3%	4%	↑	3%	5%	↑	2%	3%	↑
Family household (%)	80%	70%	↓	79%	77%	↓	72%	72%	–	72%	72%	–
Lone person household (%)	16%	25%	↑	19%	21%	↑	25%	25%	–	24%	24%	–
Group household (%)	4%	6%	↑	2%	3%	↑	3%	3%	–	4%	4%	–
Highest year of schooling – Year 12	17%	–	–	24%	–	–	23%	–	–	38%	–	–
Highest post-school qualification – Bachelor Degree	3%	–	–	5%	–	–	7%	–	–	10%	–	–
Highest post-school qualification – Certificate and/or Diploma	20%	–	–	23%	–	–	22%	–	–	19%	–	–
Physical Capital												
Fully owned	29%	24%	↓	34%	31%	↓	39%	36%	↓	36%	34%	↓
Being purchased	32%	11%	↓	40%	40%	–	33%	34%	↑	33%	34%	↑
Rented	39%	64%	↑	26%	28%	↑	27%	29%	↑	30%	31%	↑
Social Capital												
Single parent families (%)	6%	13%	↑	6%	9%	↑	7%	10%	↑	9%	7%	↓
Volunteers (%)	18%	15%	↓	20%	19%	-	17%	21%	↑	17%	17%	-

9.2 Regional Issues and Opportunities Review

Theme	Strategic Regional Land Use Plan (DoPI 2012)	Singleton Community Strategic Plan (Singleton Council 2012a)	Upper Hunter Mining Dialogue (ACCSR 2011)	Regional Needs and Opportunities Assessments (Coakes 2012a, b)
Land Use, Resource Development and the Natural Environment	• Balancing conflicting land uses – CSG, mining, agricultural, viticulture, tourism • Maintaining and enhancing opportunities for the future of: environmentally responsible mining and agriculture • Protecting strategic agricultural land, conservation lands, and lands of high biodiversity value including corridors • Developing and applying appropriate management measures to control and mitigate impacts on the environment • Developing renewable energy opportunities • Ensuring high value rehabilitation	• Developing sensitivity to the natural and built environment of the area and impacts upon it • Conserving resources, developing renewable energies and promoting sustainable ways of living • Developing environmental education and awareness • Industry and business is contributing to environmental sustainability	• Balancing conflicting land uses and protecting strategic areas – eg viticulture, farming • Addressing key impact areas of mining: environment, air, health, noise, cumulative water impacts, rehabilitation (integrated), coal trains (covered), blasting • Addressing negative perceptions of the mining industry as a whole • Enhancing relationships with individual companies • Linking SRLUP with local and other state government plans	• Addressing impacts on local environment: air quality and health, noise, water impacts • Promoting world leading rehabilitation and land management • Balancing conflicting land uses • Protecting strategic land use areas – eg viticulture, farming • Protecting local villages
Economy, Development and Employment	• Addressing land use conflicts • Balancing supply and demand for labour and employment land / areas • Developing economic diversification and resilience	• Ensuring economy is diverse and can withstand global change • Singleton is recognised on local, national and international stage • Leaders are working together to achieve these aims	• Enhancing employment and training opportunities • Ensuring employment and training opportunities for local people	• Enhancing economic growth and development and ensuring long-term sustainability of economy • Addressing local skills shortages • Developing leadership and coordination between sectors • Developing long-term and sustainable employment opportunities for Aboriginal community including training and business mentoring / support
Housing and Settlement	• Ensuring adequate land supply for housing • Addressing housing mix and affordability • Promoting liveable communities	• Increasing the range of affordable and accessible housing	• Addressing cumulative impacts of mining on the affordability and accessibility of housing in the region	• Need for accessible and affordable housing • Provision of accommodation for mining employees • Addressing homelessness and provision of emergency housing

Theme	Strategic Regional Land Use Plan (DoPI 2012)	Singleton Community Strategic Plan (Singleton Council 2012a)	Upper Hunter Mining Dialogue (ACCSR 2011)	Regional Needs and Opportunities Assessments (Coakes 2012a, b)
Services and Infrastructure	• HVCC and rail network capacity issues • Regional and cumulative impacts on existing infrastructure • Impacts on local community from mining infrastructure • Provision and funding for infrastructure to support new housing and development	• Ensuring appropriate services and facilities as the region grows • Increasing focus on prevention not just health services • Improving connections through appropriate public transport and networks	• Cumulative impacts on existing services and infrastructure • Supporting regionally significant infrastructure – both industry and government	• Stress on existing infrastructure and services • Addressing safety and capacity of transport/road networks • Developing more education and training services / opportunities • Enhancing youth, aged, mental health and Aboriginal-focused services / support programs
Community Health, Amenity and Heritage	• Impacts of air and noise pollution on community and ensuring relevant / stringent conditions • Land use conflicts and impacts on community • Visual amenity impacts • Ongoing, relevant and appropriate community consultation	• Increasing opportunities in education, recreation, social and cultural activities • Developing a strong sense of place, pride and community • Increasing tourism and business opportunities • Creating vibrant public spaces that are safe and accessible • Celebrating the region's history • Promoting sustainable lifestyles • Acknowledging key community values including: rural heritage and lifestyle; access to services and cities; community-minded people; tradition and family; a strong economy; provision of community facilities	• Ensuring industry and community work together • Cumulative impacts on air quality and associated health risks • Exploring opportunities for health risk assessments • Protecting European and Aboriginal heritage • Addressing impacts of shift work on families	• Enhancing investment, communication and engagement between mining companies and community • Addressing impacts of shift work on families and enhancing opportunities for mining families • Better assess health impacts • Addressing impacts on sense of community (e.g. mobility, mining workforce, volunteering) • Developing Aboriginal cultural heritage awareness, support programs and events • Acknowledging key community values including: local villages; rural lifestyle; social / community and recreation facilities and events; traditional community and family values; strong sense of history, culture and heritage

9.3 Media Review

Source	Title of Article	Date	Author	Key Themes
Singleton Argus	Expectant mothers in Singleton	5-Apr-11	-	Services
Singleton Argus	Environment workshop covers health matters	15-May-11	-	Health
Singleton Argus	Dust levels at Maison Dieu tip the monitor	17-May-11	-	Mining impacts / Dust
Singleton Argus	No coal seam gas in Singleton vineyards	7-Jun-11	Paul Maguire	Coal Seam Gas
Newcastle Herald	Coal dust concerns	8-Jun-11	Matthew Kelly	Health
Newcastle Herald	Coal vs cows: an ungodly row	25-Jun-11	Ian Kirkwood	Land use
Singleton Argus	Singleton mine talks	5-Jul-11	Di Sneddon	Mining industry
Singleton Argus	Singleton gets nine of the 14 air quality monitor locations	15-Jul-11	-	Mining impacts / Air quality
Singleton Argus	Health study to look at broader impacts	9-Aug-11	Sarah Lee	Health
Singleton Argus	Coal mining dust	12-Aug-11	Sarah Lee	Mining impacts / Air quality
Singleton Argus	Community united in struggle to survive	19-Aug-11	Paul Maguire	Community
Singleton Argus	Action plans to minimise open cut mining impacts	26-Aug-11	-	Land Use
Singleton Argus	Ashton debate set for Tuesday morning, September 6	2-Sep-11	-	Mine expansions
Singleton Argus	Ashton meeting today	6-Sep-11	Declan Martin	Mine expansions
Singleton Argus	Audit on risky business	16-Sep-11	Paul Maguire	Mining impacts
Singleton Argus	Open doors at Plashett	20-Sep-11	-	Heritage
Singleton Argus	Massive response to coal gas inquiry	20-Sep-11	-	Coal Seam Gas
Singleton Argus	Fifteen more miners to go	30-Sep-11	-	Mine expansions
Singleton Argus	Showdown on farm	14-Oct-11	Paul Maguire	Mine expansions
Singleton Argus	Injunction on coal operations after Plains take legal step	18-Oct-11	Louise Nichols	Mining / Heritage
Singleton Argus	Camberwell Common appeal being considered	1-Nov-11	-	Mine expansions / Community
Singleton Argus	Hospital appears safe	1-Nov-11	Paul Maguire	Health
Singleton Argus	No royalties for five years	4-Nov-11	Louise Nichols	Coal Seam Gas
Singleton Argus	Push for hospital here	4-Nov-11	Paul Maguire	Health
Singleton Argus	Dairy report makes no sense	8-Nov-11	-	Agriculture
Singleton Argus	Hearing begins	11-Nov-11	Paul Maguire	Mine expansions
Singleton Argus	Hearing begins	11-Nov-11	Paul Maguire	Mine expansions
Singleton Argus	Dust levels peak again	11-Nov-11	-	Dust
NSW Minerals Council	Upper Hunter Mining Dialogue	15-Nov-11	-	Mining impacts
Singleton Argus	Industry shares the wealth	18-Nov-11	-	Mining impacts
Singleton Argus	Singleton - Sold out	18-Nov-11	Louise Nichols	Housing
Newcastle Herald	Mines run low on Orica explosives	23-Nov-11	Ian Kirkwood	Mine industry
Singleton Argus	Mining begins under council's nose	25-Nov-11	Paul Maguire	Mining impacts
Singleton Argus	Singleton farmer fights mine in court	29-Nov-11	-	Mining impacts
Singleton Argus	New study will determine dust chemical compound	29-Nov-11	-	Dust
Newcastle Herald	Premier asked to halt NuCoal at Jerrys Plains	1-Dec-11	Frances Thompson	Mine expansions
Singleton Argus	Government requests Doyles Creek suspension	2-Dec-11	-	Mine expansions
Singleton Argus	Not over yet	2-Dec-11	Paul Maguire	Mine expansions
Singleton Argus	No access	6-Dec-11	Paul Maguire	Mine expansions
Singleton Argus	Big step for road extension	16-Dec-11	-	Roads / Infrastructure
Singleton Argus	No to Ashton coal	23-Dec-11	Paul Maguire	Mining impacts

Source	Title of Article	Date	Author	Key Themes
Singleton Argus	$4.3m mine deal accepted	6-Jan-12	Paul Maguire	Mine expansions
Singleton Argus	No shortage of jobs in coal industry	6-Jan-12	-	Employment
Singleton Argus	Health message from the chief	6-Jan-12	-	Health / Housing
Singleton Argus	Family's desperate search for a home	10-Jan-12	Paul Maguire	Housing
Singleton Argus	Gas dispute nipped before it begins	17-Jan-12	-	Mine expansions / Land Use
Singleton Argus	No new mines	20-Jan-12	Louise Nichols	Mine expansions
Singleton Argus	Spare bedrooms find a home in housing crisis	10-Feb-12	Louise Nichols	Housing
1233 ABC Newcastle	Hunter GP sounds warning over coal expansion	15-Feb-12	-	Health
Singleton Argus	Singleton coal China link	17-Feb-12	Paul Maguire	Mining
Singleton Argus	Singleton home	17-Feb-12	Paul Maguire	Housing
Sydney Morning Herald	NuCoal strikes $76m deal for Hunter Valley project	21-Feb-12	-	Exploration
Singleton Argus	Singleton land on market	24-Feb-12	Paul Maguire	Housing
Newcastle Herald	Hunter air quality monitors in action	25-Feb-12	Michelle Harris	Air Quality
Singleton Argus	Upper Hunter Air Quality Monitoring Network	28-Feb-12	-	Air Quality
Singleton Argus	Singleton dust report	28-Feb-12	Paul Maguire	Mining impacts / Dust
Newcastle Herald	Corrosive dust fallout blamed for pipe decay	29-Feb-12	Greg Ray	Mining impacts
Singleton Argus	Doyles Creek Mine	2-Mar-12	-	Land Use
Singleton Argus	Blast scare	6-Mar-12	Paul Maguire	Mining impacts / Health
Newcastle Herald	Air quality network makes a difference	8-Mar-12	Matthew Kelly	Air Quality
Singleton Argus	Strategy anger	9-Mar-12	Paul Maguire	Land Use
Singleton Argus	Coal land use strategy forum in Singleton	13-Mar-12	-	Land Use
ABC News	CCC member speaks out against Hunter coal mine	13-Mar-12	-	Exploration
Singleton Argus	Get a job in the coal mines	16-Mar-12	-	Employment
ABC News	Mine fined for exceeding dust limit	21-Mar-12	David Marchese	Mining impacts
Singleton Argus	Carbon tax will hit Singleton	3-Apr-12	Paul Maguire	Carbon tax
Singleton Argus	Angry response to new mining report	10-Apr-12	-	Mining impacts
Singleton Argus	Return more royalties	13-Apr-12	-	Royalties
Australian Mining	New apprentices for Coal & Allied	16-Apr-12	Andrew Duffy	Employment
Newcastle Herald	Camberwell open-cut mine plan revived	19-Apr-12	Michelle Harris	Mine expansions
Australian Mining	Camberwell coal mine plan renewed	19-Apr-12	Cole Latimer	Mine expansions
Singleton Argus	Ashton second chance	20-Apr-12	Paul Maguire	Mine expansions
Newcastle Herald	Row over Ashton Coal impacts	20-Apr-12	Michelle Harris	Mining impacts / expansions
ABC News	Mayor 'stunned' coal mine back on agenda	20-Apr-12	David Marchese	Mine expansions
Newcastle Herald	Ombudsman looks at Ashton Coal dealings	21-Apr-12	Michelle Harris	Mining expansions
Singleton Argus	Health talks gains	21-Apr-12	Sarah Lee	Health
Singleton Argus	Sharyn Munro's book tells story of coal mining impacts	24-Apr-12	-	Mining impacts
Newcastle Herald	Next step in Doyles Creek mine	27-Apr-12	Frances Thompson	Employment
Newcastle Herald	Camberwell residents want public hearing	28-Apr-12	Matthew Kelly	Mine expansions
Singleton Argus	Changing times on the land	1-May-12	-	Land Use
Newcastle Herald	Hunter farmers rally in Sydney	1-May-12	Frances Thompson	Land Use
ABC Newcastle	Rio Tinto accused of Mt Pleasant ploy	4-May-12	-	Mine closure
Singleton Argus	Mine workings threaten waterway	8-May-12	-	Mining impacts
Newcastle Herald	Singleton Council accused of being 'anti-mining'	8-May-12	-	Mining industry
Singleton Argus	Air pollution	11-May-12	-	Mining impacts / health

Source	Title of Article	Date	Author	Key Themes
Singleton Argus	Singleton misses federal funding	11-May-12	-	Royalties
Muswellbrook Chronicle	Rio tight-lipped on mine's future	11-May-12	Stacey Post	Mine Closure
Singleton Argus	Coal boom steadies	15-May-12	Paul Maguire	Mining impacts
Singleton Argus	Environment workshop covers health matters	15-May-12	-	Air Quality / Health
Singleton Argus	Air quality exceedance	15-May-12	-	Air Quality
Newcastle Herald	Integra Coal in dispute with Camberwell residents	16-May-12	Matthew Kelly	Mine expansions / Community
Newcastle Herald	Research: does CSG cause farmer stress?	16-May-12	Frances Thompson	Mining impacts
1233 ABC	Mine applies for 'minor' extension	17-May-12	David Marchese	Mine expansions
Singleton Argus	Coal loader brings on more health debate	18-May-12	Paul Maguire	Coal industry / expansions
Singleton Argus	Bypass push is on	18-May-12	-	Mining impacts
Singleton Argus	Great Greta issued with pollution plan	18-May-12	-	Mining impacts / Water
Singleton Argus	Mine site rehabilitation prompts new techniques	22-May-12	-	Rehabilitation
Singleton Argus	Mine cops dust fine	25-May-12	-	Mining impacts / Dust
Newcastle Herald	McGeoch's talks to happen behind closed doors	25-May-12	Paul Maguire	Royalties
Singleton Argus	Ashton Coal Planning Assessment hearing	29-May-12	Paul Maguire	Mine expansions
1233 ABC	Ashton fight resumes in Singleton	31-May-12	-	Mine expansions
Singleton Argus	Ashton heats up	1-Jun-12	Paul Maguire	Mine expansions
Singleton Argus	Warkworth mine heads to Land and Environment Court	5-Jun-12	Paul Maguire	Mine expansions
Singleton Argus	Singleton mine back open after fire	5-Jun-12	-	Mine expansions
Newcastle Herald	Singleton coal opportunities	19-Jun-12	Di Sneddon	Mining industry
Newcastle Herald	Coal roads reclassification application	22-Jun-12	-	Roads / Infrastructure
Newcastle Herald	Court to hear mine subsidence to blame for damage	26-Jun-12	-	Mining impacts
Newcastle Herald	Plan to extend Ravensworth mine	28-Jun-12	Ian Kirkwood	Mine expansions
Singleton Argus	Stoner to comment on coal cash	3-Jul-12	Paul Maguire	Royalties
Singleton Argus	Singleton road safety audit	6-Jul-12	-	Roads / Infrastructure
Singleton Argus	Mine changes help stop fumes	6-Jul-12	-	Mining impacts
Singleton Argus	Singleton mine job	6-Jul-12	Louise Nichols	Employment /Mining industry
Singleton Argus	Singleton Council signs $4.3 million deal	10-Jul-12	Paul Maguire	Voluntary planning agreement
Singleton Argus	Chamber links business to coal	13-Jul-12	-	Employment / Local business
Newcastle Herald	Impact of mining boom on property to be examined	18-Jul-12	Frances Thompson	Mining impacts
Newcastle Herald	Upper Hunter housing demand at desperate level	30-Jul-12	Frances Thompson	Housing
Newcastle Herald	Work on Hunter rail tracks	6-Aug-12	Michelle Harris	Rail / Infrastructure
Newcastle Herald	Inquest begins into death of Ravensworth miner	21-Aug-12	Dan Proudman	Workplace Health & Safety

APPENDIX 3

Blast Impact Assessment

ENVIRO STRATA CONSULTING Pty Ltd
A.B.N. 35 122 301 795
ESC

24 Albert Street
Valentine NSW 2280
T/F: (02) 4946 1864
Mob: (0407) 005 352
Email: enviro.strata@gmail.com

Thomas Lewandowski
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M., M.I.S.E.E.,
M.EFEE.

UMWELT AUSTRALIA ON BEHALF OF XSTRATA MT OWEN

BLAST IMPACT ASSESSMENT OF THE RAVENSWORTH EAST RESOURCE RECOVERY PROJECT ON THE ADJACENT COMMUNITY, INFRASTRUCTURE AND UNDERGROUND WORKINGS

REPORT NO. UM-1205-221012

Thomas Lewandowski
22nd October 2012

UMWELT AUSTRALIA ON BEHALF OF XSTRATA MT OWEN

BLAST IMPACT ASSESSMENT OF THE RAVENSWORTH EAST RESOURCE RECOVERY PROJECT ON THE ADJACENT COMMUNITY, INFRASTRUCTURE AND UNDERGROUND WORKINGS

REPORT NO. UM-1205-221012

Table of Contents

ENVIRO STRATA CONSULTING Pty Ltd
A.B.N. 35 122 301 795
E S C

24 Albert Street
Valentine NSW 2280
T/F: (02) 4946 1864
Mob: (0407) 005 352
Email: enviro.strata@gmail.com

Thomas Lewandowski
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M., M.I.S.E.E.,
M.EFEE.

UMWELT AUSTRALIA ON BEHALF OF XSTRATA MT OWEN

BLAST IMPACT ASSESSMENT OF THE RAVENSWORTH EAST RESOURCE RECOVERY PROJECT ON THE ADJACENT COMMUNITY, INFRASTRUCTURE AND UNDERGROUND WORKINGS

REPORT NO. UM-1205-221012

1. INTRODUCTION

Enviro Strata Consulting was engaged by Umwelt Australia Pty Limited (Umwelt), to undertake a blast impact assessment study for the proposed development of the Ravensworth East Resource Recovery (RERR) Project (proposed modification), on behalf of Xstrata Mt Owen (XMO). The proposed modification is located within the Mt Owen Complex in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres northwest of Singleton, 24 kilometres southeast of Muswellbrook and to the north of Camberwell Village. The proposed modification is a continuation of the existing mining activities, including drilling and blasting, currently undertaken at West pit and to be moved/continued at the new RERR pit.

The assessment presented below addresses the ground vibration and airblast/overpressure impacts on the following areas:

- Adjacent community
- Existing infrastructure
- Adjacent Integra Underground Mine

Each of these areas have been assessed separately and reported in three separate parts. Part A addresses the impact of the proposed modification on the adjacent community. The report addresses blasting issues, such as ground and air vibrations, that may impact on the existing houses and residents.

Part B provides a detailed assessment in regards to the potential impact on the existing nearby infrastructure facilities, including historical structures, TP1 Tailings Dam, mine facilities, as well as public infrastructure. The assessment and its findings are presented in the context of the existing vibration limits for this infrastructure and possible implications should vibration limits be exceeded, if applicable.

Part C is designed to address the possible blasting risks and blast risk management to the adjacent Integra Underground Mine (IUM). The assessment is undertaken in relation to previous mine experiences that deal with blast impacts from 2005/06, as well as a standardised approach when dealing with the impact of open cut blasting on immediately adjacent underground mines.

The available technologies and the mines' approach in dealing with blast minimisation issues are also discussed. In particular, blast impact minimisation on the adjacent community.

2. PROJECT DETAILS

RERR is a continuation of the open cut mining activities within the existing mining lease. The proposed extraction area is immediately adjacent to the currently operational West Pit.

The proposed extraction area is limited to the rhomboidal section with approximate dimensions of 500 x 1,000 metres. The proposed RERR pit is to be located adjacent to the existing operational pits, including Barrett and West pits. A section of the RERR pit is also located immediately adjacent to the two previously extracted smaller pits including Tailings Pit 1 (TP1) and the Eastern Rail Pit (ERP) extracted in 2005/2006. The parameters for blasting in the RERR pit will be similar to those for the West pit, as the seams are the same with similar dips and interburden thicknesses. Considering the proposed location of RERR mining area, a similar impact from blasting to that currently experienced from the Barrett and West pits can be deduced.

The extraction of the RERR pit will be for a relatively short duration of approximately six years. Commencement is scheduled for 2013.

The RERR pit would include the extraction of a number of coal seams down to the Bayswater seam, which is approximately 200 metres from the current surface level. The extraction includes drilling and blasting activities. The initial material to be excavated is previously mined spoil, which will not require blasting. Drill and blast activities will commence once sufficient spoil has been removed. The primary focus of the drilling and blasting will be to blast the interburden material between the coal seams, although occasional coal seam blasting can also be anticipated, depending on the strength of the coal material.

3 CONCEPTUAL BLAST DESIGN FOR THE RERR PIT

Blasting will be undertaken in accordance with the existing Blast Management Plan (BMP) for the Mt Owen Complex (BMP, dated February 2012). The BMP specifies that blasting times are limited to Monday to Saturday between 9 am and 5 pm (EST). The BMP enables the design of each blast to minimise dust, fumes and airblast on the surrounding environment, while at the same time maximise blast efficiency. This is to enable compliance with the site specific blasting conditions.

To assess the size of the blasting benches for the RERR pit, detailed geological plans were used to estimate the thickness of the interburden material that will require blasting. Based on the current geological model, there is a total of nine coal seams proposed to be extracted. The estimated interburden thickness between coal seams varies from 3.9 to 26.2 metres, see **Table 1**. There is however substantial variability in each seam's bench height, showing other thicknesses such as 11 and 16 metre interburden thicknesses.

Table 1: Maximum Coal Seam / Interburden Thickness for the Ravensworth East Resource Recovery Project

Coal Seam	Seam / Interburden Thickness (m)	
	Seam	Interburden
Ravensworth V	1.9	
		4.7
Ravensworth U	1.7	
		16.1
Ravensworth T	1.0	
		13.9
Ravensworth S	0.9	
		11.1
Ravensworth Q	0.7	
		3.9
Ravensworth P	0.7	
		14.3
Ravensworth O	1.0	
		10.4
Ravensworth North / Ravensworth Lower	5.1	
		26.2
Ravensworth H / Ravensworth F	2.0	
		25.8
Bayswater	9.5	

Subsequently, for modelling purposes, three bench heights were selected to represent the possible range of benches (4, 16 and 26 metre benches, with 26 metres corresponding to the maximum bench height). This is to provide a feel for the various blasting scenarios and their impact on the surrounding area, including the local community and infrastructure. The blast design parameters used for modelling purposes are summarised in **Table 2**.

The mine generally utilises combinations of products including standard ammonium nitrate fuel oil (ANFO) for dry conditions, and Heavy ANFO and emulsion blends for wet conditions.

All of these details were taken into consideration when undertaking vibration modelling.

Table 2: Summary of Blast Design Parameters Used for Modelling Purposes

Bench Height	ANFO MIC (kg)	Heavy ANFO MIC (kg)	Explosive Column (m)	Stemming Column (m)
4-m bench	26	39	1	3
16-m bench	311	466	12	4
26-m bench	549	824	21	5

4. GROUND VIBRATION AND AIRBLAST PREDICTIVE MODELS

4.1 Ground Vibration Predictive Model for Surface Conditions

The developed ground vibration predictive model is based on vibration monitoring data collected from blasts undertaken in the Barrett and West pits, which are located in the area adjacent to the proposed RERR pit. The analysed sample of data is in excess of 170 blasts collected over a one year period.

As both pits are relatively close to the RERR pit, the results are considered representative for the undertaken analysis. Also, the vibration monitoring data used in this assessment includes results from Camberwell Village, Camberwell Church and Green Acres monitoring stations, for the location of these stations see **Figure 1 Part A**. The same monitoring stations will continue to be used for RERR blast monitoring.

These results were used to develop a site law formula, which is generally site specific for given strata conditions. The site law formula is specified as follows:

$$\mathbf{V} = \mathbf{k}\left(\frac{D}{\sqrt{m}}\right)^{a}$$

Where: **V** = Peak Particle Velocity (mm/s)
D = Distance from blast (m)
m = Charge mass per delay (kg)

a = Site exponent
k = Site constant

Note that for ground vibration the square-root scaled distance is more appropriate and is widely used across the mining industry. The collected monitoring results were plotted using a standard log / log plot. The presented site law analysis was undertaken using two approaches. The first approach involved analysis of each station's data individually, whilst in the second all data sets were combined and analysed simultaneously. As an example the Church monitoring station's sample is shown in **Figure 1**, while the site law analysis for all stations is presented in **Figure 2**. The parameters summarising the site law analysis (governing ground vibration behaviour) are specified as follows:

$$\mathbf{V} = \mathbf{2694} \left(\frac{D}{\sqrt{m}} \right)^{-1.6}$$

Where: **a** = -1.6 (Site exponent)
k = 2694 (Site constant)

It should be noted that the final model is based on a 95% confidence line. The 95% confidence line advocated by the Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines allows for the inherent variation in emission levels. This is by allowing 5% exceedance of general criterion. Also, for completeness each site law diagram includes a median line (that is, Peak Particle Velocity (PPV) 50% line).

Figure 1 – Site Law Analysis for Camberwell Church

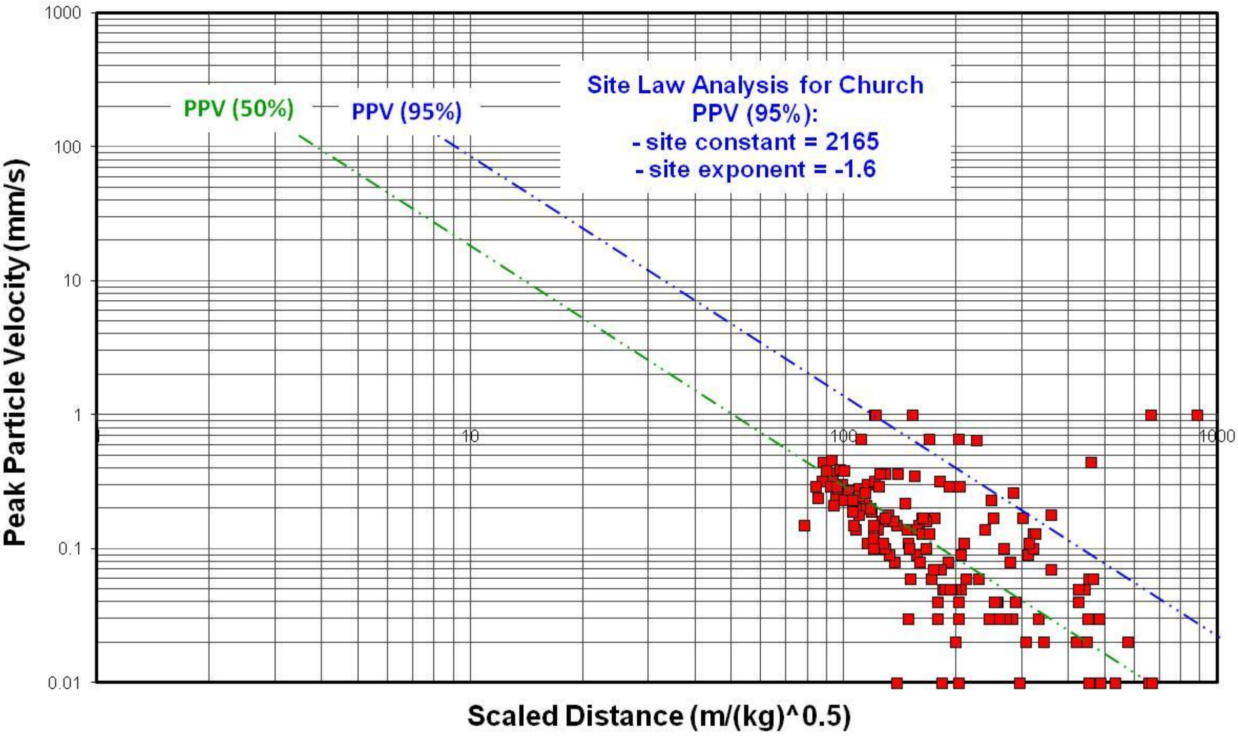
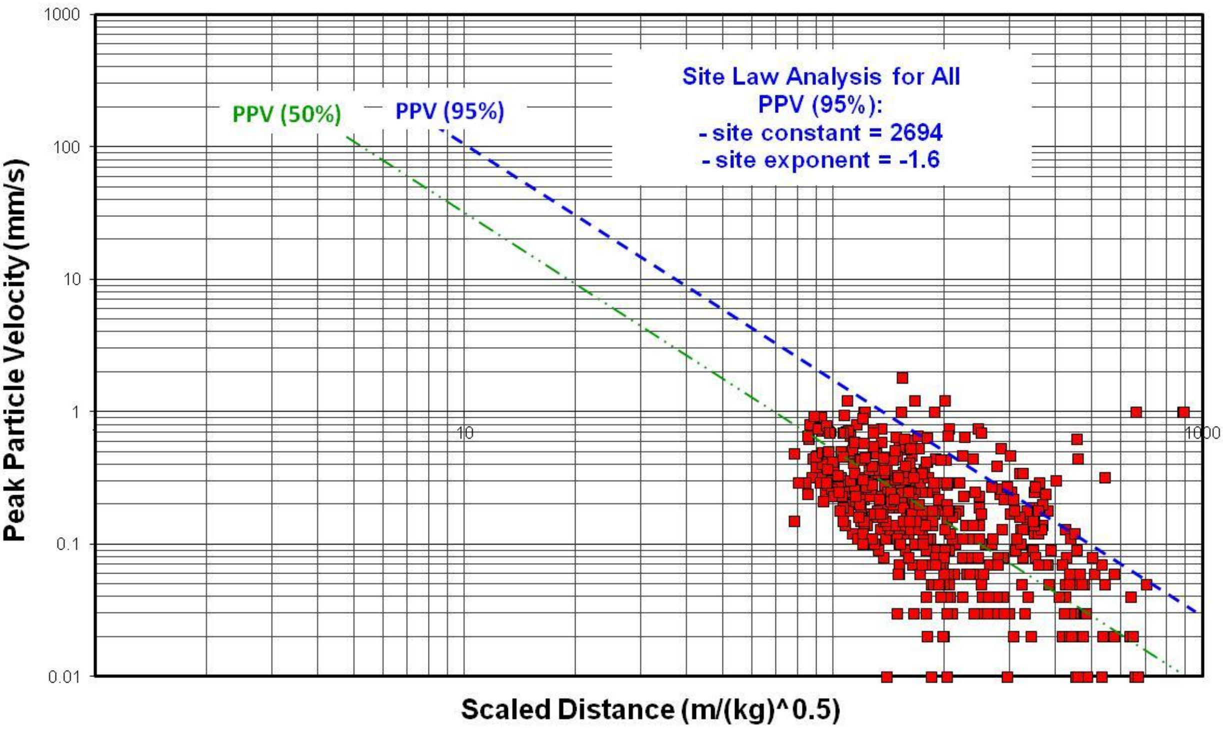


Figure 2 – Site Law for All Stations



4.2 Air Vibration Predictive Model

To address the air vibration impact from the proposed modification on the adjacent community, an air vibration predictive model has been developed. This is based on the obtained vibration monitoring data from the Barrett and West pits, which is considered to be representative for the RERR pit.

The impact of the generated airblast levels from the source of the blast is generally guided by the sonic decay law.

The sonic decay formula is specified as follows:

$$P = K\left(\frac{D}{\sqrt[3]{W}}\right)^{a}$$

Where:	P	=	Peak Pressure (kPa)
	K	=	Site constant
	a	=	Site exponent
	D	=	Distance from blast (m)
	W	=	Charge mass per delay (kg)

There are some limitations to this type of assessment as air vibrations are affected by a number of factors. The major limitation is the exclusion of stemming column height in the analysis. Other factors, for example topographical features, blast confinement and weather conditions are also not taken into account. This can generally be justified on the proviso that the impact of some of these factors is controlled by an appropriate pre-blast check procedure, which can, as an example, eliminate blasting in adverse weather conditions (BMP, section 3.1.3 Meteorological Assessment). Therefore, the development of the air vibration model is more complex than that of the ground vibration model.

Prior to the assessment, an initial filtration of obtained data was undertaken. This included an inspection of air vibration records and elimination of wind affected results. The air vibration samples were then analysed with the results presented in **Figure 3** for the Green Acres monitoring station and in **Figure 4** for the Camberwell Village monitoring station. In each case, there are two lines corresponding to the median of the measured data set (marked as Sound Pressure Level (SPL) 50%), and SPL 95% corresponding to 95% of total population of data. Note that the 5% criteria is utilised following ANZECC guidelines, which allow for the inherent variation in emission levels, by allowing a 5% exceedance of general criterion.

To facilitate the correctness of the assessment the forced exponent of **-** 1.43 has been used, which corresponds to an attenuation rate of 8.6 dBL with a doubling of distance, as specified in Australian Standard, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2).

Figure 3 – Sonic Decay Analysis for Green Acres

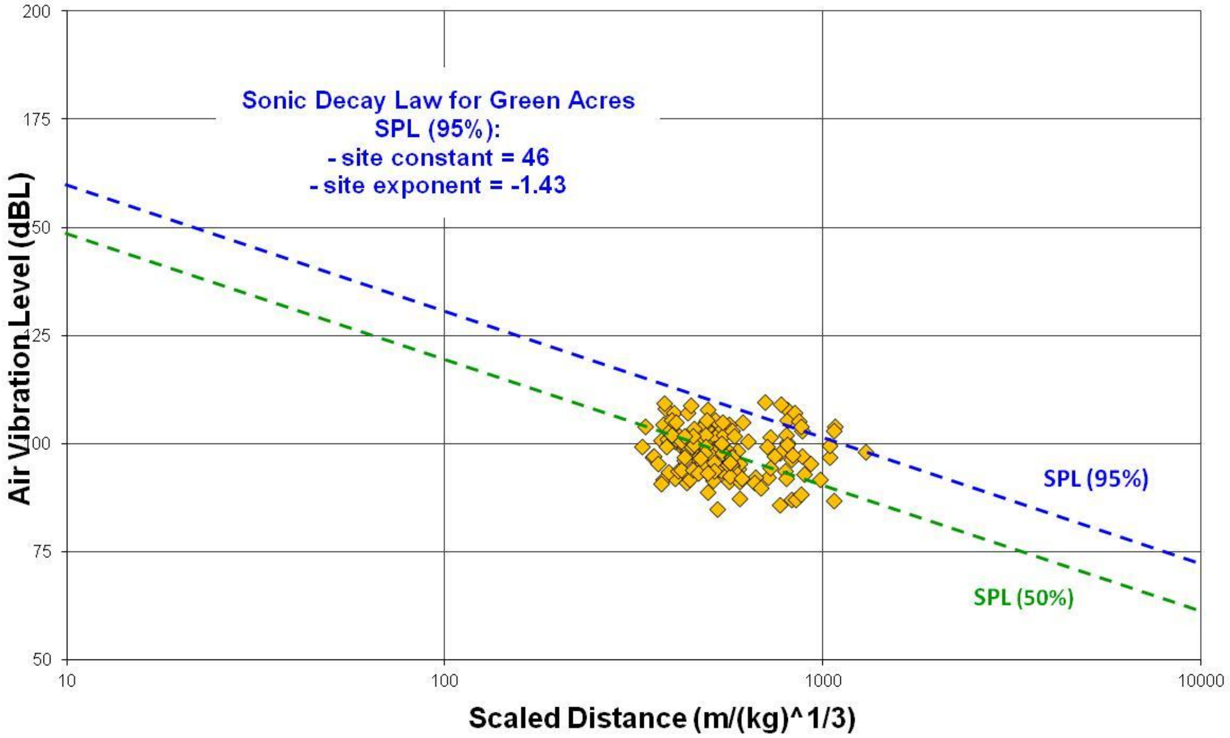
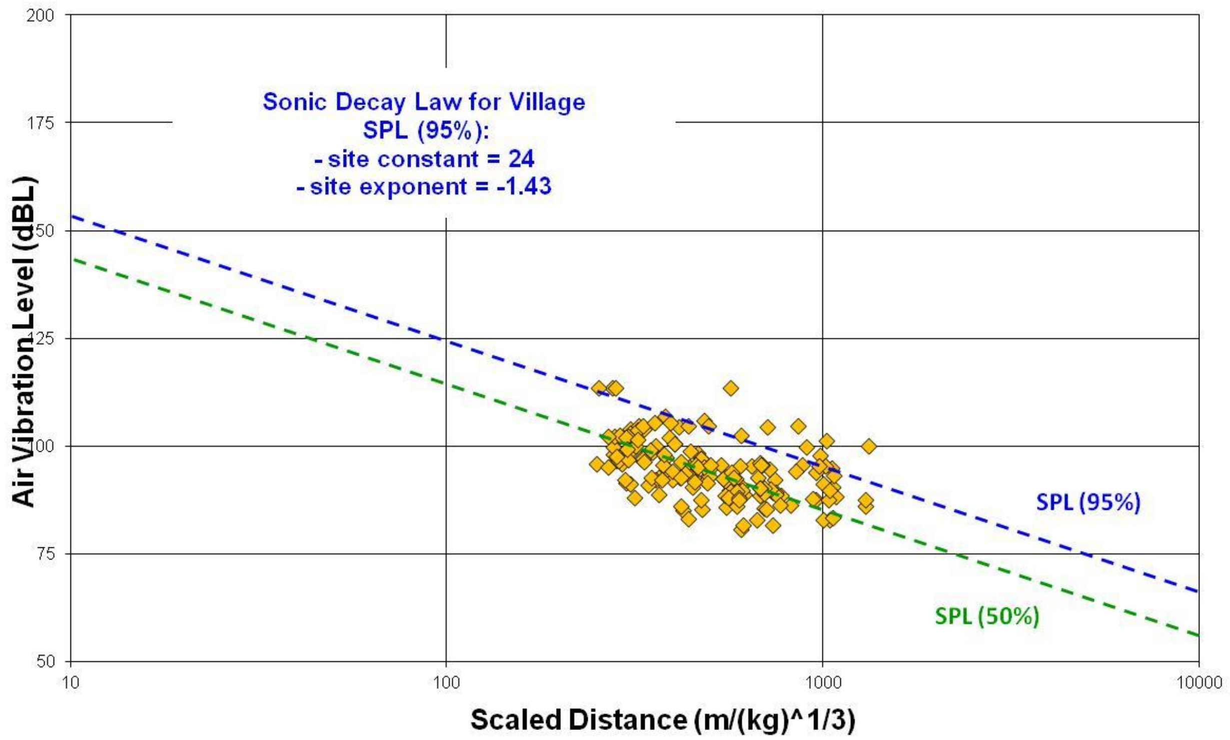


Figure 4 – Sonic Decay Analysis for Camberwell Village



The results were plotted and used to generate a sonic decay law analysis. Therefore, based on the following assessment, the estimated sonic decay parameters are as follows:

- site exponent a = -1.43
- site constant K = 46

The formula used for modelling purposes is:

$$P = 46\left(\frac{D}{\sqrt[3]{W}}\right)^{-1.43}$$

Where: P = Peak Pressure (kPa)
D = Distance from blast (m)
W = Charge mass per delay (kg)

4.3 Ground Vibration Predictive Model for Integra Underground Mine

The vibration predictive model for underground conditions was previously developed following blasting in the ERP at Mt Owen Complex in 2005/06. This included surface and underground (directly below) vibration measurements at IUM. Therefore, it is assumed that the model is suitable for the presented study.

The model is based on actual ground vibration measurements from various blasts, and details were presented in an internal report (Terrock Report 2006 No. MOM-0618-301106). The site law analyses for surface and underground conditions are presented in **Figures 5A** and **5B**. The parameters summarising the site law analysis (governing underground ground vibration behaviour) are specified as follows:

$$\mathbf{V} = \mathbf{842}\left(\frac{D}{\sqrt{m}}\right)^{-1.6}$$

Where: **V** = Peak Particle Velocity (mm/s)
a = -1.6 (site exponent)
K = 842 (site constant)
D = distance (m)
m = charge mass (kg)

The above parameters only apply to underground conditions. Different parameters were obtained for surface conditions.

Appendix 5A – Site Law for Surface Conditions – Based on Past Data (after Terrock's Report 2006)

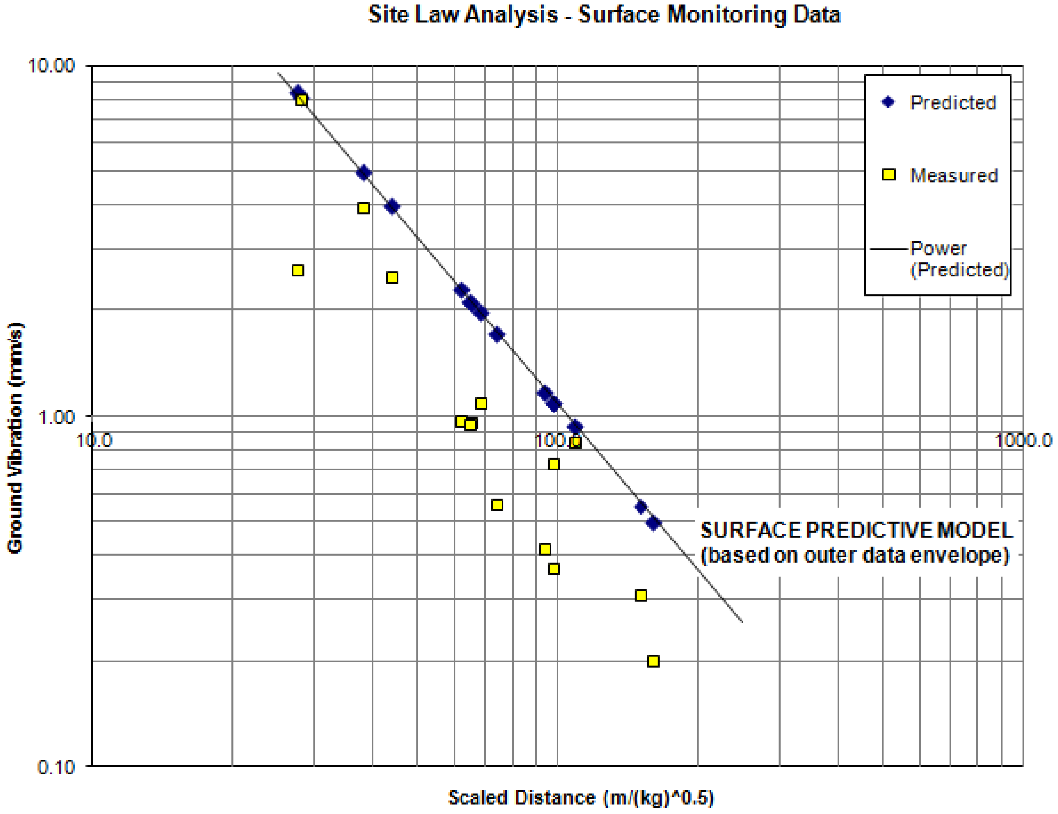
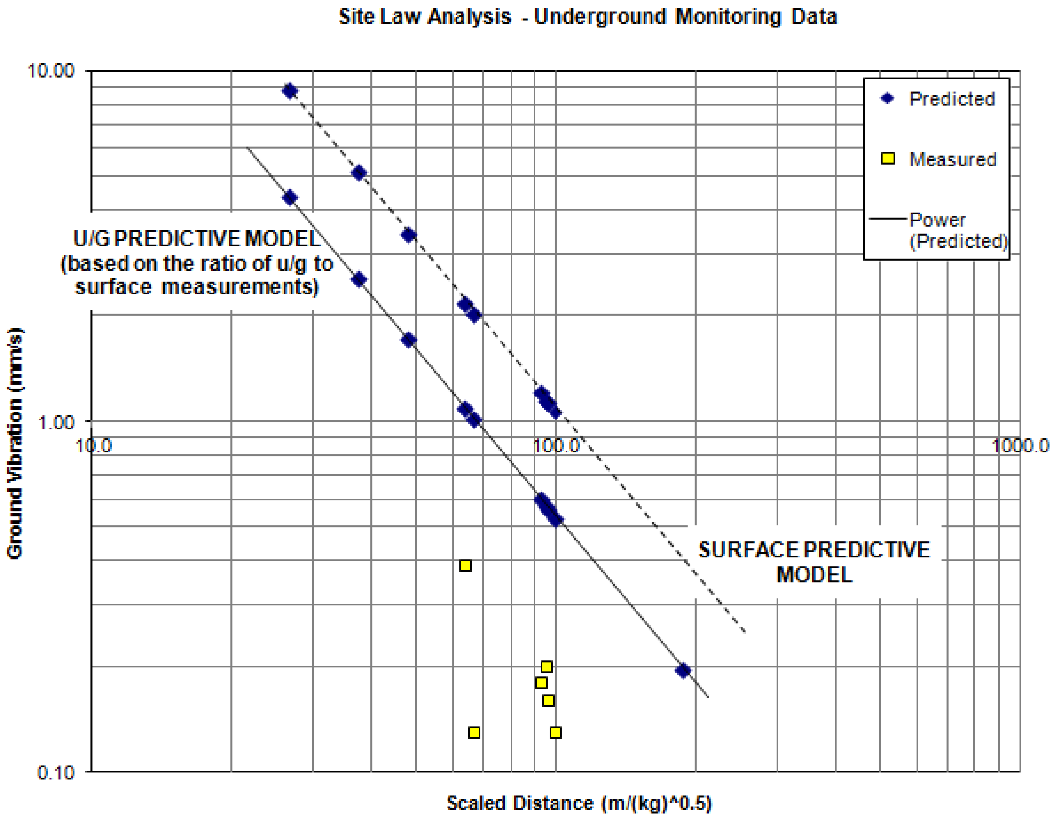


Figure 5B – Site Law for Underground Conditions – Based on Past Data (after Terrock's Report 2006)



5. IMPROVEMENT TECHNOLOGIES AND MITIGATION MEASURES

There are a number of technologies and management processes available for blast performance improvement which can minimise the impacts associated with blasting and also potentially improve the effectiveness of the blasting process, thus having a positive effect throughout the process, including productivity gains and blasting effectiveness (including breakage and fragmentation).

The blast control measures and technologies which could minimise the impact on the local community have been utilised by Mt Owen Complex and are included in the current BMP.

The points listed below were identified as potential new issues that might be encountered. Consequently the BMP will require to be modified accordingly.

Interaction with Integra Underground Mine

The study identified that the proximity of Integra Underground will require interaction between both operations. This could be achieved either by amendment to the existing BMP or an appropriate blasting protocol. A similar protocol was introduced between the mines in 2005/06 when blasting in the ERP. The protocol will require a notification procedure and management of underground personnel using the 10 mm/s vibration limit cut-off criteria. Due to the existence of this previous protocol both operations are familiar with the concept of blast management and the need for appropriate interaction between mine managements. The same system is currently used in various mines across the Hunter Valley with similar issues.

Management of Ground Vibration for the TP1 Tailings Dam

Management of the blast impacts on the adjacent TP1 Tailings Dam are required to be included in the BMP. The study identified that blasting smaller benches (i.e. 16 metres or less), within the proximity of the TP1 Tailings Dam can generally be undertaken effectively without any constraints. Blasting in the northern section (immediately adjacent to TP1) with bigger size benches (such as 26 metres) will require additional blast management measures to be included in the BMP. This can be achieved successfully with the implementation of best blasting practice. This is to ensure that the applicable vibration limit (such as 50 mm/s) imposed on the dam wall is not exceeded.

Management of Blasting Impacts on the Rail Spur

Due to the proximity between the closest section of the rail spur and the RERR pit the study identified the need for additional blast management measures to be implemented via the BMP. The major issue identified is that of a potential flyrock incident. The risk of flyrock and its impact is considered to be limited to a 500 m radius, that is, the exclusion zone. The exclusion zone precludes the presence of any personnel and essential equipment within this 500 metres during the blast and as such trains will not be operating nor can they be present within the exclusion zone during blasting. The management of this issue has been undertaken successfully in the past when blasting in the ERP in 2005/06. The implementation of a similar procedure is therefore required to ensure the issue is managed successfully again.

Final Comments

The Mt Owen Complex is considered a mature operation with well-developed blasting systems and blasting is conducted in accordance with an approved BMP. As the current operational system is well established and functioning very efficiently the same system will be introduced to the proposed modification.

A review of the current operation revealed relatively limited blasting benches, i.e. 4 – 26 metres (similar to the proposed modification) and considerable distances from the residences (in excess of 3.5 km). All of these factors are in favour of producing negligible impacts on the surrounding environment.

Also, it is probable that with time, as the RERR pit gets deeper, some topographical shielding will emerge due to a change in the contours of the area. This will assist with noise reduction and lessen the impact on the adjacent community.

PART A - BLAST IMPACTS ON THE COMMUNITY

BLAST IMPACT ASSESSMENT OF THE PROPOSED MODIFICATION ON THE ADJACENT COMMUNITY

1. INTRODUCTION

This part of the report addresses the potential vibration exposure of the proposed modification on the adjacent community. This section assesses potential issues associated with blasting, such as ground and air vibrations exposure, which may impact on the existing houses and residents.

The impact of the proposed modification is discussed in the context of the applicable ground vibration and airblast limits.

The findings of this report also identify appropriate precautionary measures to be implemented to manage any identified issues and therefore reduce any impact on the adjacent community.

2. LOCATION OF LOCAL RESIDENCES AND IMPLICATIONS FOR THE PROPOSED MODIFICATION

The proposed location of the RERR pit and the location of the adjacent community are highlighted in **Figure 1**. The residences of the adjacent community are not grouped in one area but are rather widely spread. The diagram highlights the proposed RERR pit and selected local residences, schools, a church and current monitoring stations.

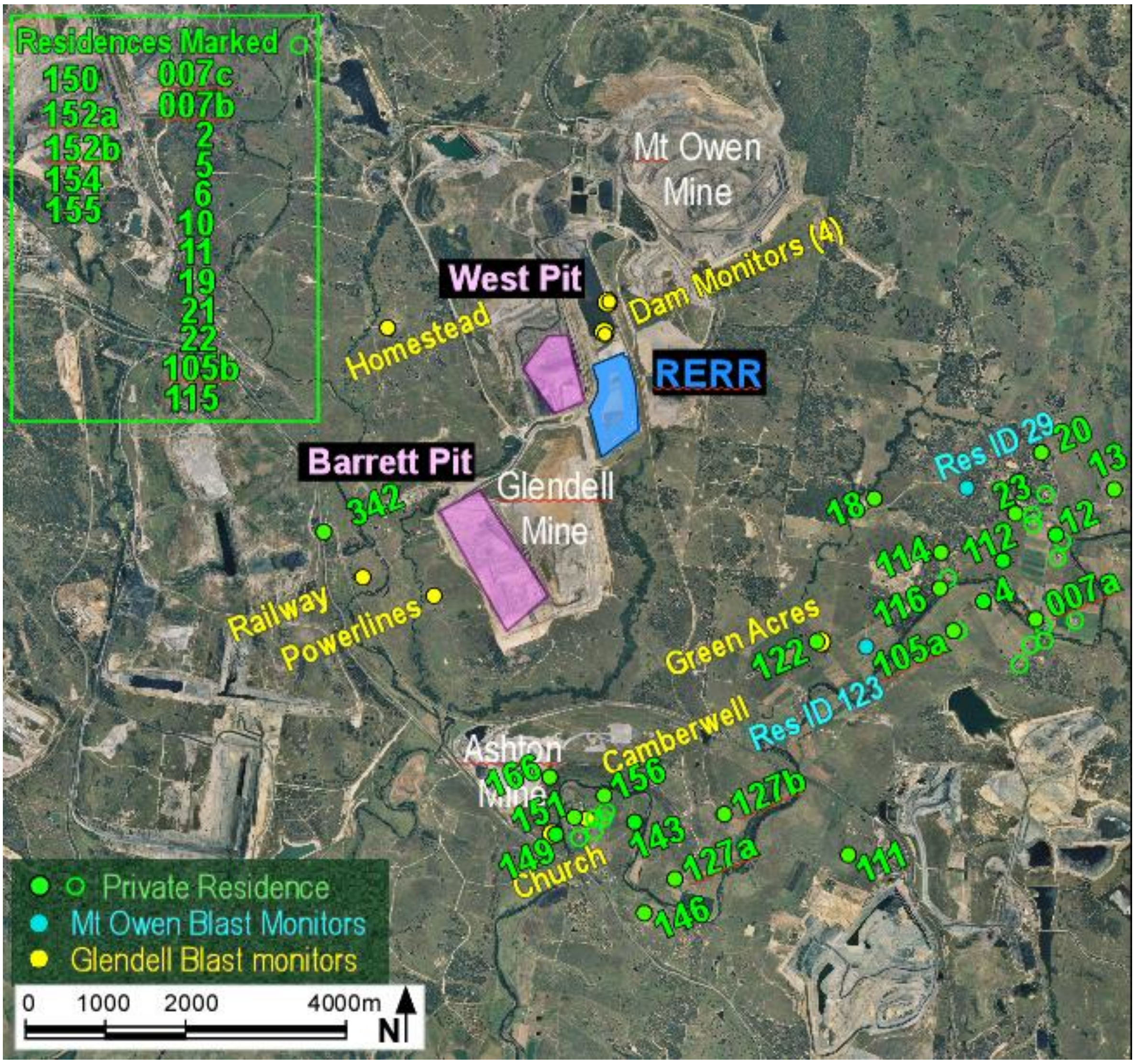
Mt Owen Complex operates six vibration monitoring stations relevant to residential areas. These stations are placed in strategic locations and are considered representative for the local community. The stations are:

- Green Acres
- Camberwell Village
- Camberwell Church
- Ravensworth Homestead
- Res ID 29
- Res ID 123

The Res ID 29 and 123 monitoring stations relate specifically to the Mt Owen operations, the remaining monitoring locations relate to Glendell and Ravensworth East Operations. The same monitoring stations will be utilised for blast impact monitoring for the proposed modification.

For the locations of the monitoring stations refer to **Figure 1**.

Figure 1 - Locations of Private Residences and the RERR Pit



As shown in the presented figure, the majority of the residences of concern are located to the south and south-east. The closest residence and station is represented by Green Acres monitoring station. This station will be located approximately 3.5 km from the RERR pit.

In regards to the RERR pit location, it is deduced that the impact from the project should not significantly differ from that caused by the Barrett or West pits (currently in operation). This is due to the fact that the proposed RERR pit is located in a similar location to the other pits. Also, the blasted benches will be similar in size to those blasted in the Barrett and West pits. Therefore, the proposed modification represents a continuation of current blasting activities specifically associated with the West pit.

To gauge the potential impact on the local community, estimations of minimum distances between the proposed RERR pit and the residences of concern were undertaken and are highlighted in **Table 1**. The analysis includes residences within a 6 km radius of the RERR pit. The impact from blasting is considered negligible beyond the 6 km distance. For clusters of residences (separated by a distance of less than 300 metres) only one, the closest residence to the RERR pit was included in the analyses.

It is important to note that the Mt Owen Mining Complex operates using a standard 500 metre exclusion zone (all land within a 500 m radius is owned by Xstrata). This distance is considered appropriate for managing the risk of flyrock, as it is used widely across the mining industry. Therefore, the issue of flyrock impact and potential risks to adjacent residences is considered very low. This is due to the fact that the closest residence is located approximately 3.5 km from the proposed RERR pit.

3. BLAST EMISSION AND BLAST DAMAGE CRITERIA FOR RESIDENCES

Blast Emission Criteria for Human Comfort

To minimise the impact on the local community and residences, the Office of Environment and Heritage (OEH) adopts the ANZECC (Australian and New Zealand Environment and Conservation Council) guidelines “Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration”. The guidelines indicate the following:

- The general criterion for ground vibration is 5 mm/s, Peak Particle Velocity (PPV).
- The PPV of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The upper PPV level of 10 mm/s should not be exceeded at any time.
- The general airblast criterion is 115 dBL (decibel Linear).
- The level of 115 dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The airblast level should not exceed 120 dBL at any time.
- Blasting should generally be permitted Monday to Saturday between 0900 hours and 1700 hours. Blasting should not take place on Sundays or Public holidays.

Mt Owen Complex has applied these criteria to residential locations, as specified in the Mt Owen Complex BMP.

Blast Damage Criteria – Ground Vibration

In regards to blast damage criteria for residential structures, the Australian Standard AS 2187-2:2006, part entitled “Explosives – Storage and Use – Part 2: Use of Explosives” refers to other available standards, such as British Standard BS 7385-2:1993 and American (USBM) RI8507. The British Standard BS7385-2, document entitled “Evaluation and measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground Borne Vibration” and USBM RI8507 employ frequency-dependent limits, see **Appendix 1A.**

Based on the quoted standards it is inferred that the indicated blast damage criteria (that is, ranging from 15 mm/s for low frequencies and up to 50 mm/s allowed for high frequencies, see **Appendix 1B**) are well above the blast emission criteria for human comfort (i.e. 5 mm/s and 10 mm/s) as discussed above. It therefore follows that when vibration limits for human comfort are imposed, then blast damage criteria for residential structures will also be satisfied.

Blast Damage Criteria – Airblast

The Australian Standard AS 2187-2:2006, specifies a conservative limit of 133 dBL as a safe level. The AS 2187-2 also specifies that the damage to windows (considered as a most fragile/sensitive material) is considered improbable for airblast level exposures below 140 dBL.

In Blast Vibration Analysis by G. A. Bollinger (1980), a section titled "Damage Criteria – Effects of Vibrations" presents human and structural response to sound pressure levels. The original figure is presented in **Appendix 2**. The author identified potential levels of interest that are relevant to this report. These include the following indicative levels:

- 140 dBL – "No damage" level
- 150 dBL – some windows break
- 170 dBL – most windows break
- 180 dBL – structures damaged

In summary, it is inferred that for the proposed modification, when vibration limits for human comfort are imposed (as specified above), by default, the possibility of structural damage for the surrounding residential structures is eliminated.

4. GROUND VIBRATION MODELLING

Vibration modelling to assess potential impacts on the local community and residences has been undertaken using the formula below. The parameters summarising the site law analysis and thus governing ground vibration behaviour are specified as follows:

$$\mathbf{V} = \mathbf{2694}\left(\frac{D}{\sqrt{m}}\right)^{-1.6}$$

Where:	**V**	=	Peak Particle Velocity (mm/s)
	a	=	-1.6 (site exponent)
	k	=	2694 (site constant)
	D	=	distance (m)
	m	=	charge mass (kg)

The impact of ground vibrations on the surrounding residences was simulated using the contour line assessment technique. The analysis provides an indication when considering the most extreme scenario, that is, initiation of the maximum charge mass from the edge of the pit shell. The ground vibration analysis is presented as a series of contour lines overlying the area adjacent to the discussed residences (see **Figures 2 - 4**). Each case is described by up to 7 contours of interest ranging from 0.3 to 3 mm/s.

This assessment included six different simulations involving 4, 16 and 26 metre benches accounting for ANFO and Heavy ANFO products. The analysis is summarised in **Table 1**.

Table 1: Results of Ground Vibration Modelling for Private Residences – Maximum Vibration Estimates

Residential ID	Min. Distance (m)	Direction from RERR	Estimated Max Ground Vibration (mm/s)					
			4-m Bench		16-m Bench		26 m Bench	
			ANFO 26 kg	Heavy ANFO 39 kg	ANFO 311 kg	Heavy ANFO 466 kg	ANFO 549 kg	Heavy ANFO 824 kg
007a	5,500	SE	< 0.1	0.1	0.3	0.4	0.4	0.6
105a	4,670	SE	< 0.1	0.1	0.4	0.5	0.6	0.8
4	4,800	SE	< 0.1	0.1	0.3	0.5	0.5	0.7
12	5,360	E	< 0.1	0.1	0.3	0.4	0.5	0.6
13	5,980	E	< 0.1	< 0.1	0.2	0.3	0.4	0.5
18	3,070	E	0.1	0.1	0.7	1.0	1.1	1.5
20	5,040	E	< 0.1	0.1	0.3	0.4	0.5	0.7
23	4,810	E	< 0.1	0.1	0.3	0.5	0.5	0.7
111	5,870	SE	< 0.1	< 0.1	0.2	0.3	0.4	0.5
112	4,820	E	< 0.1	0.1	0.3	0.5	0.5	0.7
114	4,080	E	0.1	0.1	0.4	0.6	0.7	1.0
116	4,260	SE	0.1	0.1	0.4	0.6	0.7	0.9
122	3,460	SE	0.1	0.1	0.6	0.8	0.9	1.3
127 a	5,360	S	< 0.1	0.1	0.3	0.4	0.5	0.6
127 b	4,700	ES	< 0.1	0.1	0.4	0.5	0.6	0.8
143	4,600	S	0.1	0.1	0.4	0.5	0.6	0.8
146	5,740	S	< 0.1	< 0.1	0.3	0.4	0.4	0.6
149	4,760	S	< 0.1	0.1	0.3	0.5	0.5	0.8
151	4,520	S	0.1	0.1	0.4	0.5	0.6	0.8
156	4,230	S	0.1	0.1	0.4	0.6	0.7	0.9
166	4,060	S	0.1	0.1	0.4	0.6	0.7	1.0
342	3,590	W	0.1	0.1	0.5	0.8	0.9	1.2

4.1 Modelling Results - the Impact of Ground Vibrations for a 4-m Bench

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 26 and 39 kg (that is, using ANFO and Heavy ANFO respectively) are shown in **Figures 2A** and **B.** The estimated maximum vibration levels for the residences of concern are also summarised in **Table 1.**

Due to the predicted low vibration levels of less than 0.2 mm/s for all residences of concern the blast impact generated by 4 metre benches is considered as negligible.

4.2 Modelling Results - the Impact of Ground Vibrations for a 16-m Bench

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 311 and 466 kg (that is, using ANFO and Heavy ANFO respectively) are shown in **Figures 3A** and **B.**

The ground vibration contour line assessment revealed that the impact of 16 metre benches on the analysed residences is negligible/ low. The indicative ground vibration level for all residences should be in the order of 0.8 mm/s or less. However, the predicted vibration exposure for the majority of the residences is expected to be less than 0.5 mm/s, see **Table 1.**

4.3 Modelling Results - the Impact of Ground Vibrations for a 26-m Bench

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 549 and 824 kg (i.e. using ANFO and Heavy ANFO respectively) are shown in **Figures 4A** and **B**

The ground vibration contour line assessment revealed that the impact of blasting 26 metre benches on the analysed residences is low. The indicative ground vibration levels for the closest residences are in the order of 1.3 mm/s or less. Further residences will be exposed to vibration levels in the order of 0.3 – 0.8 mm/s, see **Table 1**.

Overall, the predicted vibration levels for all three different bench sizes using 4, 16 and 26 metre benches revealed either low or negligible vibration impact on the surrounding residences (should not exceed 1.3 mm/s). This is well below the discussed blast emission criteria of 5 and 10 mm/s applicable to the proposed modification.

Figure 2A – Ground Vibration Contours for a 4-metre bench and MIC of 26 kg

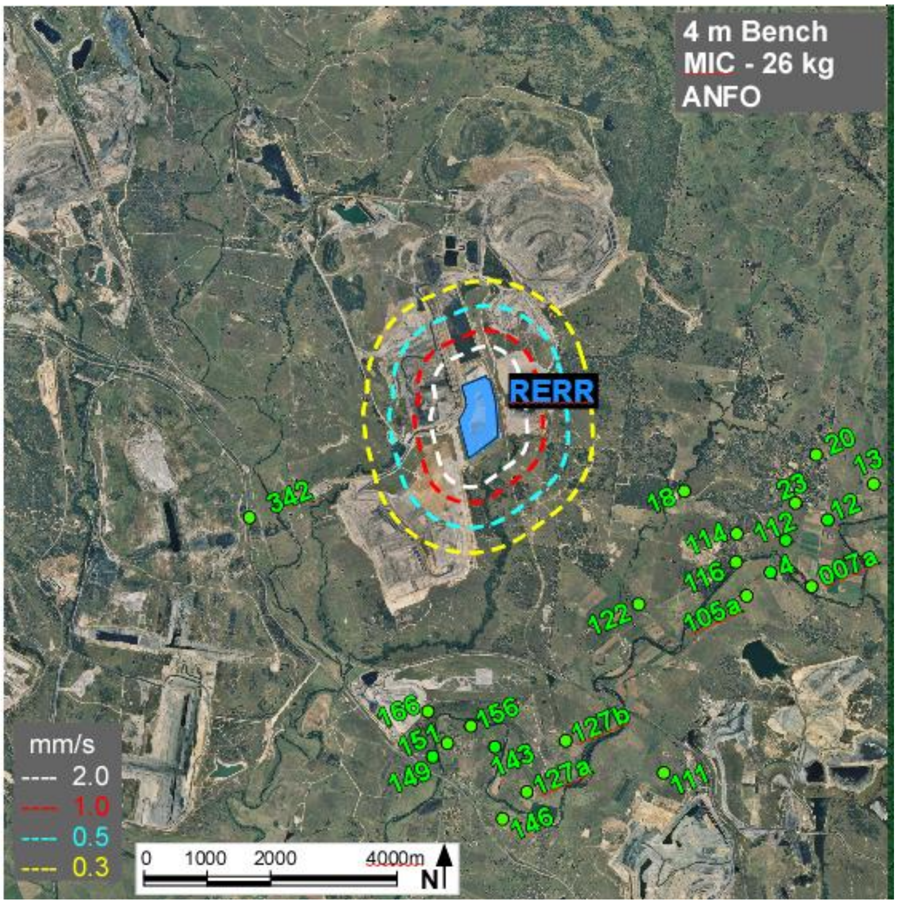


Figure 2B – Ground Vibration Contours for a 4-metre bench and MIC of 39 kg

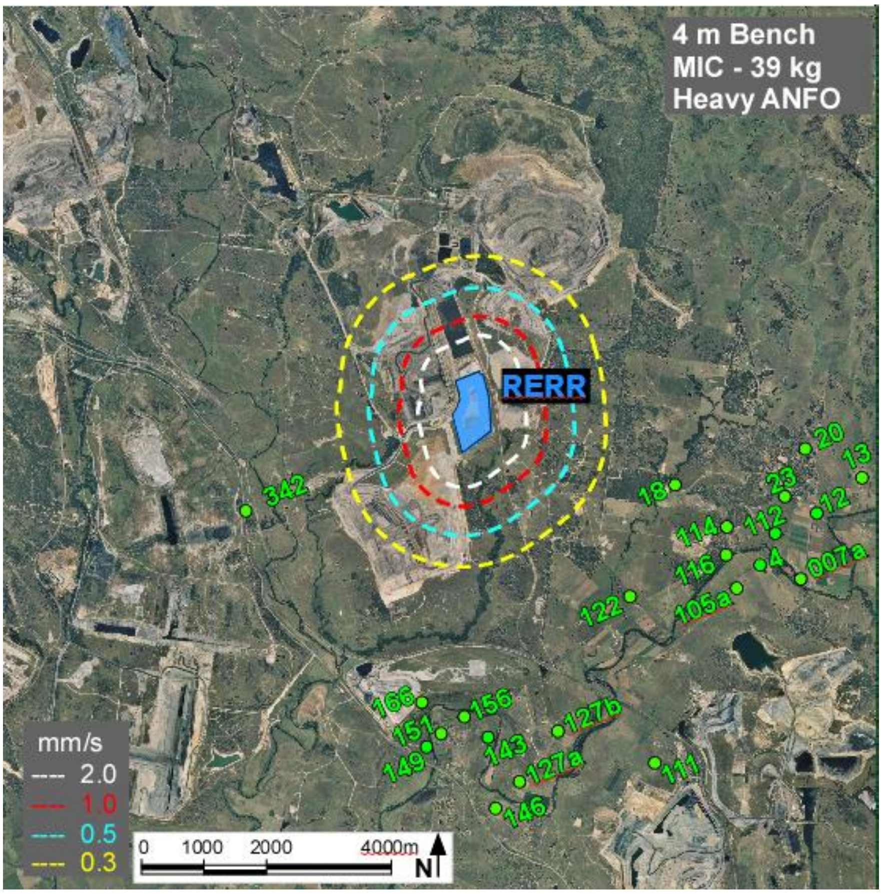


Figure 3A – Ground Vibration Contours for a 16-metre bench and MIC of 311 kg

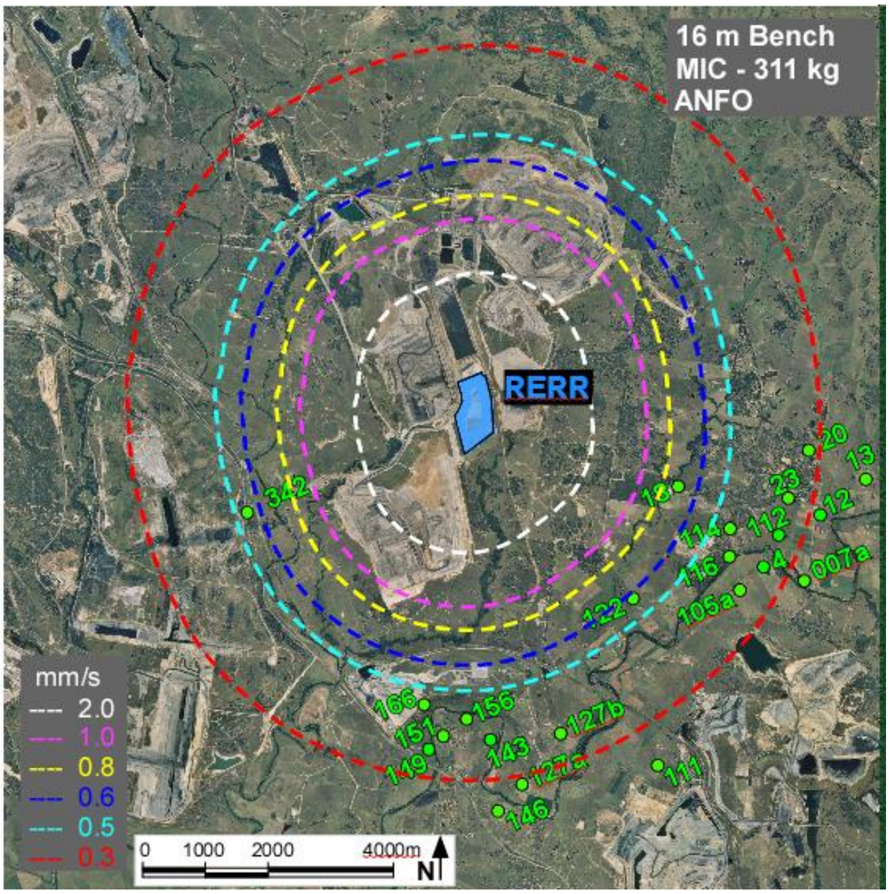


Figure 3B – Ground Vibration Contours for a 16-metre bench and MIC of 466 kg

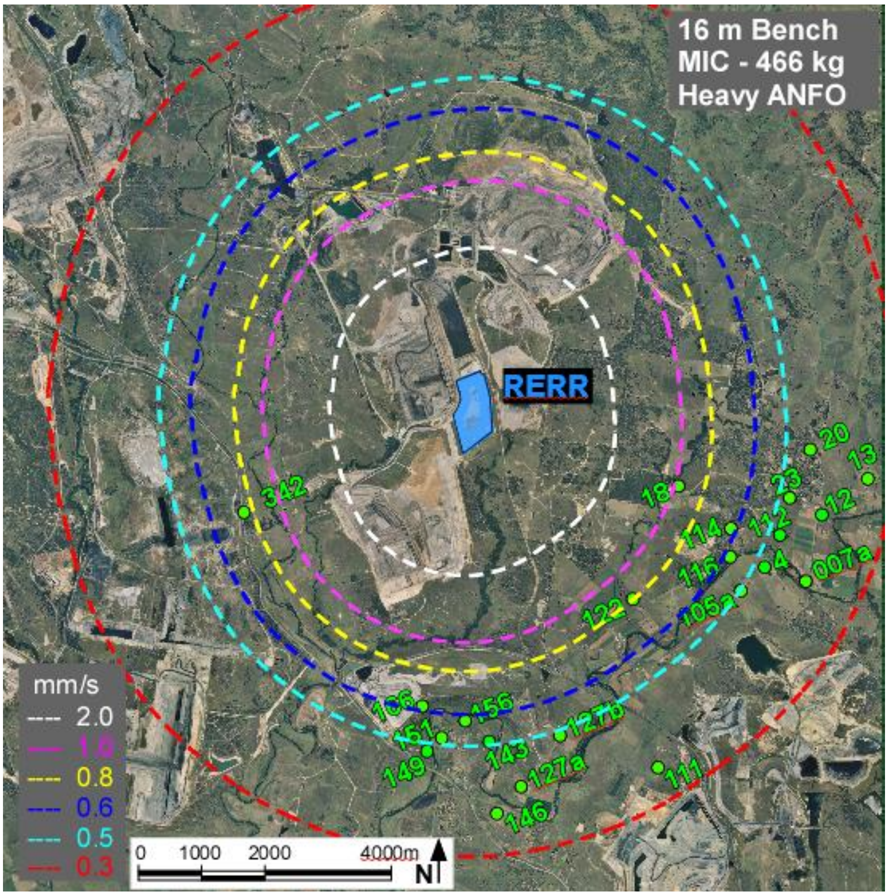


Figure 4A – Ground Vibration Contours for a 26-metre bench and MIC of 549 kg

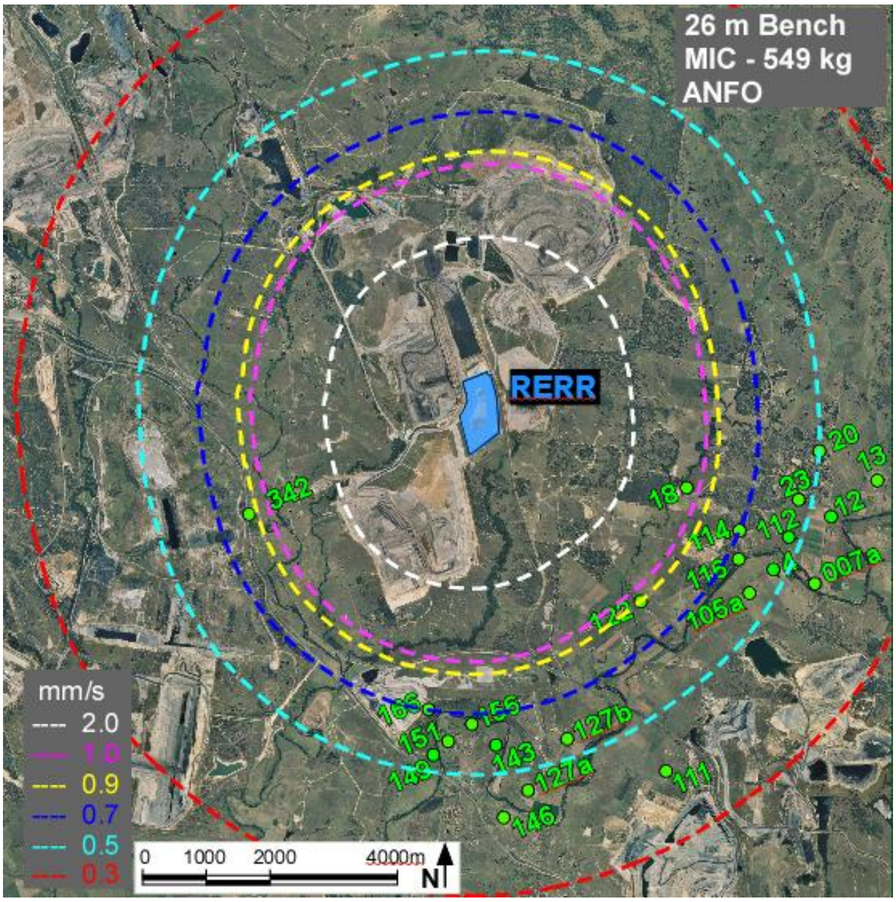
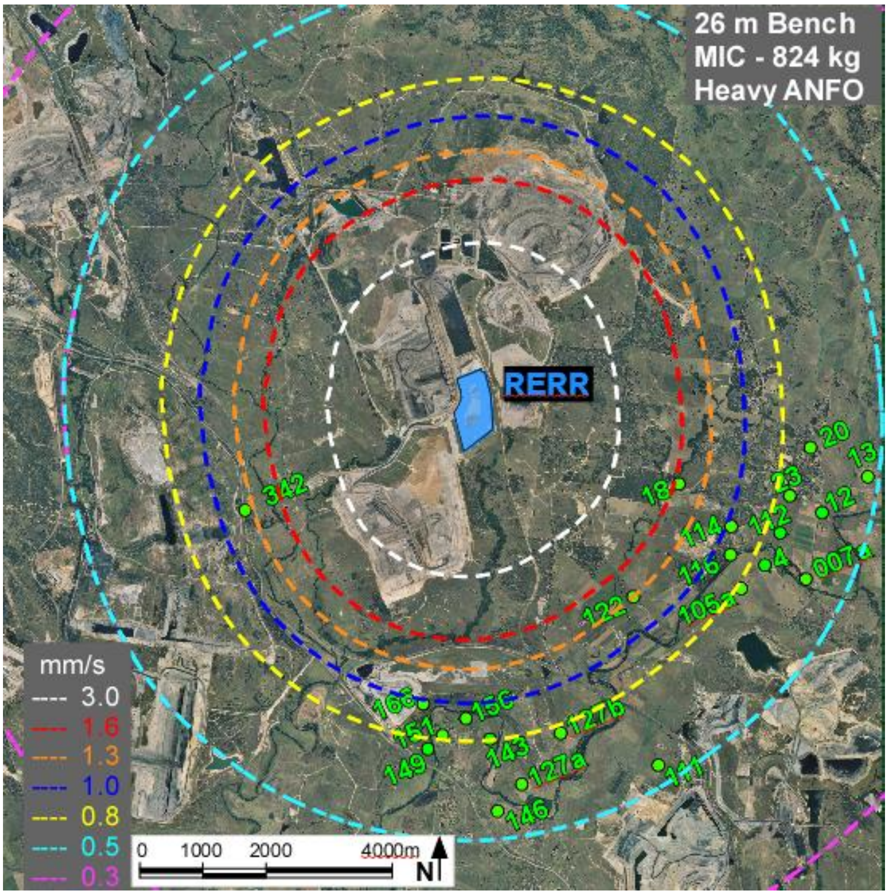
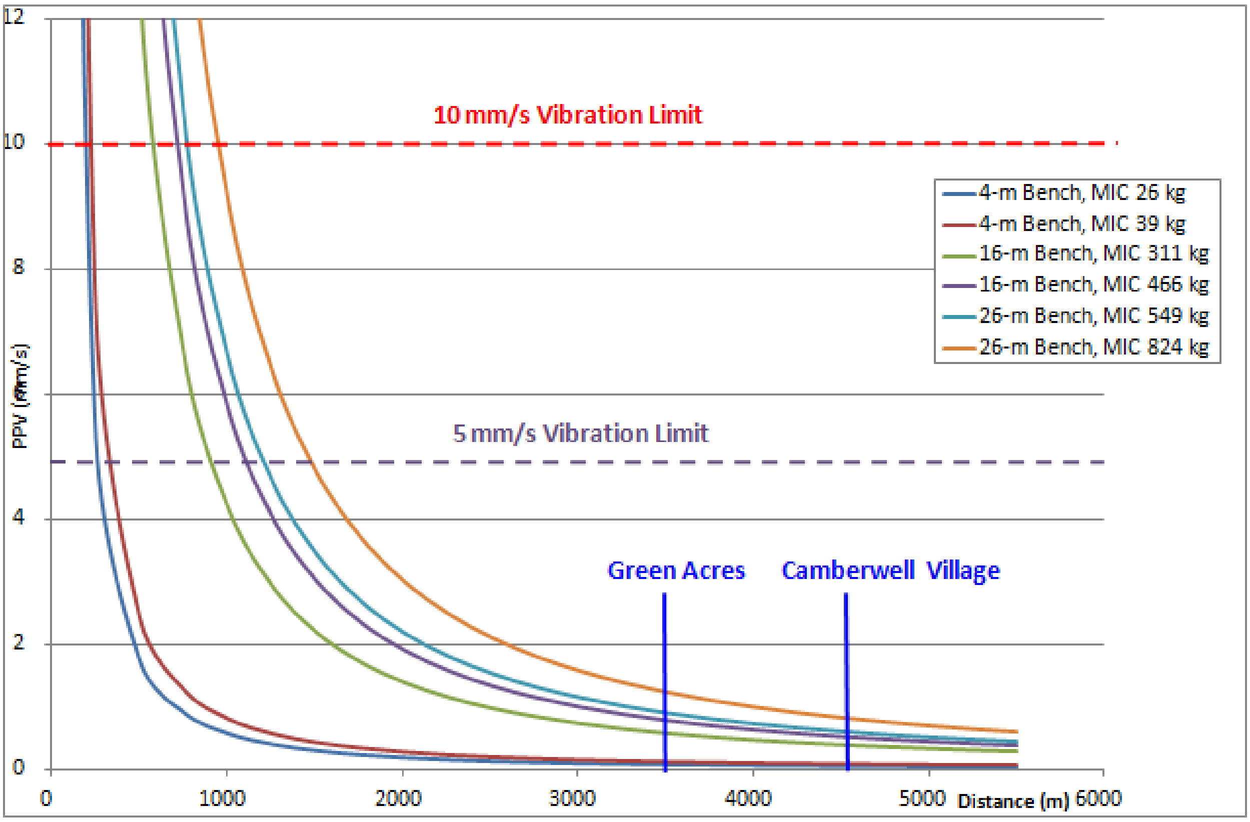


Figure 4B – Ground Vibration Contours for a 26-metre bench and MIC of 824 kg



The results of the vibration modelling are summarised as vibration decay curves, each curve corresponding to one of the discussed charge masses, see **Figure 5**. This shows two critical monitoring points; Green Acres (representing the closest residence) and Village (representative monitoring station for Camberwell Village) and the expected vibration exposures.

Figure 5 - Vibration Modelling Presented as Vibration Decay Curves for Critical Monitoring Stations (Green Acres and Camberwell Village)



5. AIRBLAST MODELLING

To perform air vibration modelling the following sonic decay formula was utilised.

$$P = 46\left(\frac{D}{\sqrt[3]{W}}\right)^{-1.43}$$

Where:	P	=	Peak Pressure in kPa
	K	=	Site constant = 46
	a	=	Site exponent = -1.43
	D	=	Distance from blast (m)
	W	=	Charge mass per delay (kg)

Note that the model assumes that emissions from the blast are fully controlled and there is no abnormal behaviour such as stemming ejection or face burst taking place.

The impact of an airblast on the surrounding residences was simulated using the contour line assessment technique. The analysis gives an indication when considering the most extreme scenario, that is, initiation of the maximum charge mass from the edge of the pit shell. The air vibration analysis is presented as a series of contour lines overlying the area adjacent to the discussed residences (see **Figures 6-8**). There were up to 7 air vibration contours drawn for each case; ranging from 90 to 116 dBL.
As with the ground vibration modelling, the assessment involved six different simulations including 4, 16 and 26 metre benches as well as ANFO and Heavy ANFO products. The analysis is summarised as follows:

5.1 Modelling Results - the Impact of Air Vibrations for a 4-m Bench

The projected air vibration contour lines for the surface area due to blasting using charge masses of 26 and 39 kg (that is, using ANFO and Heavy ANFO respectively) are shown in **Figures 6A** and **B**. The estimated maximum air vibration levels for the locations of concern are also summarised in **Table 2.**

Due to the predicted low air vibration levels of less than 102 dBL for all residences of concern the blast impact generated by 4 metre benches is classified as negligible.

5.2 Modelling Results - the Impact of Air Vibrations for a 16-m Bench

The projected air vibration contour lines for the surface area due to blasting using charge masses of 311 and 466 kg (that is, using ANFO and Heavy ANFO respectively) are shown in **Figures 7A** and **B.** The estimated maximum air vibration levels for the locations of concern are also summarised in **Table 2**.

The air vibration contour line assessment revealed that the impact of 16 metre benches on the analysed residences is below the discussed airblast criteria of 115 dBL. The estimations for the closest two residences revealed airblast levels in the order of 110-111.5 dBL, see **Table 2.**

5.3 Modelling Results - the Impact of Air Vibrations for a 26-m Bench

The projected air vibration contour lines for the surface area due to blasting using charge masses of 549 and 824 kg (that is, using ANFO and Heavy ANFO respectively) are shown in **Figures 8A** and **B.** The estimated maximum air vibration levels for the locations of concern are also summarised in **Table 2**.

The air vibration contour line assessment revealed that the impact of 26 metre benches on the analysed residences is acceptable (below discussed airblast criteria of 115 dBL). The indicative air vibration levels for the two closest residences are in the order of 112-113.8 dBL. The other residences located at 4-5 km distance should be exposed to airblast levels no higher than 110 dBL. The far distance residences (i.e. more than 6.5 km) will be exposed to vibration levels of less than 106 dBL.

The airblast modelling is based on a normal airblast emission. This is excluding any unusual abnormalities due to blasting deficiencies or weather impacts, as it is considered that these parameters are sufficiently managed by procedures documented in the approved BMP.

Table 2: Results of Air Vibration Modelling for Private Residences – Maximum Vibration Estimates

Residential ID	Min. Distance (m)	Direction from RERR	Estimated Max Air Vibration (dBL)					
			4-m Bench		16-m Bench		26-m Bench	
			ANFO 26 kg	Heavy ANFO 39 kg	ANFO 311 kg	Heavy ANFO 466 kg	ANFO 549 kg	Heavy ANFO 824 kg
007a	5,500	SE	94	95	104	106	106	108
105a	4,670	SE	96	97	106	108	108	110
4	4,800	SE	95	97	106	107	108	110
12	5,360	E	94	96	104	106	107	108
13	5,980	E	93	94	103	105	105	107
18	3,070	E	101	103	111	113	114	115[1]
20	5,040	E	95	97	105	107	107	109
23	4,810	E	95	97	106	107	108	110
111	5,870	SE	93	95	103	105	106	107
112	4,820	E	95	97	106	107	108	110
114	4,080	E	97	99	108	109	110	112
116	4,260	SE	97	99	107	109	110	111
122	3,460	SE	100	101	110	111	112	114
127 a	5,360	S	94	96	104	106	107	108
127 b	4,700	ES	96	97	106	108	108	110
143	4,600	S	96	98	106	108	109	110
146	5,740	S	93	95	103	105	106	108
149	4,760	S	96	97	106	107	108	110
151	4,520	S	96	98	106	108	109	110
156	4,230	S	97	99	107	109	110	111
166	4,060	S	98	99	108	109	110	112
342	3,590	W	99	101	109	111	112	113
MONITORS - Mt Owen Complex Monitoring System								
Res ID 29	4,190	E	97	99	107	109	110	111
Res ID 123	3,930	SE	98	100	108	110	111	112
Homestead	2,610	W	103	105	113	115[2]	116[2]	117[2]
Railway	3,340	SW	100	102	110	112	113	114
Powerlines	2,720	SW	102	104	113	114	115[3]	117[3]
Church	4,750	S	96	97	106	108	108	110
Camberwell	4,560	S	96	98	106	108	109	110
Green Acres	3,460	SE	100	101	110	112	112	114

[1] - Vacant land – no applicable limits
[2] - 126 dBL air vibration limit applies
[3] - No applicable air vibration limit

Figure 6A – Air Vibration Contours for a 4-metre bench and MIC of 26 kg

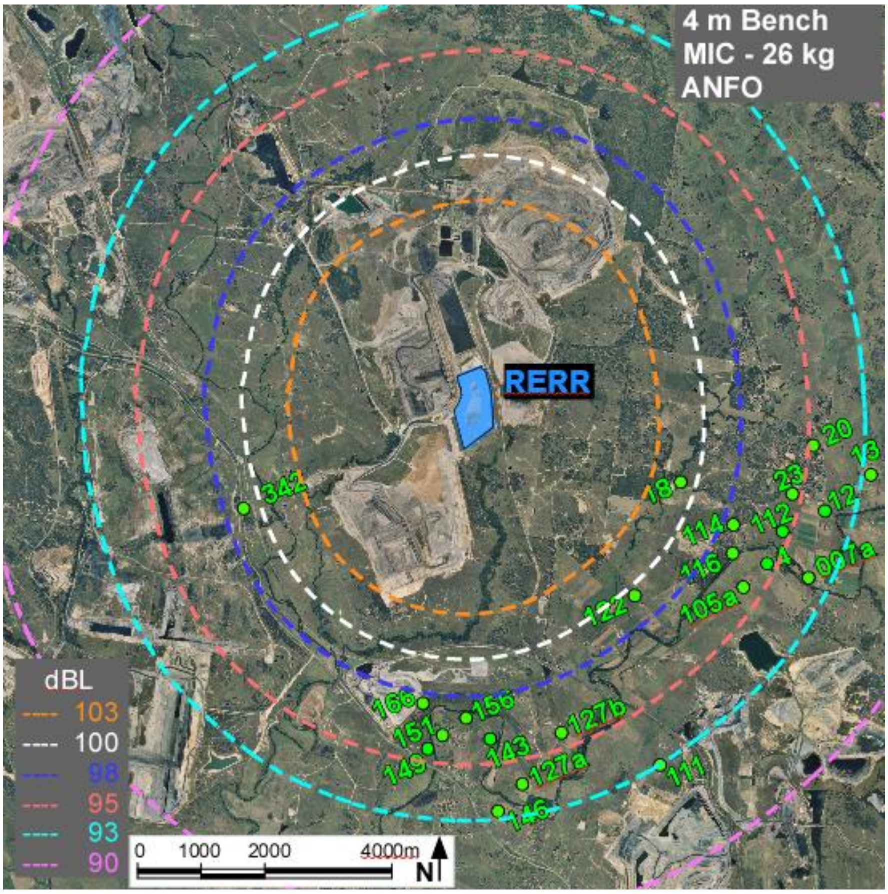


Figure 6B – Air Vibration Contours for a 4-metre bench and MIC of 39 kg

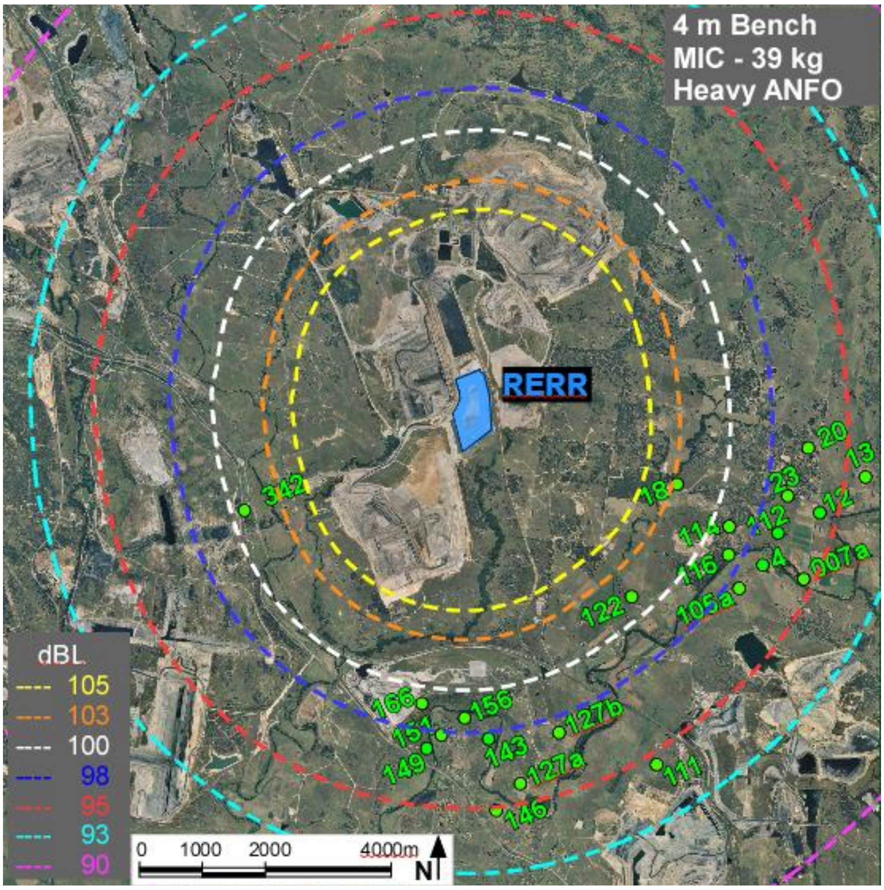


Figure 7A – Air Vibration Contours for a 16-metre bench and MIC of 311 kg

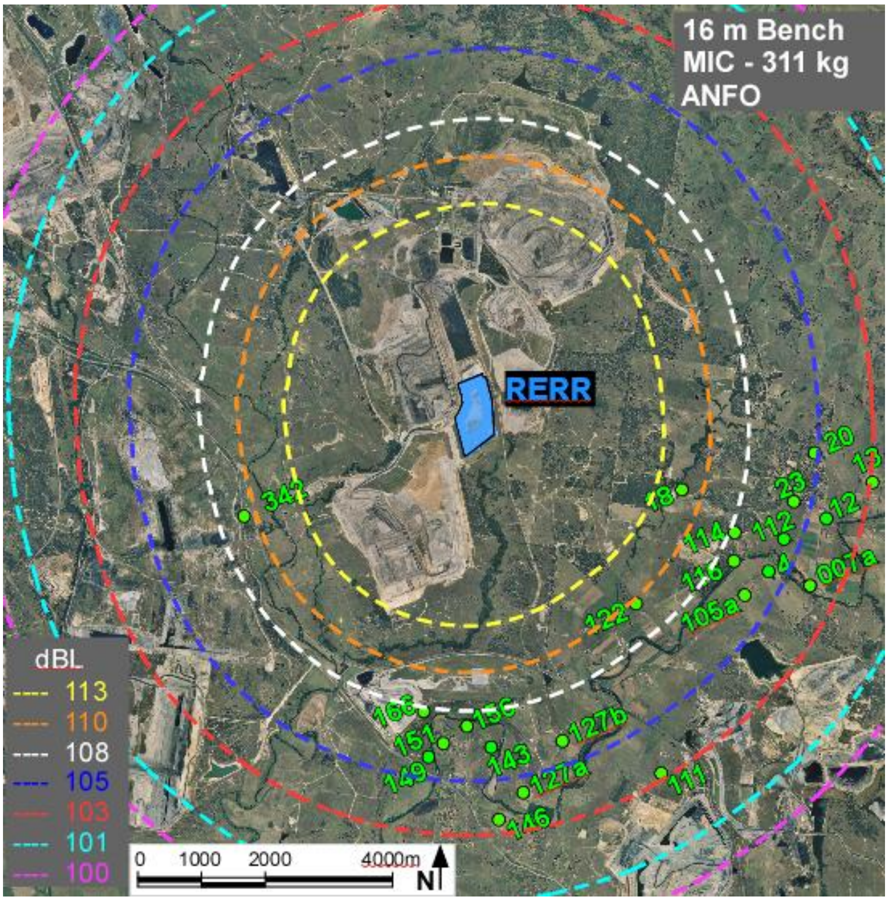


Figure 7B – Air Vibration Contours for a 16-metre bench and MIC of 466 kg

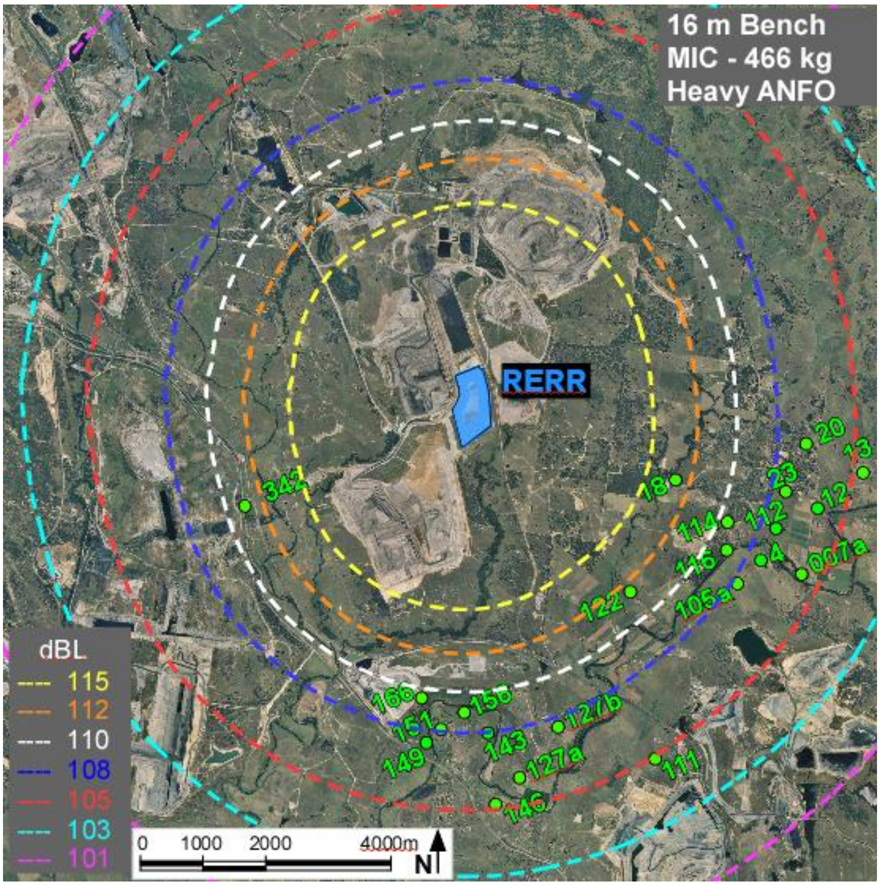


Figure 8A – Air Vibration Contours for a 26-metre bench and MIC of 549 kg

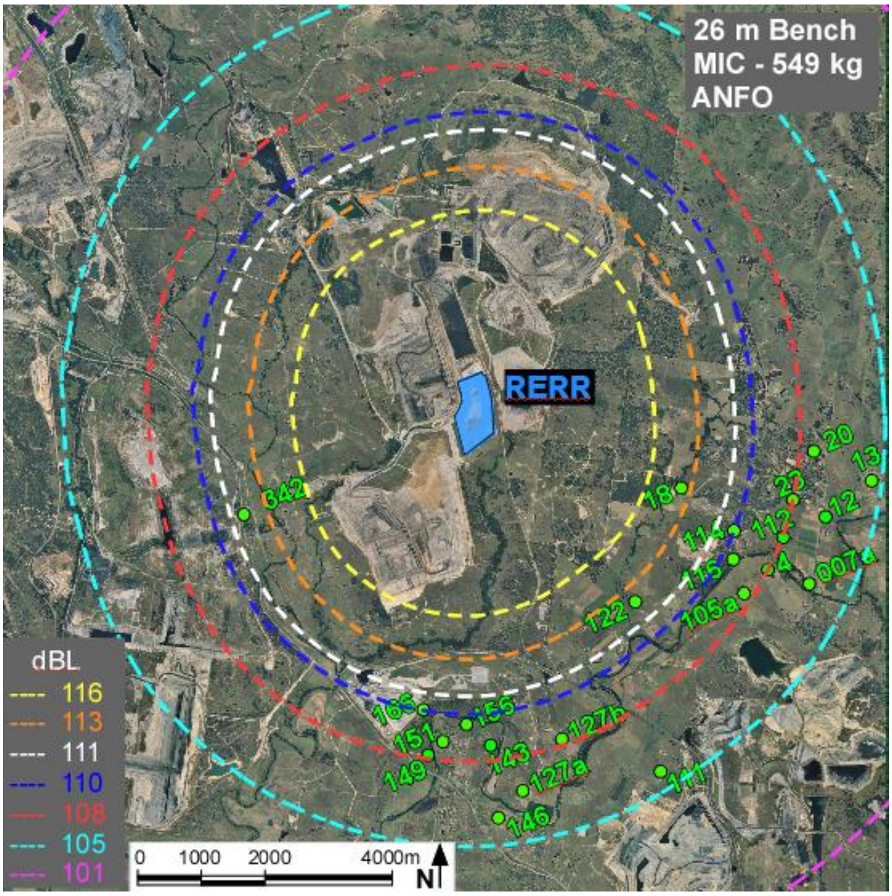
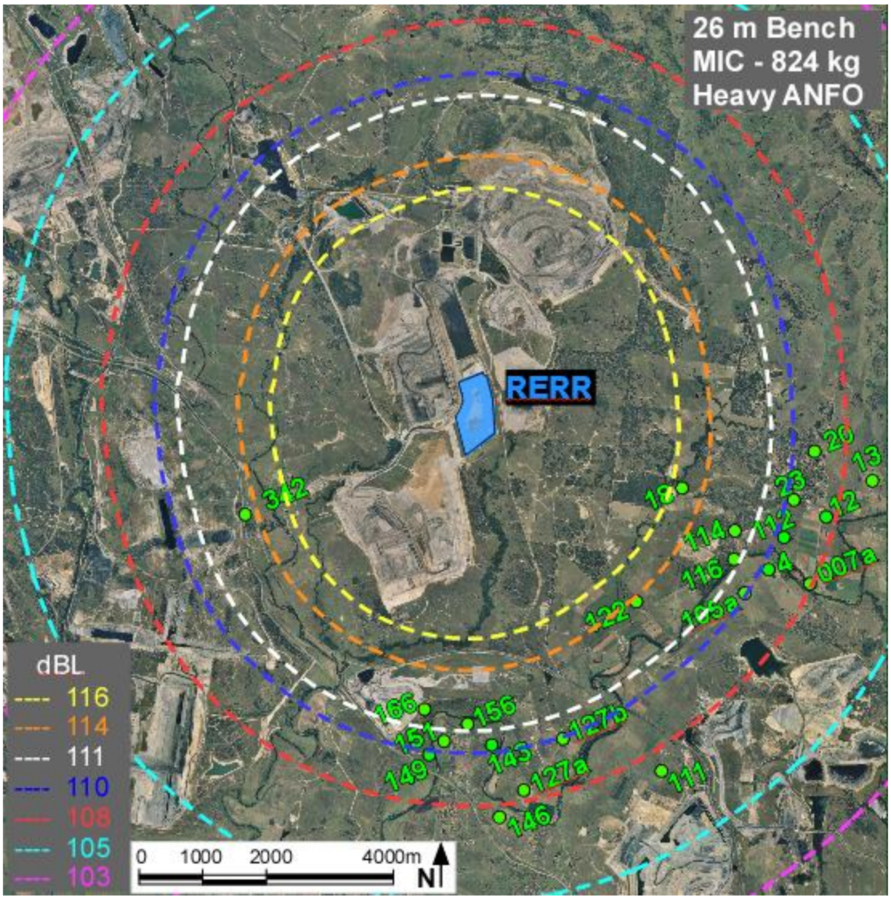


Figure 8B – Air Vibration Contours for a 26-metre bench and MIC of 824 kg



6. CONCLUSIONS

Part A of this report summarises the impact of blasting activities associated with the proposed modification on the surrounding community. The results of the analysis can be summarised as follows:

- The proposed RERR pit boundary was discussed in the context of the impact on the local community. The proposed RERR pit is to be located adjacent to the currently operational Barrett pit (Glendell) and the West pit (Ravensworth East). The blasting parameters are similar to the current operational parameters of the West pit. The blasting of interburden material could vary between 4 to 26 metre bench sizes.
- The local residences were identified. The closest residence will be located approximately 3.5 km from the proposed pit (that is, Residence ID 122). The location of the other residences varies between 3.5 km and 6 km.
- The blast emission and blast damage criteria were specified in Section 3 of this report. All predicted impacts are within the current operational vibration limits used by the Mt Owen Complex (that is, 5 mm/s allowed for 95% of blasts, and 10 mm/s not to be exceeded, 115 dBL allowed for 95% of blasts and 120 dBL not to be exceeded).
- The impact of ground vibration on the surrounding residences was simulated using the contour line assessment technique. The analysis gives an indication of the most extreme scenario, that is, blasting from the edge of the pit. The simulation included three different bench sizes, that is, 4, 16 and 26 metres and two different blasting products. The modelling revealed that for all three bench sizes the estimated ground vibration levels should be well below the 5 mm/s vibration limit criteria. The highest estimated vibration level for the closest residence was in the order of 1.3 mm/s.
- The impact of an airblast on the surrounding residences was simulated using the contour line assessment technique. Similarly to ground vibration modelling the impact of 3 different bench sizes and 2 different blasting products was modelled. The modelling revealed that for all three bench sizes the estimated airblast levels are predicted to be below the 115 dBL vibration limit criteria.
- The current operating standard in regards to blasting practice (the BMP) is appropriated and accordingly XMO will continue to manage blasting activities in accordance with the currently approved BMP.

REFERENCES

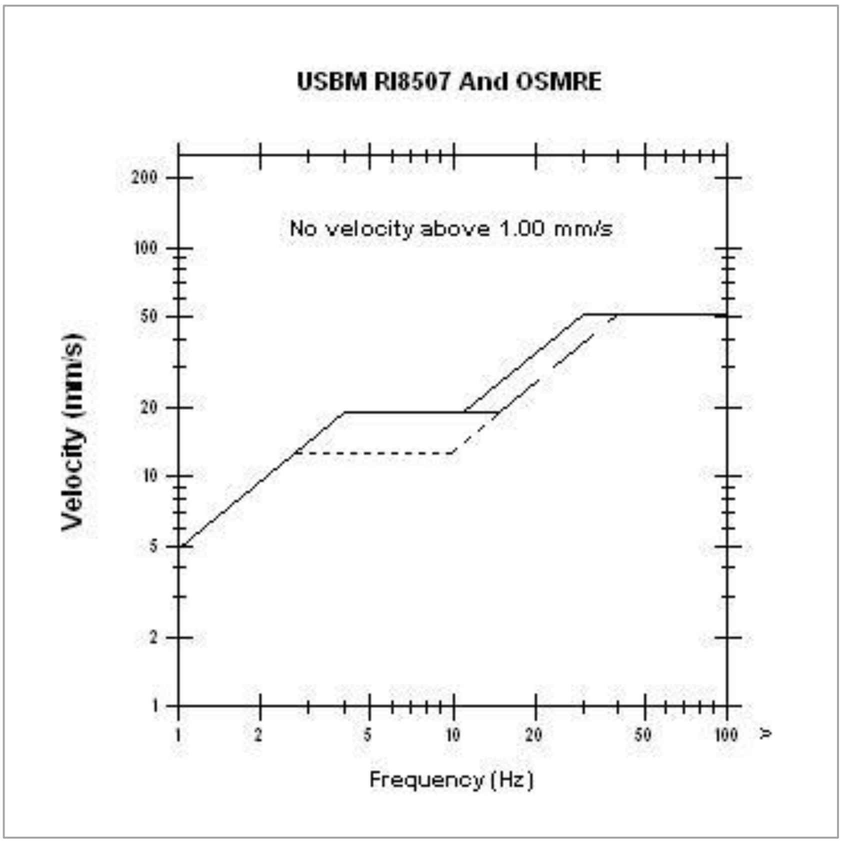
1. Australian & New Zealand Environment and Conservation Council (ANZECC) ‘Guidelines Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration’ September 1990.
2. Australian Standard AS 2187.2:2006, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2).
3. Blast Management Plan Mt Owen Complex – February 2012.

4. Bollinger 1980, “Blast Vibration Analysis”. Southern Illinois University Press Carbondale and Edwardsville, Feffer and Simons, Inc. London and Amsterdam, pp 103.

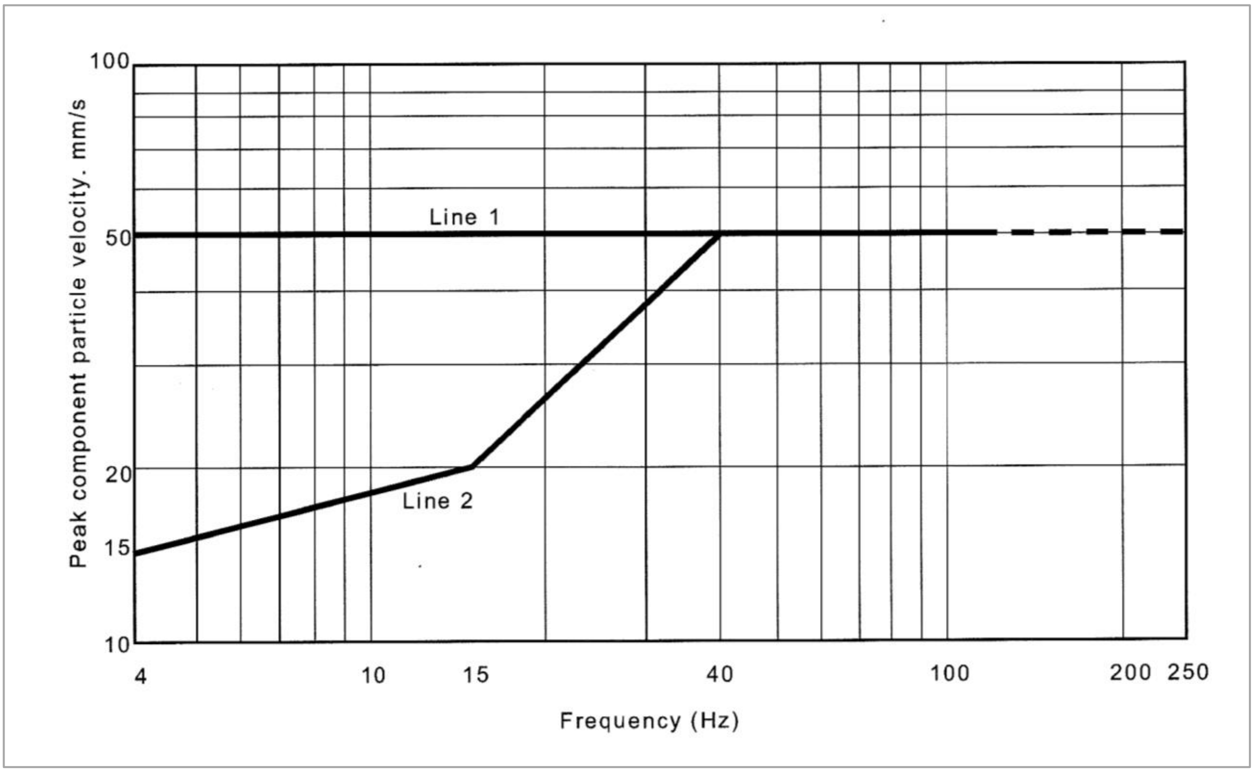
5. British Standard BS 7385-2:1993, Evaluation and measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground Borne Vibration.

6. US Bureau of Mines, USBM RI8507.

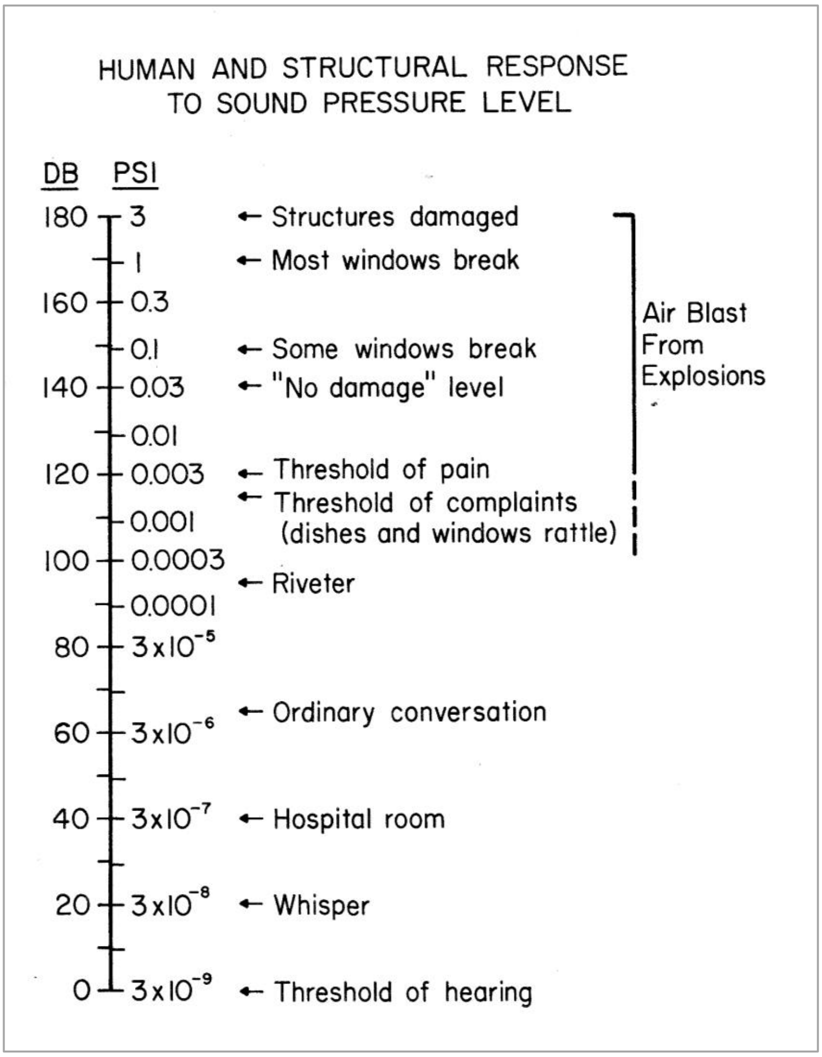
Appendix 1A – Safe level blasting criteria from USBM RI8507



Appendix 1B – Transient Vibration Guide Values for Cosmetic Damage - British Standard (BS 7385-2:1993)



Appendix 2 – Human and Structural Response to Sound Level (after Bollinger 1980)



PART B - BLAST IMPACTS ON INFRASTRUCTURE

BLAST IMPACT ASSESSMENT OF THE PROPOSED MODIFICATION ON ADJACENT INFRASTRUCTURE

1. INTRODUCTION

Part B of the report addresses the potential vibration exposure of the proposed modification on the adjacent infrastructure. The analysis is based on vibration modelling, site assessment and appropriate studies / experiences in the area of blast vibration impacts on infrastructure facilities. The vibration modelling results are analysed in the context of existing vibration limits for specific infrastructure.

The identified main infrastructures assessed include the following (refer to **Figure 1**):

- Power Transmission Lines, including the 330 kV and 132 kV powerlines
- St Clements Church, Camberwell
- Ravensworth Homestead
- Water and Tailings dams
- Existing Mt Owen Complex infrastructure (including Mt Owen and Glendell mine infrastructure area (MIA)
- Rail Spur and Rail Loading Facility
- Local roads

The main aim of this part of the report is to ascertain the impact of future blasting activities on the existing infrastructure to ensure any potential disruptions or delays are mitigated.

2. INFRASTRUCTURE OVERVIEW AND INITIAL REVIEW OF RISKS

A general inspection of the surrounding infrastructure was carried out by an ESC engineer and Xstrata representatives on the 19th of June 2012. The inspection included a site visit and identification of the individual infrastructure points.

An emphasis was placed on a review of the relevant monitoring stations. Where appropriate, an applicable vibration limit for each infrastructure item has been discussed.

The infrastructures specified below were identified and are considered in the report:

- 330kV and 132 kV Powerlines
- St Clements Church, Camberwell

- Ravensworth Homestead
- Water and Tailings dams
- Glendell mine infrastructure including:
    - Offices
    - Workshop and Store
    - Fuel Farm
    - Miscellaneous items, including pipes and water hydrants
- Mt Owen mine infrastructure including:
    - Offices
    - Workshop and Store
    - Conveyor Belts
    - Coal bins
    - Processing Plant
    - Fuel Farm
    - Miscellaneous items, including pipes and water hydrants
    - Rail Spur and Rail Loading Facility
- Hebden Road

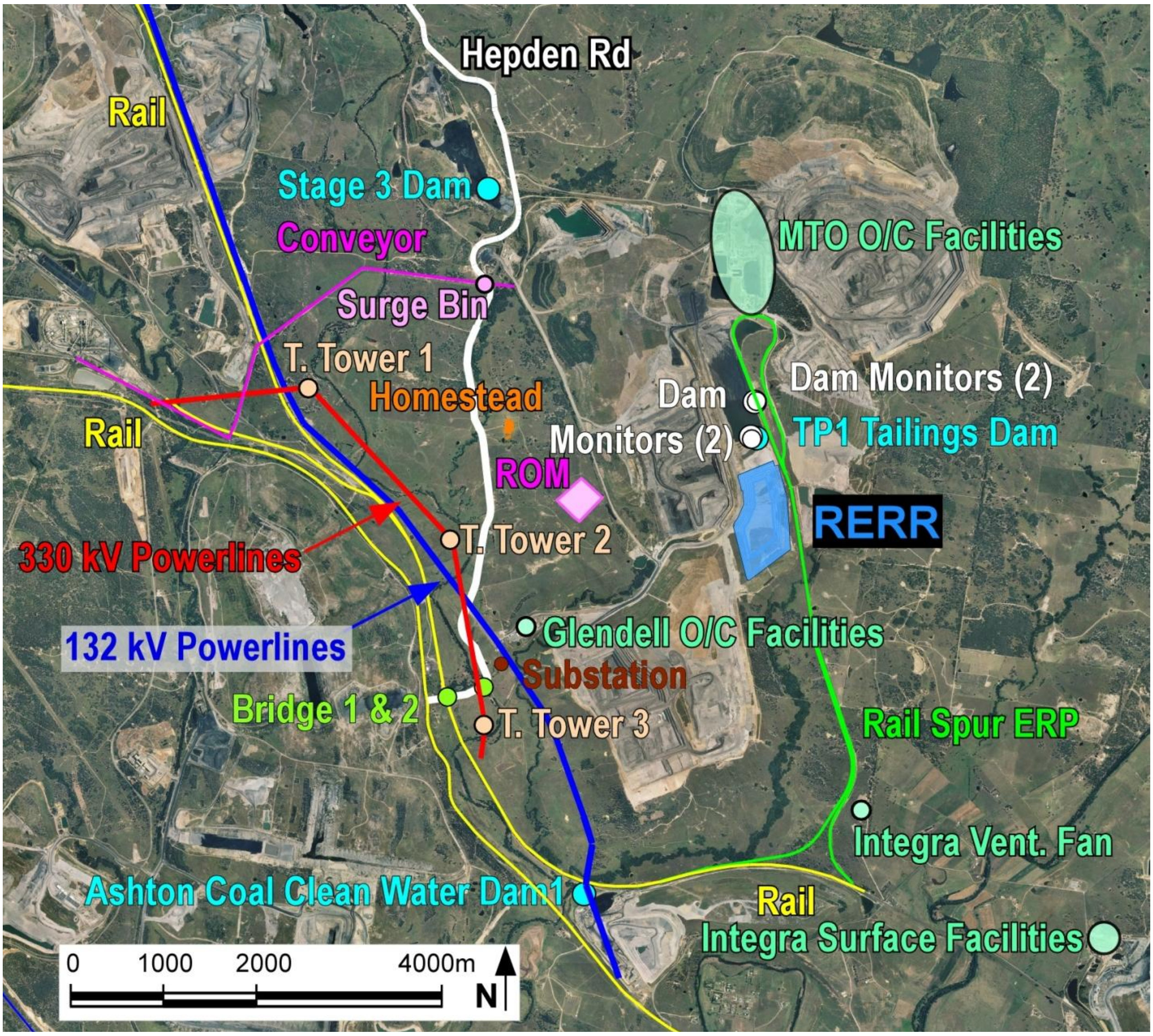
Due to the nature of blasting there are some inherent risks related to blasting in the proximity of infrastructure. Generally, these risks diminish with an increased distance from the blasting area. The efficient way to perform an initial overview of risks is via an assessment of the minimum distances between the proposed open cut area of the RERR pit and the infrastructure of concern.

The locations of the infrastructure points of concern are presented in **Figure 1**. This initial assessment also took into consideration the existing or inferred vibration limits for each particular infrastructure. This can provide a broad understanding of potential issues, which could range from flyrock, ground vibration exposure, airblast and even fume exposure. For the distance estimation to each infrastructure item refer to **Table 3;** applicable vibration limits are discussed in Section 3.

Based on the generated table it appears that the majority of the considered infrastructure are located in excess of 1,400 metres, including the surface mine infrastructure area (MIA), coal handling and preparation plant (CHPP), and Mt Owen rail loading facility. Therefore, in view of the substantial distance, no detailed assessment analysis is necessary for these infrastructures except for an overview of the existing or applicable limits. The exceptions are the TP1 Tailings Dam and the rail spur which, at the closest point, are located 295 and 90 metres respectively from the proposed RERR pit. These two infrastructure sites are within the 500m exclusion zone buffer.

In addition, relevant vibration monitoring data collected from some of the infrastructure points was obtained and assessed; the results of the analysis are also included in this report.

Figure 1 – Locations of the Infrastructure and the RERR Pit



Typically, when dealing with moderate or high levels of ground vibrations, it is vital to assess in detail the strength and quality of the infrastructure as well as the underlying rock strata conditions. That way the potential response of the structure to induced ground vibrations will be thoroughly understood.

When dealing with low levels of ground vibrations however, a detailed assessment is not paramount. It would be expected that structures (assumed to be of a robust construction) would not undergo damage when exposed to low levels of ground vibrations.

More often than not for infrastructure located at greater distances a detailed analysis is not required. For the infrastructure located closer to the blasting area however a more detailed assessment is needed.

Generally, it can be stated that for infrastructure located further than a 500 metre radius, the impact of blasting should be of no major concern.

3. BLAST EMISSION CRITERIA FOR INFRASTRUCTURE

It is important to highlight the existing vibration emission criteria for various infrastructure points of concern.

Power Transmission Lines

A vibration limit criterion of 50 mm/s (applicable to transmission power poles) has been used by Glendell Open Cut as specified in the Mt Owen Complex BMP.

It is noteworthy to highlight that the 50mm/s vibration limit is not the same for the whole mining industry. The powerlines and transmission towers are owned by TransGrid (NSW electricity grid operator). ESC's experience with other Hunter Valley mines with a similar issue, i.e. blasting next to transmission towers, shows that, historically TransGrid usually specify one of two vibration limits, i.e. either 25 mm/s or 50 mm/s. The majority of mines operate with the imposed vibration limit of 50 mm/s.

The latest trend observed in the Hunter Valley for mines dealing with blasting next to transmission towers revealed an increased allowance for high vibration exposure for transmission towers. This probably follows the Australian Coal Association Research Program (ACARP) project findings (ACARP Report No. C14057, 'Effect of Blasting on Infrastructure').

Nowadays, TransGrid generally uses a vibration limit of 100 mm/s. This applies to free standing pylons. However, for tension towers (generally located at the corners/bends), lower vibration limits such as the 50 mm/s still apply.

St Clements Church, Camberwell – historical building

The applicable vibration limit criteria for St Clements Church, located in Camberwell Village, are specified in BMP. These include 2 and 5 mm/s vibration limits with the following conditions attached:

- The PPV of 2 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months.
- The upper PPV level of 5 mm/s should not be exceeded at any time.

In addition, the vibration measurements should be undertaken in accordance with applicable guidelines including DECC's Assessing Vibration: A Technical Guideline (2006).

To address community concerns regarding protection of the church XMO have committed to designing blasts to achieve vibration levels not exceeding 2 mm/s as outlined in the BMP.

Ravensworth Homestead

The Ravensworth Homestead is located 2,485 metres to the west of the proposed modification. The Ravensworth Homestead is a historic complex comprising of a farmhouse and several associated out-buildings. The recommended vibration limits adopted in the BMP are as follows:

- 126 dBL - for airblast; and
- 5 mm/s - for ground vibration

These vibration limits are applicable to the proposed RERR pit. There is an ongoing monitoring program at the Homestead to ensure compliance with the imposed criteria.

Dam

The TP1 Tailings Dam is a prescribed dam within close proximity (295 m at the closest point), of the proposed RERR pit. The imposed vibration limit by the Dams Safety Committee (DSC) applicable to the dam wall is 50 mm/s, as stated in the DSC Annexure "D" dated 16.12.2011. In addition, a minimum requirement requested by the DSC is that monitoring of blast vibration be undertaken at the closest point to the blast on the embankment crest. Mt Owen Complex operates up to four vibration monitoring stations located along the dam's crest and toe on the southern and eastern sides; the locations are marked in **Figure 1**. On this basis, the 50 mm/s vibration criterion has been used for TP1. The other two dams, that is, Stage 3 and Ashton Coal Clean Water1, are both prescribed dams and are located a substantial distance away, namely 4,100 and 3,805 metres respectively.

Surface Mine Infrastructure Facilities

Mine infrastructure facilities generally present a significant combination of various materials. As such, various vibration limits are applicable. When undertaking blasting in close proximity of mine infrastructure, the application of appropriate limits is a function of material strength, construction and other factors. Therefore, in certain situations (i.e. generally less than 500 metres), a detailed investigation to establish vibration limits for each infrastructure is necessary. In the RERR case, as blasting is to be undertaken a substantial distance away from all mine infrastructure facilities (generally in excess of 1 km), there is no requirement to undertake such a detailed study.

Some general guidelines in regards to vibration limits for mine infrastructure were provided in Australian Standard AS 2187.2-2006 "Explosives - Storage and Use - Part 2: Use of Explosives". These include:

- 25 mm/s – for occupied non-sensitive sites, such as factories and commercial premises
- 100 mm/s – for unoccupied structures of reinforced concrete or steel construction
- Frequency-dependent damage limit criteria – for other structures or architectural elements that include masonry, plaster and plasterboard in their construction

Mine facilities are erected according to building standards; therefore the expected strength and robustness for each structure will provide sufficient stiffness and resistance to vibration impacts.

As such, the indicative vibration limit could be in the order of 30 mm/s for softer types of material, such as gyprock walls and others. For more robust types of building material, a 100 mm/s vibration limit is more appropriate. The 30 mm/s vibration level is an indicative limit only and could signify the possible onset of cosmetic damage. The origin of the 30 mm/s vibration level (or similar) can be traced back to various overseas studies such as those undertaken by the University of Leeds (England) and USBM (USA), which indicate the possible onset of cosmetic damage.

Some general vibration limits for mine facilities were recommended following ACARP Report No. C14057, which covered a wide-ranging review of various mines' experiences. The limits quoted below were recommended as a first pass if no detailed investigation was available:

- Mine offices, houses – 50 mm/s
- Fixed mine plant and buildings – 100 mm/s
- Buried communication cables and pipelines – 100 mm/s
- Conveyor structures – 100 mm/s

Rail Spur and Rail Loading Facility

The Xstrata railway line for Mt Owen Complex includes a rail spur, which consists of a rail loop and a rail loading facility (i.e. coal loading bin, conveyor belt and miscellaneous infrastructure), see **Figure 1**. Based on the provided plans, the railway spur is located approximately 60 metres to the closest point from the RERR pit. Note that at this point blasting will not be undertaken, this area only requires excavation activity. The minimum distance from the closest blasting section will therefore be in the order of approximately 90 metres. Also, the RERR pit is located approximately 1,580 metres from the rail loading facility (i.e. Mt Owen coal loading section of the Rail loop including coal loading bin and conveyor).

The typical approach in dealing with blasting in the proximity of railway lines includes an appropriate protocol including train clearance, allowance for appropriate windows for track occupation and a post blast track inspection procedure. This approach is sufficient and utilised by a number of mines, without specification of vibration limits.

Some of the mines operate using vibration limits, which apply mainly for the railway line infrastructure such as bridges, culverts, embankments, cuttings etc.

A summary of ACARP studies of various approaches of railway line vibration limits in Hunter Valley Mines is presented in **Table 1**.

Table 1: Summary of Railway Line Vibration Limits at some Hunter Valley Mines (after ACARP, Report No. C14057)

Site	Infrastructure	Vibration Limit (mm/s)	Comments
Drayton	Rail Culvert	20	Not currently an issue but will begin to have an impact as the mine advances north over the next few years.
	Rail Overbridge	25	
	Concrete Power Poles	50	
Bengalla	Rail Line	No limits	No blasting within 500m of track if train present. Notify rail authority and check for fly rock.
Camberwell	Rail Line	No specified limits	Notification and track clearance when blasting within 600m.
Rix's Creek	Rail Line	No limits	Previously blasted to 150m of rail line, but no longer an issue.
Mt Owen	Rail Line	No limits provided	Limited blasting remaining close to the rail line.
Unnamed	Culverts	80 mm/s	
	Rail Line	200 mm/s (95%<100 mm/s)	
Liddell	Embankments/cuttings	200 mm/s	Small diameter blasting tailored to most critical monitor, with >4ms arrivals using electronic dets.
	Rail Bridge	25 mm/s	
	Culverts	20 mm/s	
	Concrete Power Poles	50 mm/s	
Ashton	Rail Culvert	20 mm/s	Blasting generally less than 20 mm/s.

The ACARP study concluded that conservative "safe" blasting levels for railway infrastructure were specified as follows:

- Rail line – 200 mm/s
- Embankments and cuttings – 200 mm/s*
- Buried communication cables – 200 mm/s
- Concrete culverts – 100 mm/s

** An instrumented observational approach is recommended beyond 100 mm/s*

The authors also specified that the above "safe" limit can be increased pending a more detailed site specific investigation.

The following vibration limits are an example of site specific vibration limits utilised by another Xstrata mine:

- Railways embankments – 300 mm/s
- Railway cuttings – 250 mm/s
- Railway culvert – 400 mm/s
- Railway bridge and underpasses – 250 mm/s

The mine also specifies monitoring requirements, when blasting within 350 metres of these infrastructures.

It is stressed that in 2005 / 06 comparable blasting activities were undertaken and managed by XMO in the ERP. The ERP pit was located at a similar distance to the analysed rail spur but on the eastern side of the railway line. Blasting did not negatively impact the rail spur and there were no incidents. As management of the issue was undertaken successfully in the past, it is therefore considered that if a similar approach (including implementation of appropriate protocol) is executed the issue will again be managed successfully.

Public Roads

A comprehensive overview of the existing allowable vibration limits for various infrastructure was presented in the ACARP Report No. C14057. Following a wide-ranging review of various mines' experiences, conservative blasting levels for infrastructure were recommended. Vibration levels for roadways were specified as follows:

- Public Roads – 100 mm/s
- Concrete bridges – 100 mm/s (also referenced in Australian Standard AS2187.2-2006)

The above limits were recommended as a first pass if no detailed investigation was available.

4. GROUND VIBRATION MODELLING

The vibration modelling undertaken in this section has been performed using the formula below. The parameters summarising the site law analysis (governing ground vibration behaviour) are specified as follows:

$$\mathbf{V} = \mathbf{2694}\left(\frac{D}{\sqrt{m}}\right)^{-1.6}$$

Where:	**V**	=	Peak Particle Velocity (mm/s)
	a	=	-1.6 (site exponent)
	k	=	2694 (site constant)
	D	=	distance (m)
	m	=	charge mass (kg)

The impact of vibrations on the existing infrastructure was simulated using the contour line assessment technique. The analysis provides an indication for the most extreme scenario, that is, initiation of the maximum charge mass from the edge of the proposed final pit shell (where each contour is drawn from). The ground vibration analysis is presented as a series of contour lines overlying the area adjacent to the discussed infrastructure (see **Figures 2-4**). Note that up to seven main contours of interest were drawn for each scenario, depicting a selection from the following contour ranges 0.3 - 6.0 and 30 - 65 mm/s. These contours were used for modelling purposes. The highest value contours correspond to vibration levels at the TP1 Tailings Dam while the lowest value contours represent the most distant locations.

4.1 Modelling Results - the Impact of Ground Vibrations for a 4-m Bench

*Small size benches – 4 metres, see **Figures 2A** and **B.***

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 26 and 39 kg are shown in **Figures 2A** and **B.** The results of the assessment are also presented in **Table 3**.

The highest estimated vibration is for the rail spur and is in the order of less than 38 mm/s (the ACARP recommended vibration limit is 200 mm/s). The second highest estimated vibration is for TP1 and is in the order of less than 6 mm/s (where a vibration limit of 50 mm/s applies). The impact on other infrastructure is in the order of 0.5 mm/s or less and is considered negligible. Therefore, the ground vibration contour line assessment revealed that blasting of 4 metre benches can be fired without any restrictions as vibration levels are negligible/low.

4.2 Modelling Results - the Impact of Ground Vibrations for a 16-m Bench

*Medium size benches – 16 metres, see **Figures 3A** and **B**.*

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 311 and 466 kg are shown in **Figures 3A** and **B.** The ground vibration contour line assessment revealed that blasting 16 metre benches could generate vibration levels in the order of 199 to 274 mm/s for the rail spur when blasting 90 metres away (that is, the shortest estimated distance from the blasting zone). Bench heights should be considered together with the distance from the blast, as the effective vibration will be decreasing as the distance increases. To manage vibration levels for the rail spur refer to **Table 2.** The blast design will be managed according to the vibration limit criteria and the actual distance from the blast area. The ground vibration assessment for the TP1 dam wall revealed vibration levels in the order of 30 to 41 mm/s. The impact on other infrastructure is considered negligible/low, that is, generally no higher than 3 mm/s, see **Table 3**. The assessment revealed that 16 metre benches (or smaller) can be fired without any restrictions as vibration levels are below the applicable vibration limit criteria for the TP1 dam wall (representing the closest infrastructure).

Table 2 – Minimum Distance Requirements for a given MIC to Comply with Particular Vibration Limits

Vibration Limit (mm/s)	Estimated Minimum Distance from Rail Spur (m)			
	16-m Bench		26-m Bench	
	MIC 311 kg	MIC 466 kg	MIC 549 kg	MIC 824 kg
200	90	110	120	150
250	78	95	105	127
300	70	85	92	113

4.3 Modelling Results - the Impact of Ground Vibrations for a 26-m Bench

*Large size benches – 26 metres, see **Figures 4A** and **B**.*

The projected ground vibration contour lines for the surface area due to blasting using charge masses of 549 and 824 kg are shown in **Figures 4A** and **B**. The ground vibration contour line assessment revealed that the vibration level could be in the order of 313 – 433 mm/s for the rail spur when blasting 90 metres away. To manage vibration levels for the rail spur refer to **Table 2.** Again, the blast design will need to be managed according to the vibration limit criteria and the actual distance from the blast area. The ground vibration level for the TP1 dam wall could be in the order of 47 – 61 mm/s. To meet the vibration limit criteria therefore some restrictions on blasting parameters will be required. This could include limitation of charge mass via the introduction of deck charges, or blasting smaller bench sizes than the 26 metre benches modelled here. It is highlighted however that this issue will be limited to a relatively narrow area of the pit (immediately adjacent to the dam wall). For further explanation refer to the note below highlighting details. The impact on other infrastructure is still considered negligible/low, that is, generally no higher than 5 mm/s, see **Table 3**.

Note that the level of vibration when blasting will vary for all infrastructure items due to variations in distances. For the majority of the time, the actual distances will be greater than the distances stated in **Table 3**. It is stressed that the simulation is undertaken from the edge of the proposed pit shell. For example blasting 100 metres from the edge of the pit shell will cause a substantial reduction in vibration levels as the overlying contour lines will be shifted 100 metres away from the edge of the pit shell.

Table 3: Results of Ground Vibration Modelling for Infrastructure – Maximum Vibration Estimates

Infrastructure	Min. Distance (m)	Direction from RERR	Estimated Max Ground Vibration (mm/s)					
			4-m Bench		16-m Bench		26 m Bench	
			ANFO 26 kg	Heavy ANFO 39 kg	ANFO 311 kg	Heavy ANFO 466 kg	ANFO 549 kg	Heavy ANFO 824 kg
Homestead	2,485	W	0.1	0.2	1.0	1.4	1.5	2.1
Camberwell Church	4,760	S	0.1	0.1	0.3	0.5	0.5	0.8
Surge Bin	3,410	NW	0.1	0.1	0.6	0.8	0.9	1.3
Conveyor Belt	3,150	NW	0.1	0.1	0.7	0.9	1.1	1.5
Stage 3 Dam	4,100	NW	0.1	0.1	0.4	0.6	0.7	1.0
TP1 Tailings Dam	295	N	4.0	5.6	30	41	47	65
Ashton Coal Clean Water Dam1	3,805	SW	0.1	0.1	0.5	0.7	0.8	1.1
Road - Existing	2,615	W	0.1	0.2	0.9	1.3	1.4	2.0
Road Option	4,550	W	0.1	0.1	0.4	0.5	0.6	0.8
Bridge 1	3,420	SW	0.1	0.1	0.6	0.8	0.9	1.3
Bridge 2	3,020	SW	0.1	0.1	0.7	1.0	1.1	1.6
Railway line	3,060	W to S	0.1	0.1	0.7	1.0	1.1	1.5
132kV powerlines	2,600	W	0.1	0.2	0.9	1.3	1.4	2.0
330kV powerlines	2,990	W	0.1	0.1	0.7	1.0	1.2	1.6
Tension Tower 1	4,705	NW	0.1	0.1	0.4	0.5	0.6	0.8
Tension Tower 2	3,020	W	0.1	0.1	0.7	1.0	1.1	1.6
Tension Tower 3	3,210	SW	0.1	0.1	0.7	0.9	1.0	1.4
Rail Spur	90	E	27	38	199	274[1]	313[1]	433[1]
Mt Owen Rail Loading Facility	1,580	N	0.3	0.4	2.0	2.8	3.2	4.4
ROM	1,440	W	0.3	0.5	2.4	3.2	3.7	5.1
Substation	2,790	SW	0.1	0.2	0.8	1.1	1.3	1.8
Glendell O/C Facilities	2,390	SW	0.1	0.2	1.0	1.4	1.6	2.3
Mt Owen Complex O/C Facilities	1,570	NW	0.3	0.4	2.0	2.8	3.2	4.5

[1] Vibrations to be managed through appropriate blast design according to the actual distance from the blast

Figure 2A – Ground Vibration Contours for a 4 metre bench and MIC of 26 kg

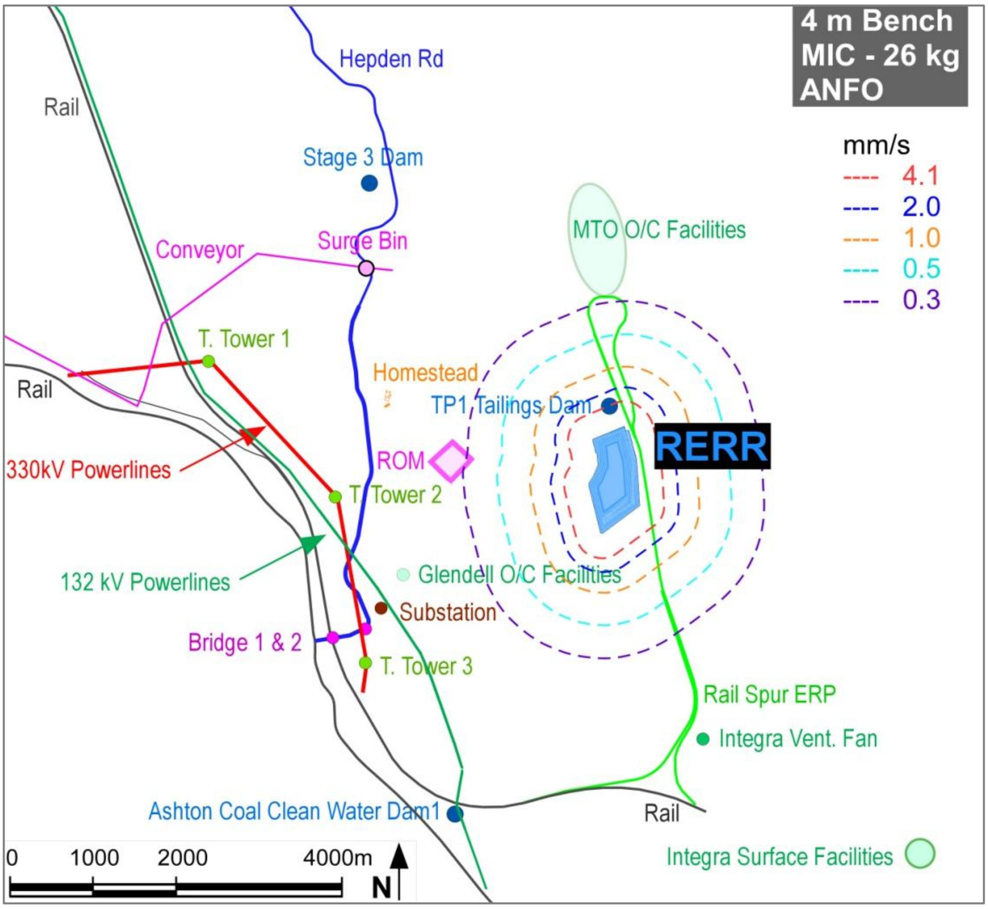


Figure 2B – Ground Vibration Contours for a 4 metre bench and MIC of 39 kg

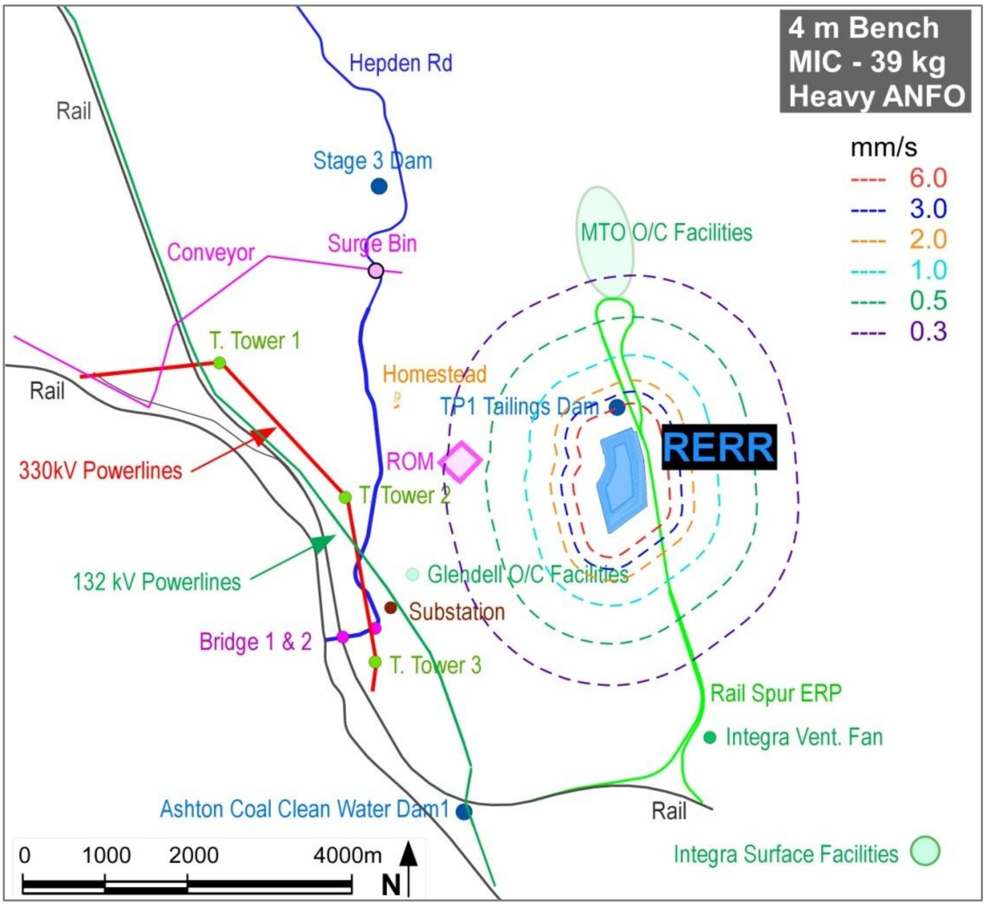


Figure 3A – Ground Vibration Contours for a 16 metre bench and MIC of 311 kg

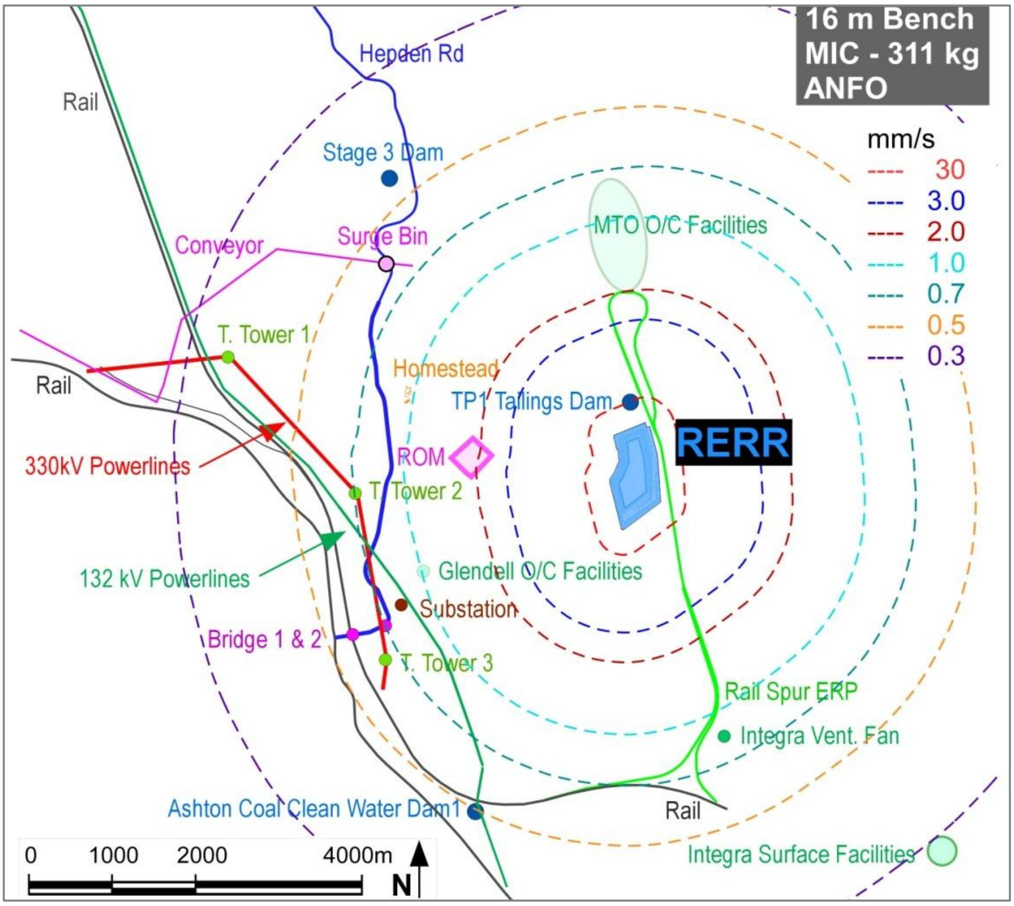


Figure 3B – Ground Vibration Contours for a 16 metre bench and MIC of 466 kg

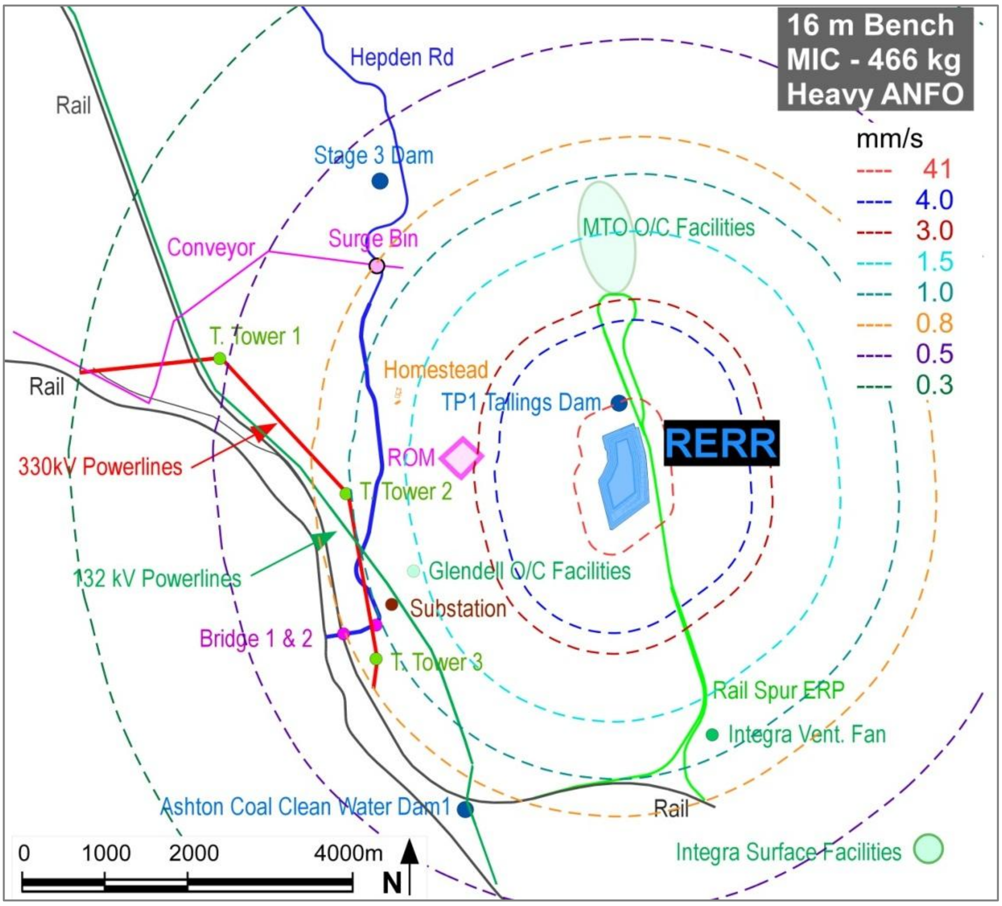


Figure 4A – Ground Vibration Contours for a 26 metre bench and MIC of 549 kg

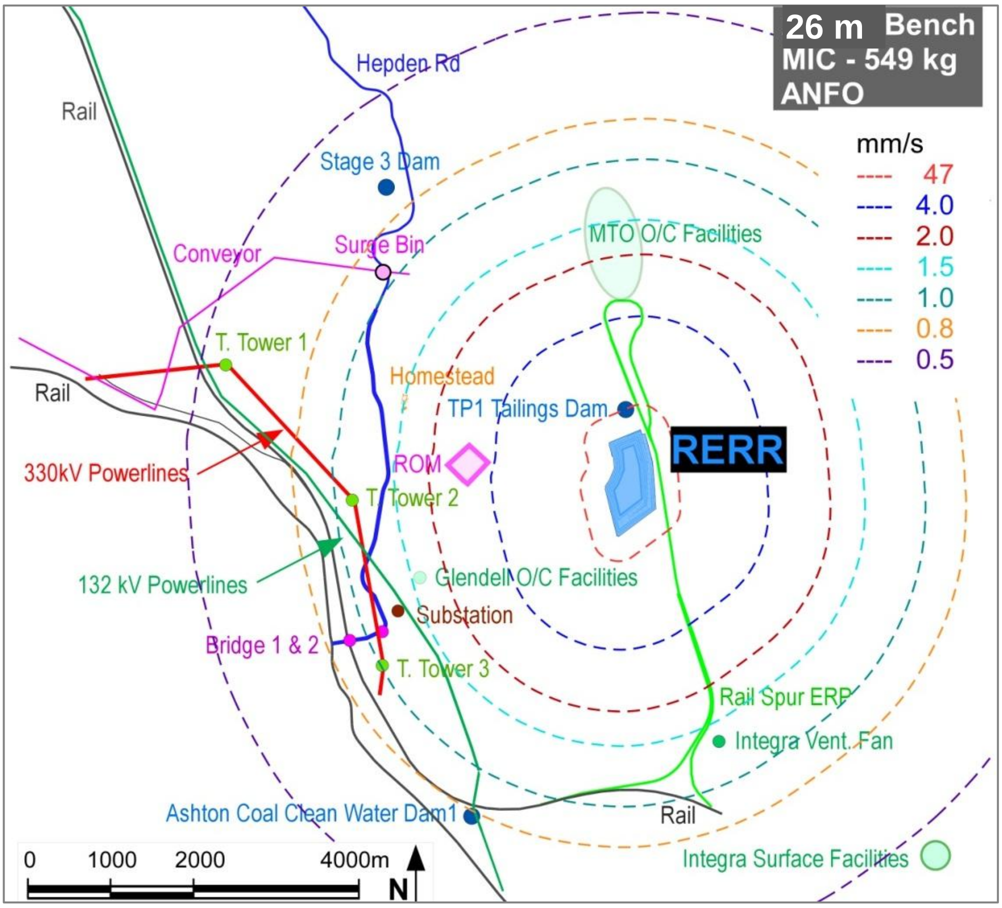
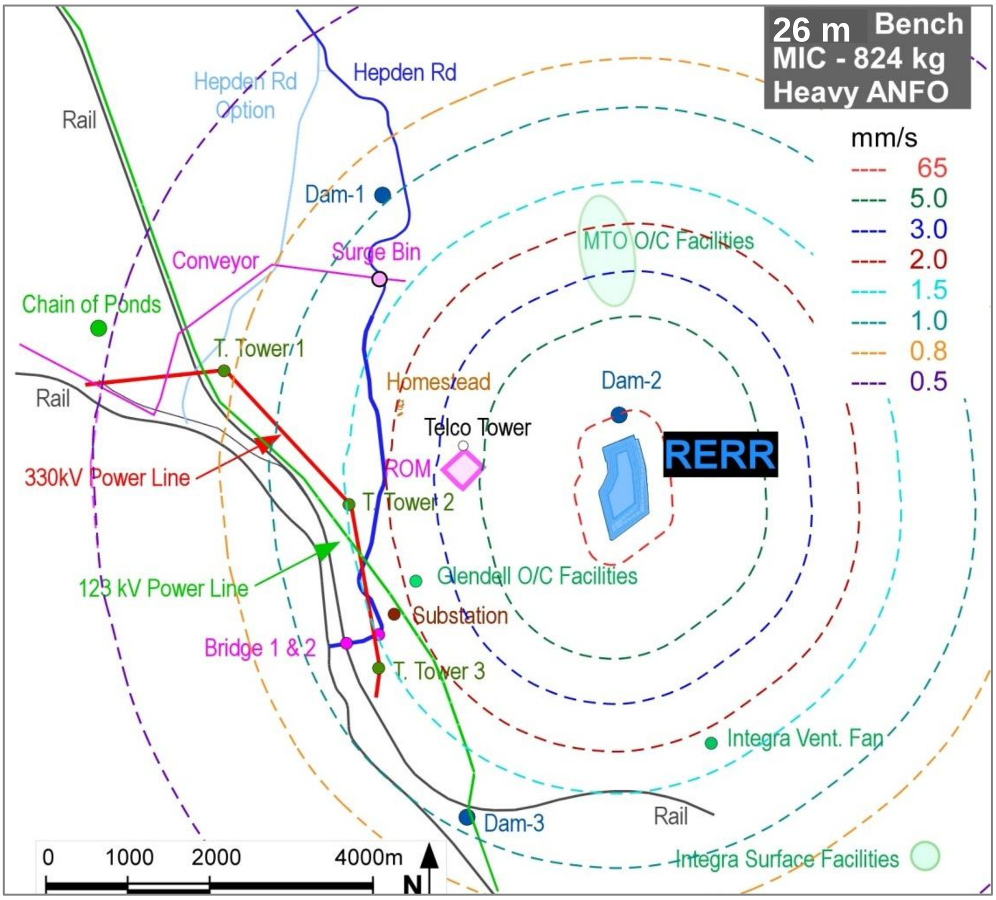


Figure 4B – Ground Vibration Contours for a 26 metre bench and MIC of 824 kg



5. CONCLUSIONS

Part B of this report outlines the impact of blasting activities associated with the proposed modification in relation to the surrounding infrastructure. The assessment can be summarised as follows:

- The proposed RERR pit is to be located adjacent to the currently operational West pit (Ravensworth East) and the Barrett pit (Glendell). Blasting in the proposed RERR pit will include blasting of interburden material in the order of 4 – 26 metres.
- All infrastructure facilities were identified and distances from the RERR pit were estimated. The infrastructure facilities are located more than 1,400 metres from the proposed RERR pit, with the exception of the rail spur and TP1 Tailings Dam, which are placed approximately 90 and 295 metres away.
- The blast emission criteria for each infrastructure item were specified in Section 3 of this report.
- The vibration modelling revealed that the most significant impact of blasting will be for the immediately adjacent rail spur and tailings dam (TP1), due to their close proximity.
    - Assessment for TP1 Tailings Dam:
        - Blasting 4 - 16 metre benches can be undertaken without any restrictions (providing that blast design parameters will be similar to those used for modelling).
        - Blasting 26 metre benches will require additional blast management measures (to be specified in the BMP). The area of increased blast management will be limited to an approximate 100 metre radius of the north section of the RERR pit. The introduction of additional blast management measures is to facilitate the vibration limit criteria of 50 mm/s imposed on the dam wall by the DSC. This could include the application of deck charges or smaller bench blasting. The mine is familiar with blast control practices such as the application of deck charges and the use of electronic detonators, therefore this should not provide any major impediment.
    - Assessment for the rail spur:
        - Blasting 4 metre benches can be undertaken without any restrictions (providing that blast design parameters will be similar to those used for modelling).
        - Blasting 16 - 26 metre benches will require additional blast management measures such as the application of deck charges or smaller bench blasting. The blast design will be managed according to the applicable vibration limit criteria and the actual distance from the blast area.

    During 2005 / 06 comparable blasting activities were undertaken in the ERP. The pit was located at a similar distance to the rail spur but on the eastern side of the railway line. There was no negative impact on the rail spur observed due to blasting and there were no incidents. The management of the issue was undertaken adequately in the past, it is therefore concluded that with a similar approach (including implementation of appropriate protocol) the issue will again be managed successfully.

- Vibration predictions for the 132 and 330 kV powerlines are estimated to be below 2 mm/s, well below the imposed vibration limit of 50 mm/s.
- Vibration estimates for two infrastructure items, including the Ravensworth Homestead and Camberwell Church, are predicted to be below the applicable vibration limits of 5 mm/s and 2 mm/s respectively.
- Vibration impacts on other infrastructure is considered negligible/low, that is, generally no higher than 6 mm/s. Therefore, there are no risks to infrastructure damage or vibration limit exceedance.

REFERENCES

1. ACARP Report Reference No. C14057 'Effect of Blasting on Infrastructure' Alan Richards, Adrian Moore, 2008.
2. Australian Standard AS 2187.2:2006, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2).
3. Blast Management Plan MT Owen Complex – February 2012.
4. Dam Safety Committee NSW, Annexure "D" Standard Mining Conditions. Correspondence regarding 'Xstrata Mt Owen Pty Ltd application to open cut mine adjustment to Mt Owens Rail Loop Tailings Dam within the Mt Owen Notification Area', 16.12.2011
5. DECC's (Department of Environment and Climate Change) Department of Environment and Conservation NSW (DEC); Assessing vibration: A technical guideline, February 2006.
6. Glendell Development Consent (DA 80/952) – Blasting and Vibration.

PART C - BLAST IMPACTS ON INTEGRA UNDERGROUND

BLAST IMPACT ASSESSMENT OF THE PROPOSED MODIFICATION ON THE ADJACENT INTEGRA UNDERGROUND MINE

1. INTRODUCTION

Part C of this report is designed to address the impact of the proposed modification on the adjacent Integra Underground Mine (IUM) and related infrastructure.

Based on the conceptual mine plans, the proposed open cut section of the RERR mining area is to be located approximately 250 metres above the IUM workings. Depending on both mines extraction schedules, it is likely that open cut blasting activities will be undertaken directly above active underground workings at IUM.

This section of the report addresses the blast impacts on the following:

- Underground workings
- Ventilation fan
- Surface infrastructure, including offices / bathhouse
- Envirogen 10MW gas fired power station
- Conveyor belt

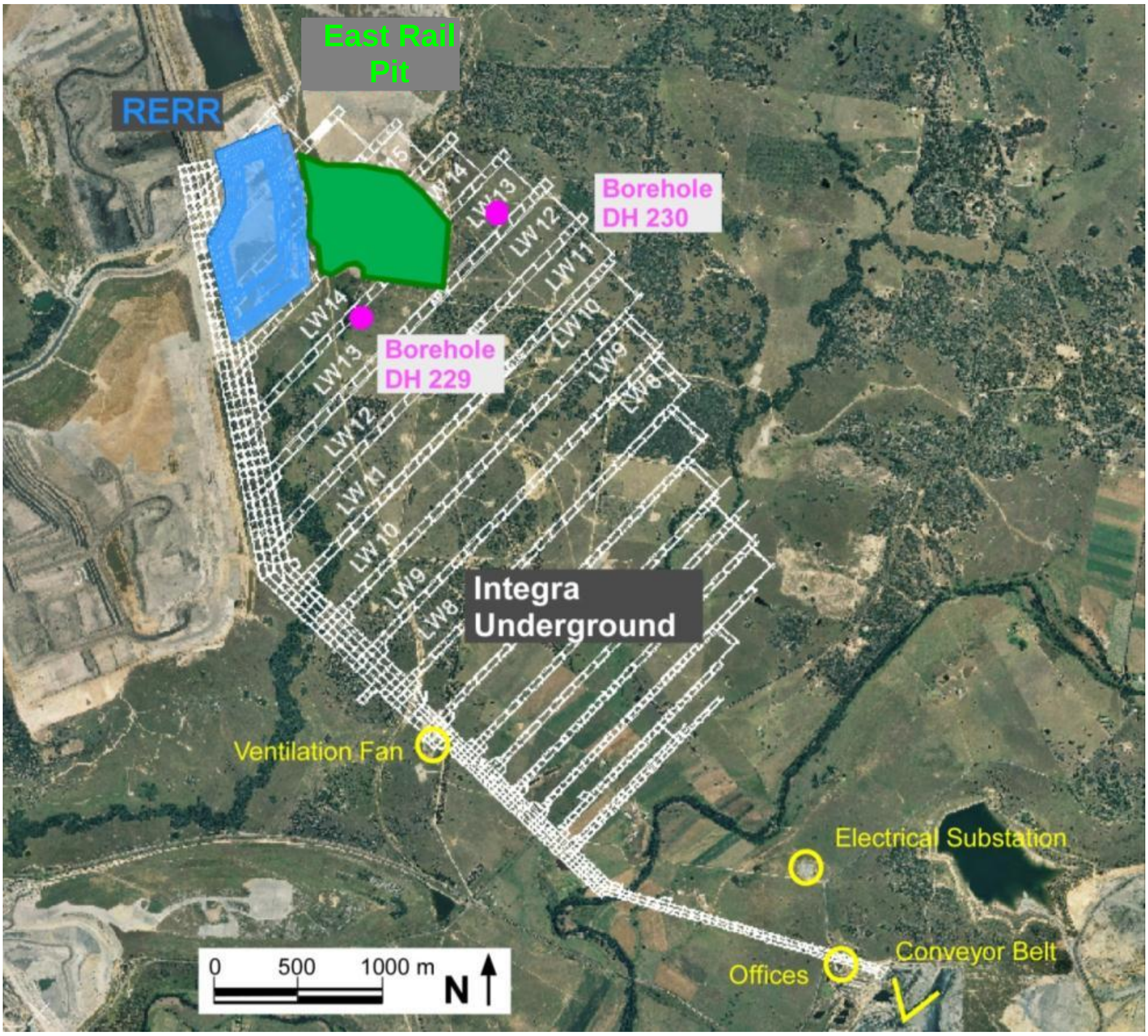
The assessment provides vibration estimates and blast emission criteria in regards to potential vibration exposure for the underground workings and related surface infrastructure. In addition, the report addresses the issue of underground personnel exposure to surface blasting and the management of such.

The presented analysis is based on vibration modelling, data from previous studies between Mt Owen Complex and IUM in 2005/06 and experiences with similar projects.

2. MINE BOUNDARIES AND IDENTIFICATION OF POTENTIAL ISSUES

The mining plans, including the proposed RERR pit and the adjacent IUM are presented in **Figure 1**. It is important to note that the Mt Owen Complex mining lease and the IUM mining leases overlap. The Mt Owen Complex has the extraction rights of the upper seams down to the Bayswater seam, while IUM has the extraction rights of the lower mining seams, extending from the currently mined Middle Liddell seam to the next seams, which are Barrett and Hebden seams.

Figure 1 – Locations of the RERR Pit and Integra Underground Mine (IUM)



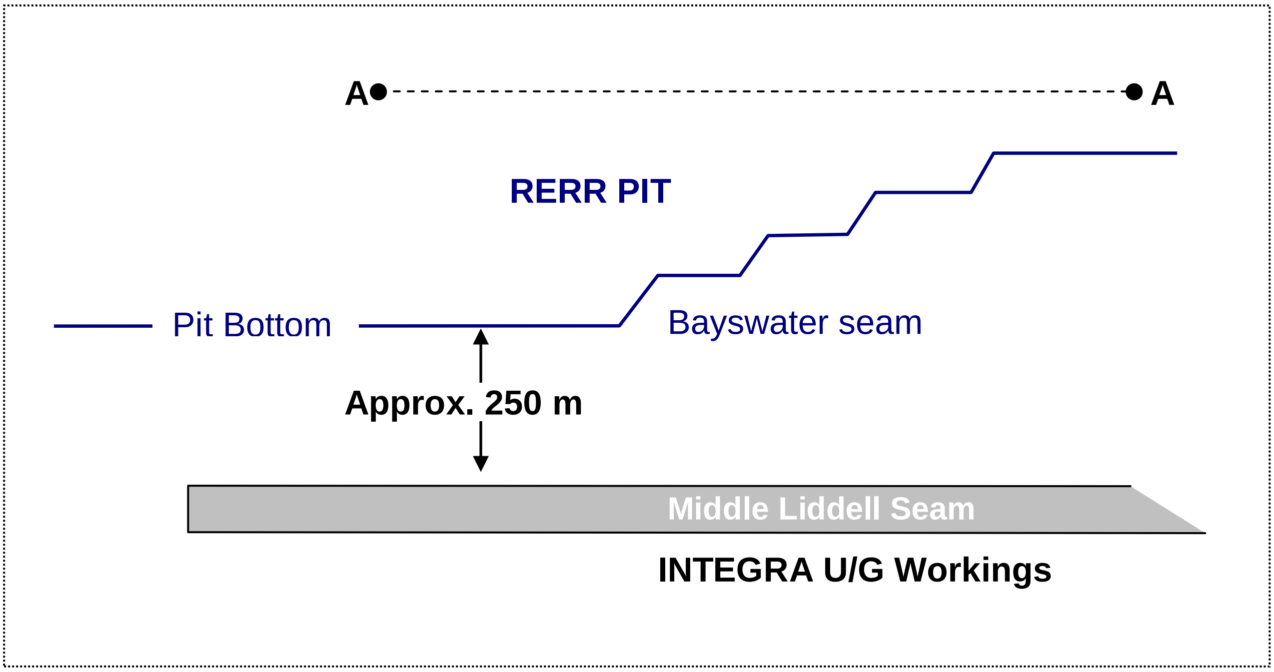
The proposed RERR activities are contained within the rhomboidal section with a relatively limited extraction area. Based on the underground plans, the IUM main headings extend from the southern end and progress to the north, which is also the case for the long-wall operations.

As the mines overlap, representative boreholes were obtained and inspected for vertical separation between the Bayswater seam (representing the bottom of the RERR pit and Middle Liddell Seam (representing the current IUM workings).

Two borehole logs from an area adjacent to the RERR pit have been obtained and include Boreholes DH229 and DH230; see **Figure 1** and **Appendices 1A** and **B** for borehole locations. The estimated vertical separations from these boreholes were in the order of 253.6 and 256.7 metres.

Based on these estimates, the schematic cross section showing the RERR pit and underground mine is presented in **Figure 2**. This is for the seams that are currently operational. However, it should be noted that with time, as the current Middle Liddell seam is fully extracted, the Integra operation will commence to mine lower coal seams. Therefore, the vertical distance between the two operations will be subsequently increased by the additional depth.

Figure 2 – Schematic Cross-section Showing the RERR Pit and Integra Underground Mine Overlapping Area



Based on the borehole information it can be inferred that a 250 metre buffer be used for modelling purposes and is considered representative for this study. To ensure the most conservative scenario (disregarding both mines extraction schedules, as these may change with time) and for the purpose of this project, the worst case scenario is assumed, i.e. that IUM will still be operating or that some facilities will still be in use at the current seam level, which is the Middle Liddell seam, when the RERR pit blasting is undertaken.

The postulated worst case scenario takes into account the possibility that blasting of the proposed RERR pit will be undertaken for a considerable period of time and therefore is likely to coincide with the underground extraction activities. Therefore, there is some probability that the underground workforce will be present during surface blasting activities, and such a possibility needs consideration.

3. GROUND VIBRATION LIMITS

3.1 Vibration Limits for Underground Workings - Blast Emission Criteria and Risk Management

Blast emission criteria for underground mines are generally specified by two different criteria, that is, Safe Vibration Limit and Vibration Limit for Personnel Withdrawal.

"Safe Vibration Limit" for an Underground Mine.

> This is a unique number mainly dependent upon rock strength characteristics. The safe vibration limit is specified as "the level at which there is a high probability of rock strata damage". To avoid any potential damage issues, the blasting should be designed below the safe vibration limit using a target vibration level (that is, specified below the safe vibration limit).

The "safe vibration limit" is a site specific limit and varies for each underground mine. The limit is mainly dependent on geological/geotechnical conditions of the rock strata, mainly related to the immediate roof/rib conditions. Generally this limit should be established for each particular mine when blasting is undertaken in close proximity to underground mines, that is, less than 1km distance.

The previous study undertaken in 2005/2006 revealed that the safe vibration limit for IUM is in the order of 250 mm/s (Terrock, 2005). Prior to the commencement of blasting, it is recommended to review the specified limit as underground conditions could have changed from those that the limit was based on.

"Vibration Limit for Personnel Withdrawal"

> Based on extensive previous studies (Lewandowski et al 2006 and 2007), a 10 mm/s vibration level has been recommended by the author and used across a number of underground mines for personnel withdrawal. The 10 mm/s limit is specified as a human comfort level, and not as a safe vibration limit (which would be higher). The same 10 mm/s vibration limit is recommended for the underground mine. Note that the mine sections exposed to predicted vibration levels of less than 10 mm/s can be manned if notification to all personnel of the predicted vibration levels is given. Personnel must also be informed of excluded sections (that is, where vibrations exceed 10 mm/s).

This limit has been used across different mines with similar issues including IUM and the Mt Owen Complex.

For an indicative human response to blast vibration in an underground situation refer to **Table 1**. These findings are based on a two year project including underground measurements and assessments undertaken at United Collieries (Xstrata Coal).

Table 1: Impact of vibration - indicative human response (after Lewandowski et al 2006)

Vibration Level (mm/s)	Description	Human Response
<2	low level of vibration no impact on roof and ribs	U/G – some personnel will not even notice blast U/G – well acceptable vibration level by underground personnel SURFACE – generally well accepted level by people in the houses
2-3	low level of vibration no impact on roof and ribs	U/G – well acceptable vibration level by underground personnel SURFACE – typical level that some people could complain depending on house response
5	elastic roof behaviour no damage to the rock strata	U/G – introduced initially as a permissible level for underground roadways with personnel SURFACE – one of the EPA environmental limits, considered as a vibration limit for house structures
10	elastic roof behaviour no damage to the rock strata	U/G – introduced as a final permissible level for underground roadways with mine personnel SURFACE – imposed by Environmental Protection Agency (Australia) vibration limit for house structures
20	stone dust starts falling from the roof elastic roof behaviour loose rock particles starts falling substantial noise level	U/G – not recommended for personnel to be underground at this level i.e. falling stone dust could provide wrong indication about imminent roof fall
35	large amount of stone dust falling loose coal particles falling elastic roof behaviour substantial noise level	U/G - vibration level described as extreme large amount of stone dust and loose rock particles falling down from the roof causing limited visibility in highly ventilated areas extremely high level of noise generated high impression of possible roof fall at this level

The risks associated with two different operations acting simultaneously can be effectively managed via the implementation of a Blast Management System between the open cut and underground mines (Lewandowski et al 2007). The system is designed to deal with the impact of blasting from an open cut mine on underground workings.

The system is designed to deal with the following issues:

- Assessment of the impact of vibration on rock strata conditions
- Detailed ground vibration predictions
- Management of underground personnel during blasting
- Vibration notification procedure and execution

The system has been developed by the author and implemented successfully in a number of different mines in the Hunter Valley with similar issues. Also, the same system has previously been introduced between the Mt Owen Complex and IUM for the Eastern Rail Pit. The work was undertaken in 2005/2006 and included the development of a small box cut pit called Eastern Rail Pit and involved interaction between Mt Owen Mine management and IUM management, see **Figure 1**.

This project included the following stages:

Stage 1 – Assessment of the proposed impact of blasting from the East Railway Open Cut Pit on the adjacent IUM, including vibration modelling

Stage 2 – Formal Risk Assessment between both sites

Stage 3 – Development of a Blast Management Plan

Stage 4 – Development of Explanatory Notes for Underground Personnel and Personnel Training

Stage 5 – Development of a Predictive Model, including surface and underground measurements

Stage 6 – Introduction of a Management Plan between both the open cut and underground mines (including the Vibration Predictive Model and notification procedure)

The study was supported by surface monitoring using multiple monitoring stations placed either directly above the underground monitoring stations or in approximately the same direction as the underground workings in relation to the blasting.

In summary, the previous monitoring study provides a strong basis for the current assessment study. Most of the findings of the previous study are fully applicable to this assessment. The previously developed System can also be utilised and transferred into the future interaction project and therefore provide a strong foundation for blast management issues for the proposed modification.

The previous interaction study in 2005/06 revealed that all major risks between the two operations can be managed effectively. It is however stressed that a pre-requisite for successful control of blast management issues lies in the cooperation of both mines.

3.2 Vibration Limits for Surface Infrastructure

Guidelines in regards to vibration limits for mine infrastructure are provided in Australian Standard AS 2187.2-2006 “Explosives - Storage and Use - Part 2: Use of Explosives”. These include:

- 25 mm/s for occupied non-sensitive sites, such as factories and commercial premises
- 100 mm/s for unoccupied structures of reinforced concrete or steel construction
- Frequency-dependent damage limit criteria for other structures or architectural elements that include masonry, plaster and plasterboard in their construction

4. BLAST IMPACT MODELLING FOR THE INTEGRA UNDERGROUND

4.1 Vibration Modelling for Integra Underground Workings

To assess the impact of blasting from the proposed RERR pit on the IUM, vibration modelling was undertaken. This was to simulate the blast impacts from open cut blasting on underground workings.

The vibration predictive model used here was previously developed following blasting in the East Rail Pit in 2005/06 (Terrock, 2006). The parameters summarising the site law analysis (governing ground vibration behaviour) are specified as follows:

$$\mathbf{V} = \mathbf{842}\left(\frac{D}{\sqrt{m}}\right)^{-1.6}$$

Where:

Where:	**V**	=	Peak Particle Velocity (mm/s)
	a	=	-1.6 (site exponent)
	k	=	842 (site constant)
	D	=	distance (m)
	m	=	charge mass (kg)

The impact of vibrations on the IUM workings was simulated using a contour line assessment technique. The modelling provides an indication in regards to the potential blast impacts on the underground workings.

The contour lines represent the extreme cases, that is, initiation of the specific charge mass, for the three bench heights considered, from the edge of the pit shell in each case. In this instance, each contour is drawn from the edge of the proposed final pit shell. The vibration modelling analysis is presented as a series of contour lines overlying the IUM workings. To take into account various possibilities, modelling of three benches was undertaken and included 4, 16 and 26 metre benches. The modelling also takes into account the application of two blasting products for dry and wet conditions (use of ANFO and Heavy ANFO respectively), which impact directly on the MIC level and therefore on vibration levels. A total of six different options have been considered. Note that up to 11 contours of interest were drawn, ranging from 0.1 to 27 mm/s using a 229 mm hole diameter.

4.1.1 Modelling Results - the Impact of Ground Vibrations for a 4-m Bench

*Small size benches – 4 metres, see **Figures 3A** and **B**.*

Due to the low charge mass (limited by bench height) the impact is classified as low/negligible. The modelling showed limited vibration exposure, generally less than 2 mm/s using ANFO product and less than 3 mm/s for Heavy ANFO product. This is considering exposure for the entire underground workings.

Based on the obtained vibration estimates, the vibration exposure for small bench sizes should be of no major concern from either a damage point of view or underground personnel exposure.

4.1.2 Modelling Results - the Impact of Ground Vibrations for a 16-m Bench

*Medium size benches – 16 metres, see **Figures 4A** and **B**.*

The vibration exposure for ANFO product revealed vibration levels of 12 mm/s or less for the area directly underneath the RERR pit boundary. The maximum vibration exposure for Heavy ANFO product revealed a vibration exposure no higher than 17 mm/s. This is including certain sections of the main headings and long-wall areas.

The modelling revealed that there is a high variability in potential vibration exposure for various sections of the mine, and it is very much dependent upon the distance between the blasting area and the actual section of underground mine.

Based on the obtained vibration estimates, the vibration exposure for medium bench sizes should theoretically be of no major concern from a damage point of view. The modelling revealed that certain sections of the underground mine could be exposed to vibration levels in excess of 10 mm/s. Therefore, this will require the implementation of a personnel withdrawal protocol. The BMP will need to be updated accordingly in consultation with IUM. This will facilitate the requirement that underground personnel are not exposed to vibration levels in excess of 10 mm/s.

4.1.3 Modelling Results - the Impact of Ground Vibrations for a 26-m Bench

*Large size benches – 26 metres, see **Figures 5A** and **B**.*

The vibration exposure for ANFO product revealed vibration levels of 19 mm/s or less for the area directly underneath the RERR pit boundary. The maximum vibration exposure for Heavy ANFO product revealed a vibration exposure no higher than 27 mm/s. This is including certain sections of the main headings and long-wall areas.

Based on the obtained vibration estimates, the vibration exposure for large bench sizes should theoretically be of no major concern from a damage point of view (that is, providing that the previously established safe vibration limit of 250 mm/s is applicable). The modelling revealed that certain sections of the underground mine could be exposed to vibration levels in excess of 10 mm/s. Therefore, this will require the establishment and implementation of a personnel withdrawal protocol. The BMP will need to be updated accordingly in consultation with IUM.

It should be acknowledged that the level of vibrations will vary greatly for underground points due to variations in distances. It is stressed that the above simulation is undertaken from the edge of the proposed pit shell. Note that blasting, for example 50 metres from the edge of the pit shell, will cause a shift in the vibration exposure pattern as overlying contour lines will be shifted 50 metres away from the edge of the pit shell.

4.2 Vibration Modelling for Integra Surface Facilities

The surface infrastructures of IUM have been identified and include standard surface facilities such as ventilation fan, office buildings, etc. It has been established that all of these facilities are located a substantial distance from the proposed RERR pit, see **Table 2.**

To assess the potential blast impacts vibration modelling was undertaken. This involved vibration estimations using the appropriate formula for surface conditions developed earlier in this report, i.e.

$$\mathbf{V} = \mathbf{2694}\left(\frac{D}{\sqrt{m}}\right)^{-1.6}$$

Where:

V	=	Peak Particle Velocity (mm/s)
a	=	-1.6 (site exponent)
k	=	2694 (site constant)
D	=	distance (m)
m	=	charge mass (kg)

The results of the vibration modelling revealed extremely low levels of vibration exposure in the order of 0.1 – 1.9 mm/s, which is considered negligible and provides no risk to Integra surface infrastructure facilities.

Table 2: Results of Ground Vibration Modelling for Integra Surface Facilities – Maximum Vibration Estimates

Infrastructure	Min. Distance (m)	Direction from RERR	Estimated Max Ground Vibration (mm/s)					
			4-m Bench		16-m Bench		26 m Bench	
			ANFO 26 kg	Heavy ANFO 39 kg	ANFO 311 kg	Heavy ANFO 466 kg	ANFO 549 kg	Heavy ANFO 824 kg
Conveyor Belt	5,610	SE	< 0.1	0.1	0.3	0.4	0.4	0.6
Power Station	4,680	SE	< 0.1	0.1	0.4	0.5	0.6	0.8
Integra Surface Facilities	5,275	SE	< 0.1	0.1	0.3	0.4	0.5	0.6
Integra Ventilation Fan	2,710	SE	0.1	0.2	0.9	1.2	1.3	1.9

Figure 3A – Ground Vibration Contours for a 4 metre bench and MIC of 26 kg

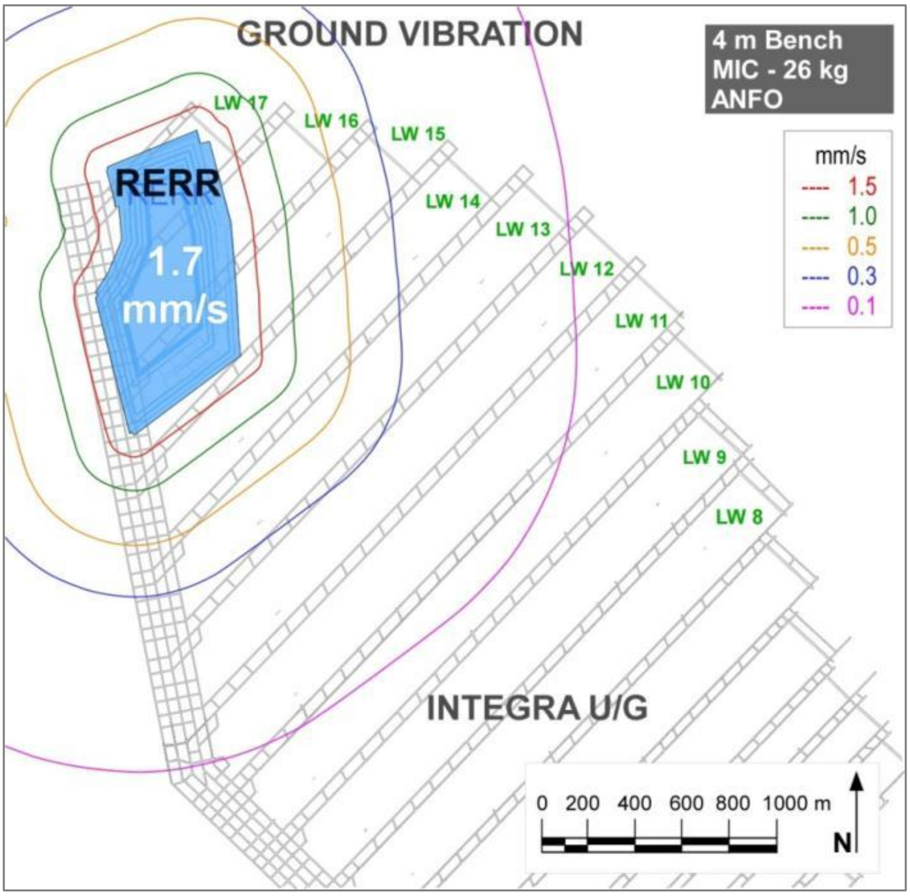


Figure 3B – Ground Vibration Contours for a 4 metre bench and MIC of 39 kg

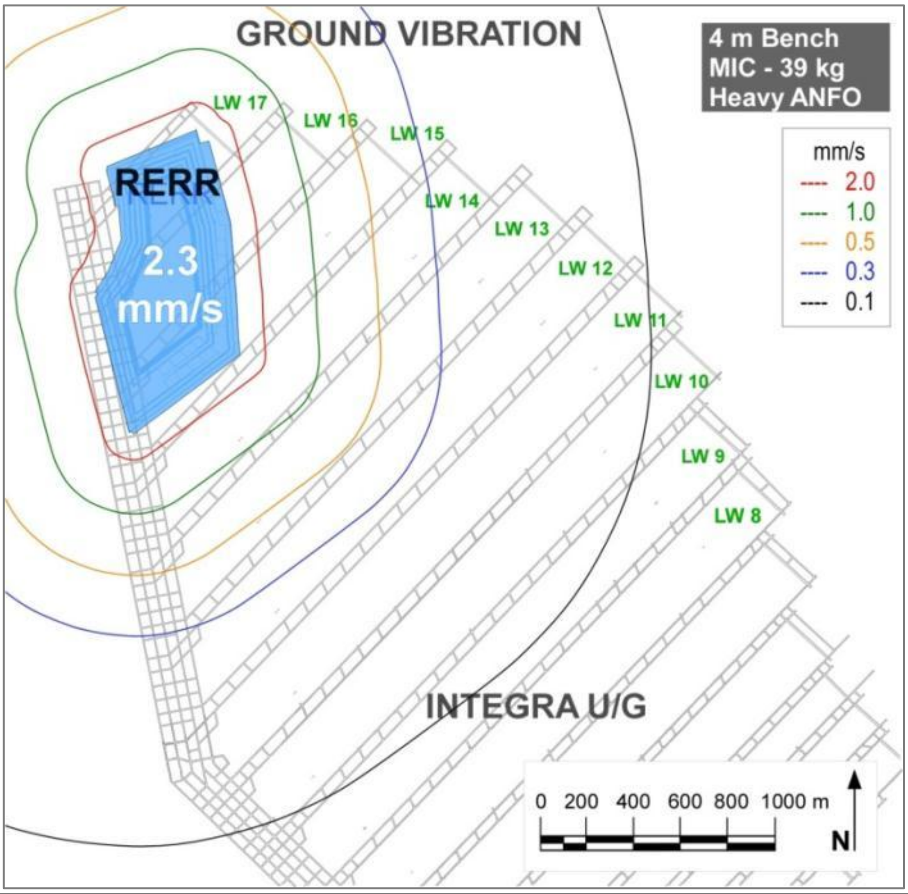


Figure 4A – Ground Vibration Contours for a 16 metre bench and MIC of 311 kg

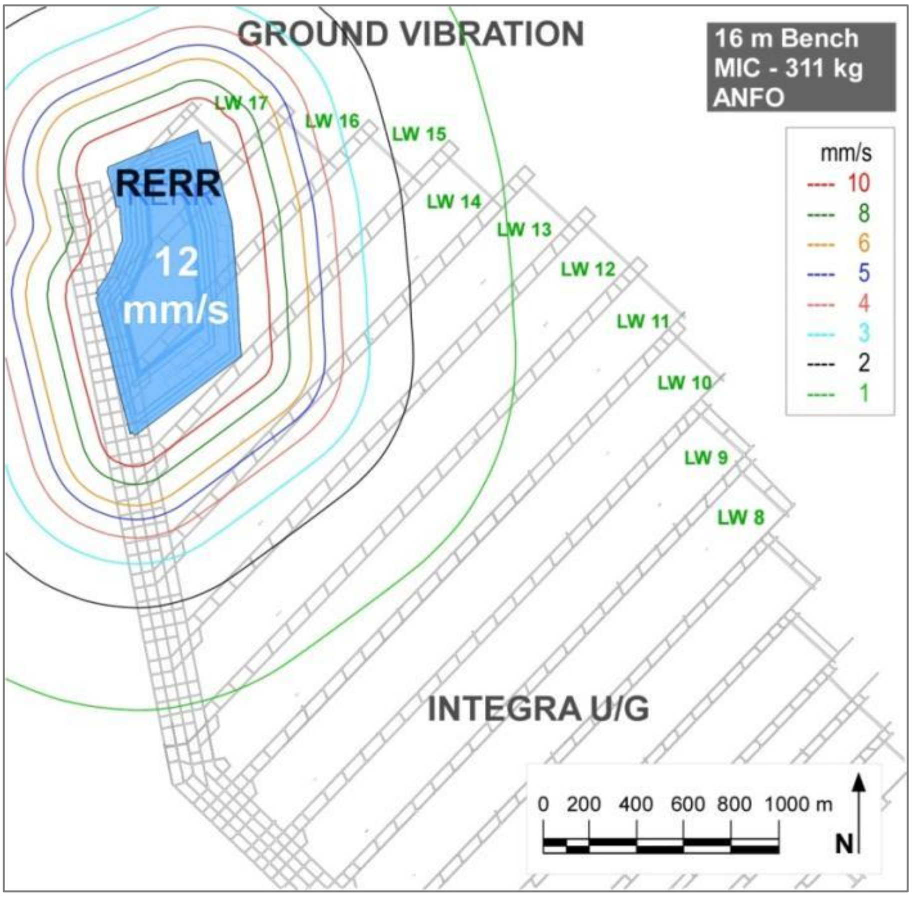


Figure 4B – Ground Vibration Contours for a 16 metre bench and MIC of 466 kg

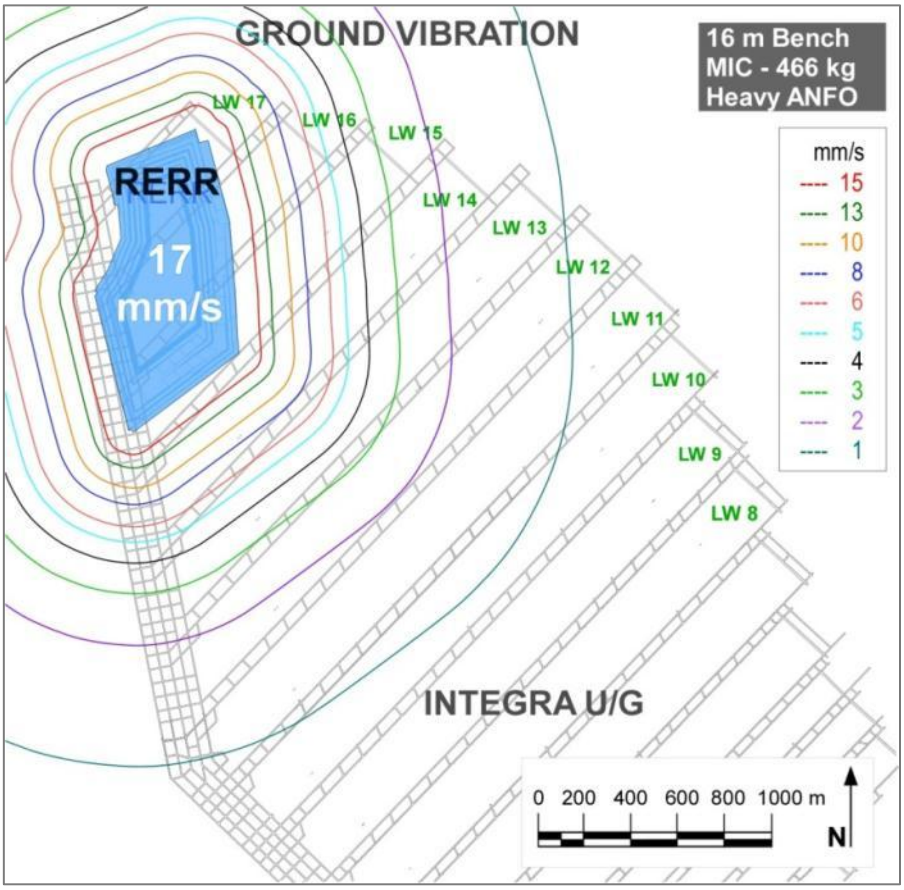


Figure 5A – Ground Vibration Contours for a 26 metre bench and MIC of 549 kg

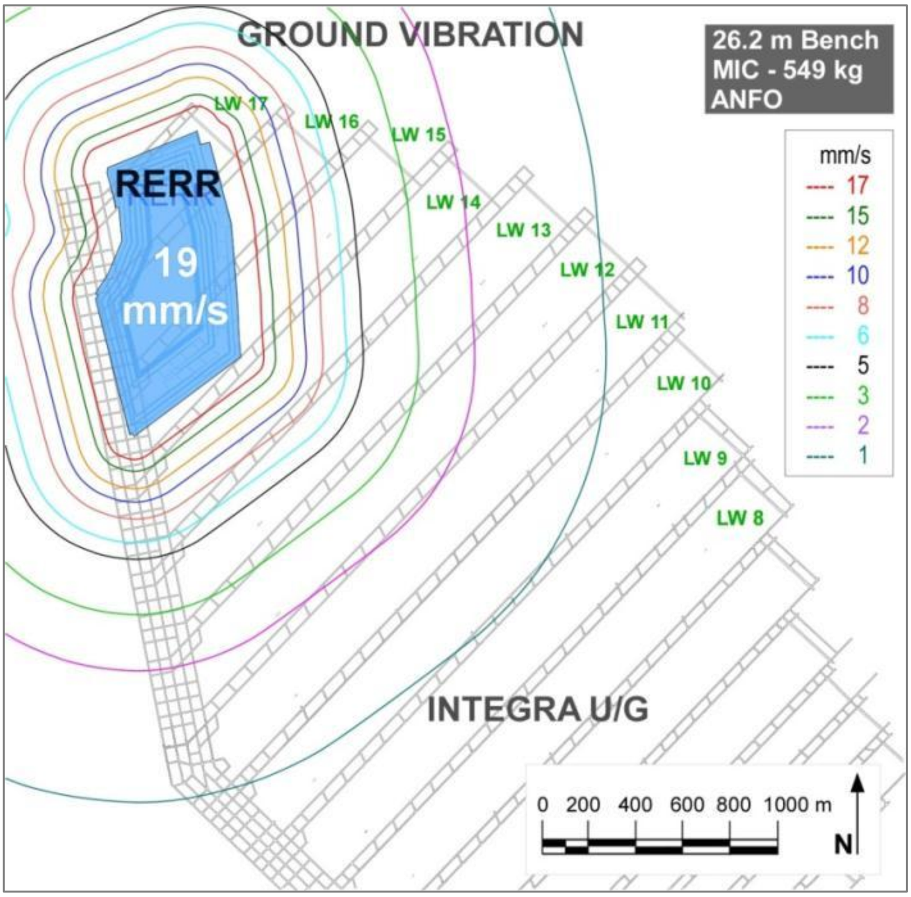
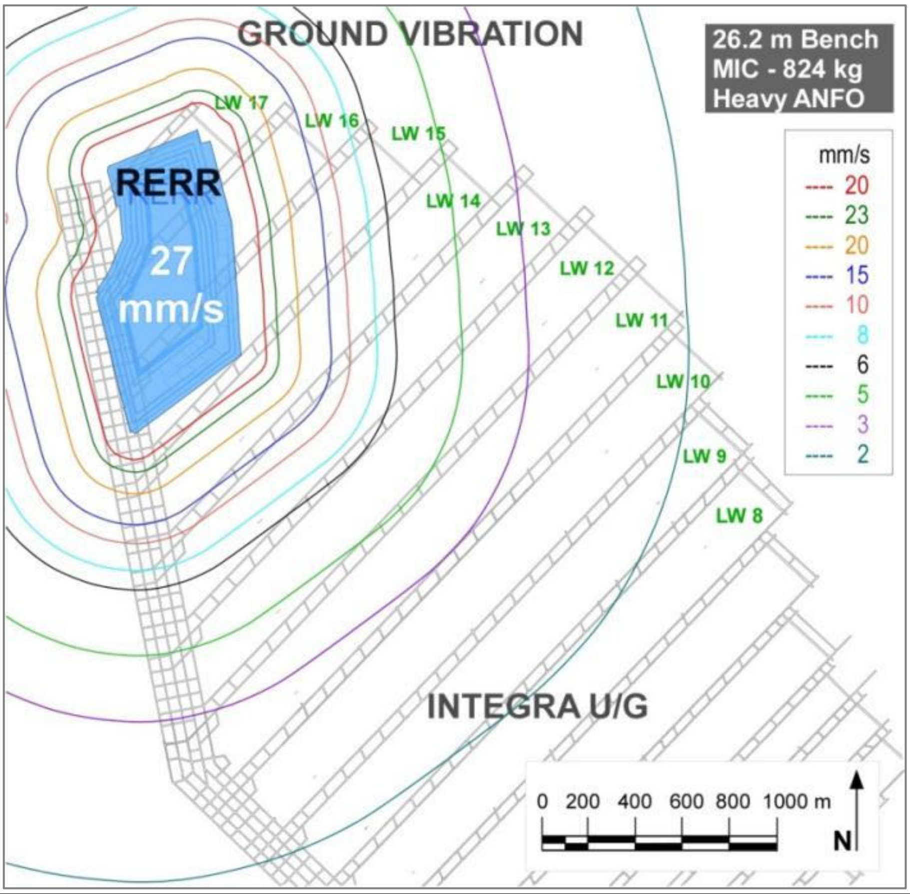


Figure 5B – Ground Vibration Contours for a 26 metre bench and MIC of 824 kg



5. CONCLUSIONS AND RECOMMENDATIONS

Part C of this report presents the results of the blast impact study of the proposed modification on the adjacent IUM. The study has been supported by a review of the previous work undertaken in 2005/06 between the Mt Owen Complex and IUM, an overview of relevant vibration limits, proposed extraction plans, and other mines experiences with similar issues. The assessment is summarised as follows:

- The proposed RERR mining area will be comprised of an open cut pit, with blast sizes comparable to West pit (Ravensworth East). The proposed blasting benches will vary between 4 and 26 metres. IUM is located underneath the proposed workings with an estimated vertical separation of approximately 250 metres.
- Vibration modelling revealed that the 4 metre bench simulation predicted vibration levels for the underground workings of less than 3mm/s. The 16 metre bench vibration modelling indicated the maximum estimated vibration impact for IUM of less than 17 mm/s, whilst blasting with a 26 metre bench revealed vibration levels no higher than 27 mm/s. Theoretically, there should be no risk of damage related to such vibration exposure for IUM. This is based on the previously established safe vibration limit of approximately 250mm/s. This should be confirmed when blasting commences via a review of vibration limits for IUM conditions.
- The vibration modelling for IUM surface infrastructure revealed low vibration exposure of no higher than 1.9 mm/s for any of the infrastructure facilities. These levels do not present any ground vibration risks for the surface infrastructure.
- The previous study revealed that the analysed underground workings can be exposed to moderate/high blast impacts. This is under the condition that a Blast Management System is introduced and successfully managed. The main issue that will require management will be in relation to vibration exposure for personnel. Also, it is imperative to undertake an additional assessment, to confirm the proposed vibration limits, as underground mine conditions at the time of the mines development could differ from that as described in the original 2005/2006 report which applied to only part of the main headings and the first few mined longwall blocks.
- The study concluded that if blasting is undertaken in the proximity of active underground workings, then the introduction of an appropriate blast management protocol is required, one that expressly includes personnel management during blasting (using the 10 mm/s vibration limit criteria). The protocol will include blast notification, vibration predictions, and underground personnel management. A similar protocol was implemented previously between the Mt Owen Complex and IUM when blasting in the Eastern Railway Pit was undertaken in 2005/2006 and as such both parties are familiar with this particular blast management system, related risk management and the need to ensure co-operation between both parties. The study did not identify any major unmanageable risks in relation to blast impacts for IUM.

Thomas Lewandowski
22nd October 2012

REFERENCES

1. Australian Standard AS 2187.2:2006, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2)
2. Lewandowski, T., Kelly, P. and Weeks, G. 2006. "Developing a Blast Management Plan for open cut coal mine adjacent to an underground colliery". In proceeding of Fragblast 8. Rock Fragmentation by Blasting - Santiago 2006, Editec S.A., p. 375 - 382.
3. Lewandowski T., Wylie S., Merchant M., Roxburgh A., 2007. "Introducing a Uniform Blast Management System for Ground Vibration Control" 4th Int. Conference Vienna. European Federation of Explosives Engineers.
4. Terrock 2005 Report No. MOM-0501-140605 "Review of Vibration Limits for Underground Headings at Glennies Creek Colliery". Internal Report for Mt Owen.
5. Terrock 2006 Report No. MOM-0618-301106 "Assessment of the Vibration Predictive Model for Integra Underground Mine". Internal Report for Mt Owen.

Appendix 1A – Summary of Borehole Log – DH 229

INTEGRA COAL

VALE

BOREHOLE No. **DH229**

BOREHOLE SUMMARY SHEET

PROJECT AND SURVEY:

PROJECT:	Integra Underground
AREA:	INTEGRA UNDERGROUND
GEOLOGIST:	Luke Johnson
COMMENCED:	15/03/2010
COMPLETED:	4/1/2010
TOTAL DEPTH:	523.18
NORTHING:	6,410,426.04
EASTING:	321,397.44
RL:	98.96
TARGET SEAM:	Lower Hebden
PURPOSE:	Resource delineation

COAL SEAMS:

CODE	TOP	BASE	INTERVAL
BAY	155.00	158.55	3.55
PG	361.99	363.61	1.62
PG	368.88	369.83	0.95
AR	406.83	409.45	2.62
AR	411.65	413.71	2.06
UL	415.31	416.29	0.98
UML	424.84	425.45	0.61
UML	426.08	426.81	0.73
ML	442.19	444.57	2.38
LL	460.49	462.77	2.28
BR	482.22	485.34	3.12
HD	500.67	503.28	2.61
LHD	514.00	515.27	1.27

REHABILITATION:

DATE CEMENTED:	14/04/2010
DATE REHABILITATED:	17/05/2010

Appendix 1B – Summary of Borehole Log – DH 230

INTEGRA COAL

VALE

BOREHOLE No. **DH230**

BOREHOLE SUMMARY SHEET

PROJECT AND SURVEY:

PROJECT:	Integra Underground
AREA:	INTEGRA UNDERGROUND
GEOLOGIST:	Luke Johnson
COMMENCED:	29/01/2010
COMPLETED:	29/01/2010
TOTAL DEPTH:	596.25
NORTHING:	6,411,069.43
EASTING:	322,225.84
RL:	118.32
TARGET SEAM:	Lower Hebden
PURPOSE:	Resource delineation

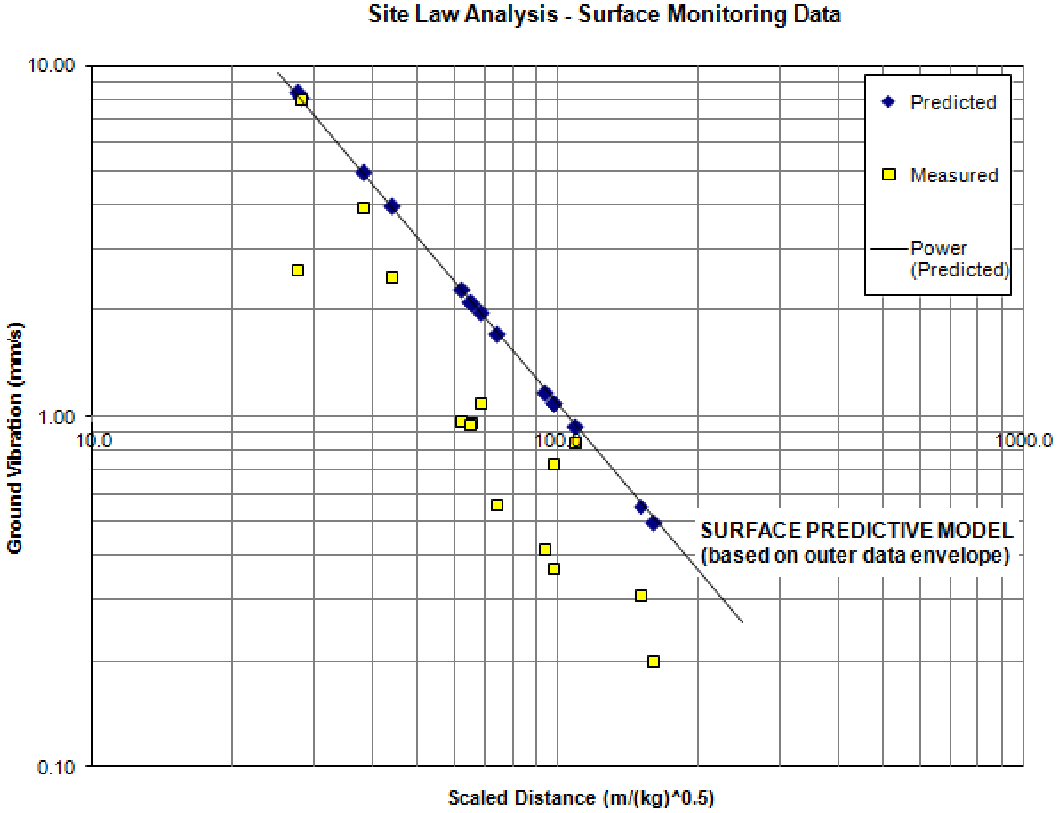
COAL SEAMS:

CODE	TOP	BASE	INTERVAL
BAY	206.45	207.60	1.15
AR	448.39	450.59	2.20
AR	459.84	461.08	1.24
UL	461.25	462.23	0.98
UML	482.23	482.66	0.43
UML	484.37	485.16	0.79
ML	498.76	501.15	2.39
LL	521.25	523.23	1.98
BR	538.39	541.12	2.73
HD	557.55	560.21	2.66
LHD	579.12	580.45	1.33

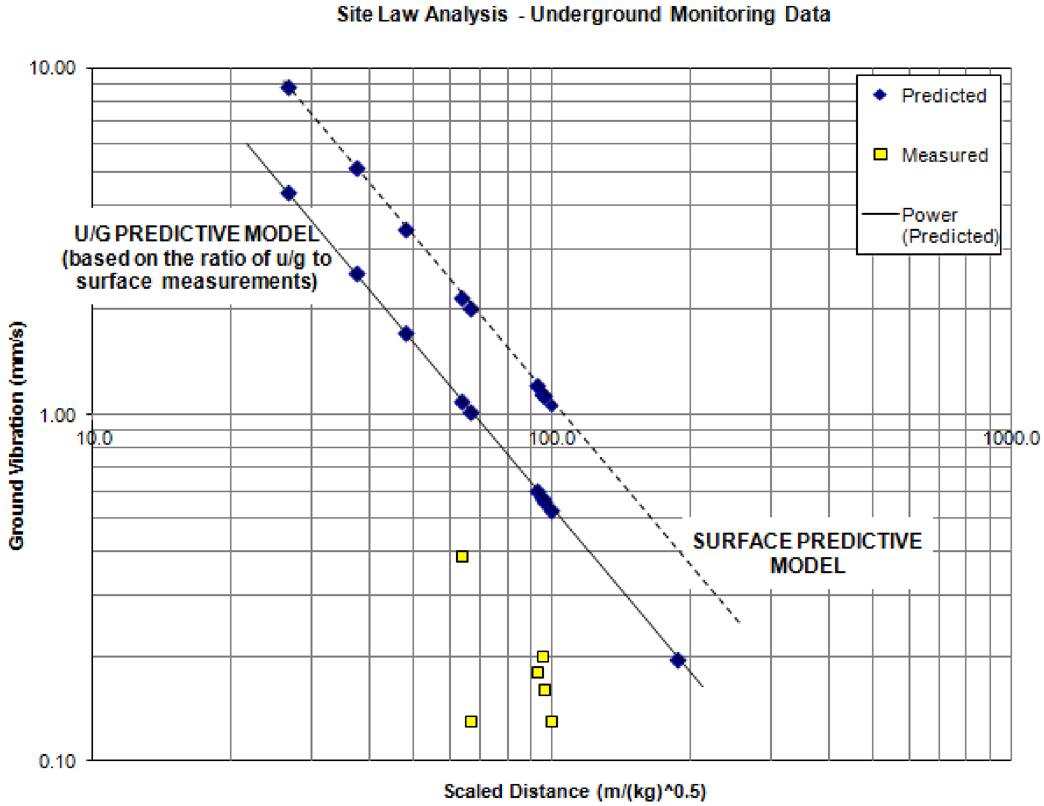
REHABILITATION:

DATE CEMENTED:	28/04/2010
DATE REHABILITATED:	17/05/2010

Appendix 2A – Site Law for Surface Conditions – Based on Past Data (after Terrock's Report 2006)



Appendix 2B – Site Law for Underground Conditions – Based on Past Data (after Terrock's Report 2006)



APPENDIX 4

Air Quality Assessment

RAVENSWORTH EAST RESOURCE RECOVERY PROJECT

AIR QUALITY IMPACT ASSESSMENT

FINAL DRAFT

Umwelt (Australia) on behalf of Xstrata Mt Owen (XMO)

Job No: 6486

11 December 2012

A PEL Company

PROJECT TITLE:	Ravensworth East Resource Recovery Project – Air Quality Impact Assessment
JOB NUMBER:	**6486**
PREPARED FOR:	Umwelt (Australia) on behalf of Xstrata Mt Owen (XMO)
PREPARED BY:	J Barnett
DISCLAIMER & COPYRIGHT:	This report is subject to the copyright statement located at www.paeholmes.com © Queensland Environment Pty Ltd trading as PAEHolmes ABN 86 127 101 642

DOCUMENT CONTROL

VERSION	DATE	PREPARED BY	REVIEWED BY
Draft 1	16.07.12	J Barnett	J Cox
Draft 2	23.08.12	J Barnett	J Cox
Draft 3	17.09.12	J Barnett	J Cox
Final Draft	20.09.12	J Barnett	J Cox
Final Draft Revised	11.12.12	J Barnett	J Cox

PAEHolmes a Division of Queensland Environment Pty Ltd
ABN 86 127 101 642

SYDNEY:
Suite 1, Level 1, 146 Arthur Street
North Sydney NSW 2060
Ph: +61 2 9870 0900
Fax: +61 2 9870 0999

PERTH:
Level 18, Central Park Building,
152-158 St Georges Terrace, Perth WA 6000
Ph: +61 8 9288 4522
Fax: +61 8 9288 4400

BRISBANE:
Level 1, La Melba, 59 Melbourne Street
South Brisbane QLD 4101
PO Box 3306, South Brisbane QLD 4101
Ph: +61 7 3004 6400
Fax: +61 7 3844 5858

MELBOURNE:
Suite 62, 63 Turner Street
Port Melbourne VIC 3207
PO Box 23293, Docklands VIC 8012
Ph: +61 3 9681 8551
Fax: +61 3 9681 3408

ADELAIDE:
35 Edward Street, Norwood SA 5067
PO Box 1230,Littlehampton SA 5250
Ph: +61 8 8332 0960
Fax: +61 7 3844 5858

GLADSTONE:
Suite 2, 36 Herbert Street, Gladstone QLD 4680
Ph: +61 7 4972 7313
Fax: +61 7 3844 5858

Email: info@paeholmes.com

Website: www.paeholmes.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

PAEHolmes have been engaged by Umwelt on behalf of Xstrata Mt Owen (XMO) to complete the air quality impact assessment for the Ravensworth East Resource Recovery (RERR) Project (the proposed modification). The proposed modification involves the continuation of the existing mining operations at Ravensworth East Mine through recovery of coal resources from the RERR mining area, an area previously disturbed by mining formerly known as Tailings Pit 2 (TP2), directly south of Tailings Pit 1 (TP1).

Existing Environment

The Mt Owen Complex currently operates an air quality monitoring network which monitors dust deposition, TSP and PM_{10} concentration levels. These data include all emission sources in the vicinity of the proposed modification, including any contribution from existing operations at the Mt Owen Complex, other nearby mining operations and other localised activities. Sources of particulate matter in the area includes mining activities, traffic on unsealed roads, local building and construction activities, farming, and animal grazing and to a lesser extent traffic from the other local roads and other sources such as wood-burning fires.

The Mt Owen complex monitoring network consists of 28 dust deposition gauges. These are made up of 13 specifically for Mt Owen, 9 for Glendell and 3 shared gauges.

There are also five High Volume Air Samplers (HVAS), all measuring PM_{10} 24-hour average concentrations and four of these measuring Total Suspended Particulates (TSP), and five PM_{10} Tapered Element Oscillating Microbalance instruments (TEOMs).

Meteorological Data

Modelling of local meteorology was undertaken using a combination of the TAPM and CALMET models. CALMET is a meteorological pre-processor endorsed by the US EPA and recommended by the NSW Environment Protection Authority (EPA) for use in complex terrain. Output from TAPM, plus regional observational weather station data were entered into CALMET as part of this assessment. As a result, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled.

TAPM is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. This model was used to generate gridded prognostic data (3D.dat) for the CALMET modelling domain.

Impact Assessment Criteria

Predicted air quality impacts as a result of the proposed modification have been assessed following EPA's guidance document titled "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**DEC, 2005**), which specifies the assessment criteria that will be used for impact assessment. These have been applied in the assessment process following the practices used in contemporary approvals for mining projects in NSW. It also applies to the cumulative impacts resulting from the proposed modification and surrounding approved mines and non-modelled sources.

The impact assessment criteria are:

- 50 µg/m^3 for 24-hour average PM_{10} for the proposed modification and other sources (excluding natural events)
- 30 µg/m^3 for annual average PM_{10} due to the proposed modification and other sources

- 90 µg/m^3 for annual average TSP concentrations due to the proposed modification alone and other sources
- 2 g/m^2/month for annual average dust deposition (insoluble solids) due to the proposed modification considered alone
- 4 g/m^2/month for annual average predicted cumulative deposition (insoluble solids) due to the proposed modification and other sources

The assessment criteria are based on considerations of possible nuisance and health effects and provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants.

Dust deposition levels refer to the quantity of dust particles that settle out from the air as measured in grams per square metre per month (g/m^2/month) at a particular location. Dust concentration refers to airborne dust and is measured in micrograms per cubic metre (µg/m^3).

Modelling and emissions parameters

Estimates of the following have been made for the dispersion modelling which would influence the predicted impacts:

- quantity of overburden and coal removed (provided by XMO)
- length and location of haul roads (provided by XMO)
- level of dust control on haul roads (estimated to be 85% through current dust suppression activities employed at the Mt Owen Complex)
- surface silt content of haul roads taken to be 2% (measured by Carbon Base Environmental on behalf of XMO on current haul roads)
- size of exposed areas that would be impacted by wind erosion (that is, any increase in rehabilitated areas would be beneficial and tend to reduce the impacts)
- assumptions regarding production rates at nearby mines for 2016

Impact Assessment

The year 2016 was modelled as a representative worst case year with regard to potential air emission impacts, considering mine and overburden production/dumping rates, potential disturbance areas, predominant wind directions as well as proximity of proposed dust generating activities to nearest potentially affected residences.

The proposed modification mine plans were analysed and detailed emissions inventories were prepared for 2016. Details of the assessment impacts and results are contained within this report. This discussion also includes a cumulative assessment with other local mines and non-modelled (background) sources.

The dispersion modelling results for 2016 indicate that no private residences, not currently subject to acquisition rights, are predicted to experience any exceedance of the relevant annual average criteria, either due to the proposed modification alone, or cumulative impacts. Predicted maximum 24-hour average PM_{10} concentrations due to the proposed modification alone are well below 50 µg/m^3 at the nearest residences.

A Monte Carlo Simulation was carried out to investigate the probability of an exceedance occurring as a result of dust sources other than the proposed modification. This is a statistical approach that combines the frequency distributions of two data sets (in this case, monitoring data and modelled results) to create a third 'cumulative' data set and associated frequency distribution. From this analysis it was determined that the probablility of cumulative 24-hour average PM_{10} concentrations exceeding the criteria of 50 µg/m^3 is less than 3% at the nearest residences.

1 INTRODUCTION

This report has been prepared by PAEHolmes for Umwelt (Australia) on behalf of Xstrata Mt Owen (XMO). It presents the air quality assessment component for the proposed Ravensworth East Resource Recovery (RERR) Project (the proposed modification).

2 DESCRIPTION OF PROPOSED MODIFICATION

Mining operations at Ravensworth East Mine are undertaken in accordance with DA 52-03-99 which allows for the extraction of 4 million tonnes per annum (Mtpa) of ROM coal until 2020. The extraction of all approved accessible coal resources within the current West Pit at Ravensworth East Mine, is expected to be complete by quarter three 2013. The proposed modification seeks to modify DA 52-03-99 under Section 75W of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to allow XMO to continue mining within the RERR mining area. The RERR mining area is a previously disturbed mining area formerly known as Tailings Pit 2 (TP2).

More specifically the proposed modification includes:

- Relocation of the existing mining fleet and operational staff from the West Pit to the RERR mining area as the extraction of resources within the West Pit is completed;
- Overburden removal and coal extraction within the RERR mining area down to a depth of approximately 200 metres utilising the existing mining fleet and methods from the West Pit; and
- Emplacement of overburden within the West Pit overburden emplacement area to a maximum height of RL180 m, an increase of 20 metres in height from the currently approved RL160 m.

The proposed modification does not include any changes to the current approved mining method or extraction rate, employment numbers, product transportation or operating hours. No alterations or additions to the existing surface infrastructure facilities are proposed and no construction activities are required.

Analysis of the mine plans for the life of the proposed modification indicated that 2016 was a representative year of the likely worst case scenario. Factors considered included the magnitude of exposed areas, distances of haul roads, production rates and volumes of overburden material required to be moved.

The active mining and dumping areas for Year 2016 are shown in **Figure 2.1**. This figure also shows the locations of the current monitoring network.

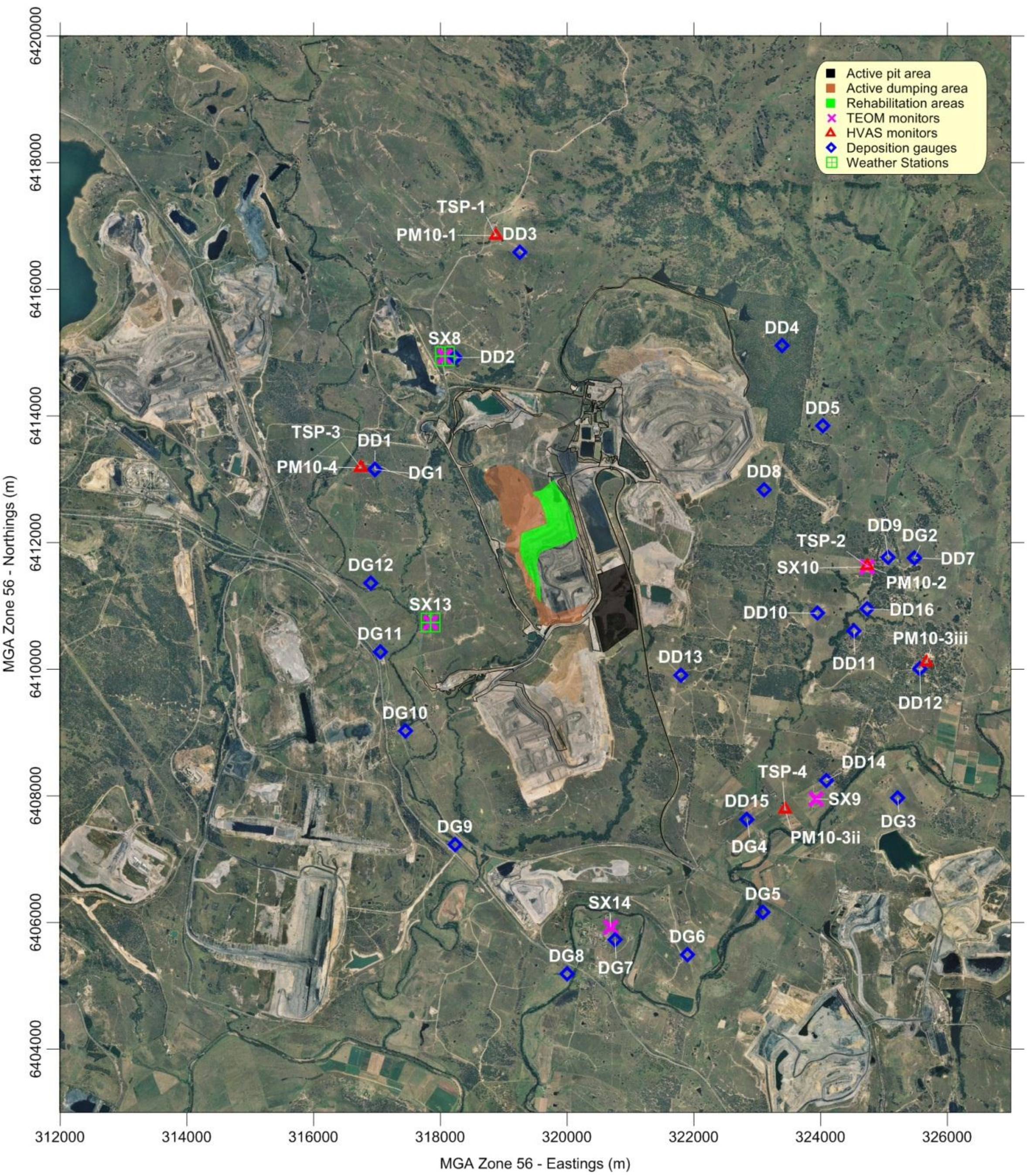


Figure 2.1: Mt Owen Complex, monitoring sites

The current landownership information showing the locations of properties and ownership details is shown in **Figure 2.2**.

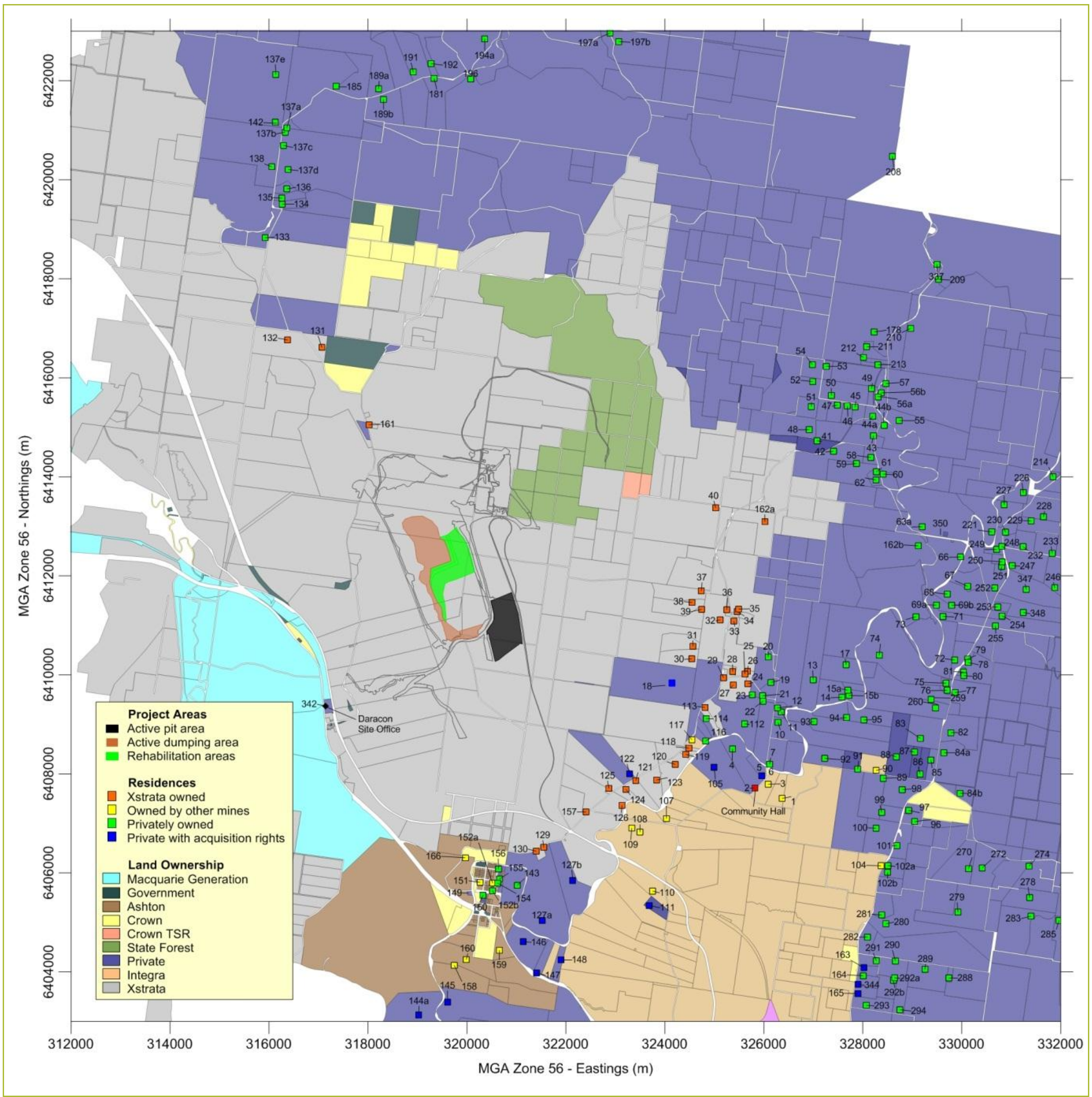


Figure 2.2: Land ownership, residence locations and ownership detail

3 AIR QUALITY CRITERIA

3.1 Introduction

Extraction of coal by open cut methods requires the clearing of land and excavation of overburden material to recover the coal by heavy earth moving equipment. These activities generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP)[a], particulate matter with equivalent aerodynamic diameters 10 µm or less (PM_{10})[b] and particles with equivalent aerodynamic diameters of 2.5 µm and less ($PM_{2.5}$).

This section provides information on the air quality criteria used to assess the predicted impacts of the proposed modification under the predicted worst case mining scenario. The assessment criteria provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants. These criteria generally reflect current Australian standards for the protection of health and protection against nuisance effects. To assist in interpreting the significance of predicted concentration and deposition levels, some background discussion on the potential harmful effects of dust is provided below.

3.2 Particulate Matter and Health

The key air quality issue for mining operations is the emission of dust and particulate matter (PM). Mining generates PM from numerous activities including excavating, handling of material, hauling by heavy vehicles, blasting and wind erosion from stockpiles and exposed surfaces. PM is formed when particulate becomes entrained in the atmosphere by the turbulent action of wind, by the mechanical disturbance of materials or through the release of particulate-rich gaseous emissions from combustion sources.

Suspended PM is defined by its size, chemical composition and source. Particle size is an important factor influencing its dispersion and transport in the atmosphere and its potential effects on human health. Typically, the size of suspended particles ranges from approximately 0.005 to 100 micrometers (µm) and is often described by the aerodynamic diameter of the particle.

The particulate size ranges are commonly described as:

- TSP – total suspended particulate matter refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm – 50 µm.
- PM_{10} –refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter (a subset of PM_{10}). Often referred to as the fine particles.
- $PM_{2.5-10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. Often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 µm, while not able to affect

[a] TSP refers to all particles suspended in air. In practice, the upper size range is typically 30 µm.

[b] PM_{10} refers to all particles with equivalent aerodynamic diameters of less than 10µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.

health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air, this is referred to as TSP. In practice particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[c] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts.

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes, such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. Mining dust is likely to be composed of predominantly coarse particulate matter (and larger).

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. This is demonstrated in **Figure 3.1** which shows the relative deposition by particle size within various regions of the respiratory tract. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air and key considerations in assessing exposure.

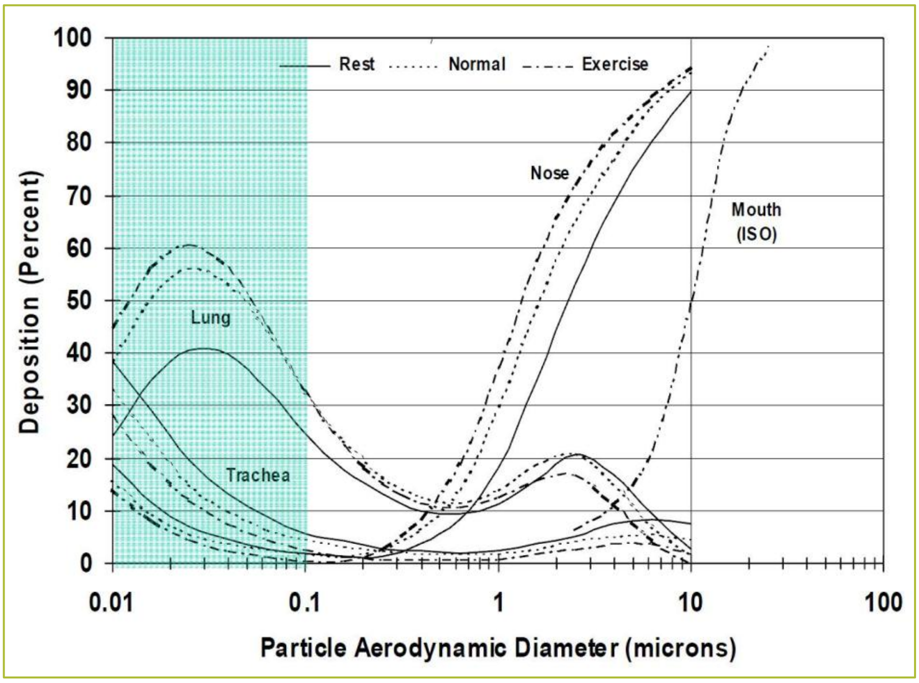


Figure 3.1: Particle Deposition within the Respiratory Tract (Source: Chow, 1996)

[c] Crustal dust refers to dust generated from materials derived from the earth's crust.

3.3 EPA Criteria

The NSW EPA *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW"* (Approved Methods) specifies air quality assessment criteria relevant for assessing impacts from air pollution (**NSW DEC, 2005**). The air quality goals relate to the total dust burden in the air and not just the dust from the proposed modification. In other words, consideration of background dust levels needs to be made when using these goals to assess potential impacts. These criteria are health-based (that is, they are set at levels to protect against health effects) and are consistent with the *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the EPA's criteria include averaging periods, which are not included in the Ambient Air-NEPM, and also references other measures of air quality, namely dust deposition and TSP.

In May 2003, the National Environment Protection Council (NEPC) released a variation to the Ambient Air National Environment Protection Measure (Air-NEPM) (**NEPC, 2003**) to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$). The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM, which is currently underway. The variation includes a protocol setting out monitoring and reporting requirements for $PM_{2.5}$ particles. It is noted that the Ambient Air-NEPM $PM_{2.5}$ advisory reporting standards are not impact assessment criteria.

Table 3.1 summarises the air quality goals for pollutants that are relevant to this study.

Table 3.1: EPA Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 μg/m^3	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 μg/m^3	24-Hour	NSW DEC (2005) (assessment criteria)
	30 μg/m^3	Annual	NSW DEC (2005) (assessment criteria)
	50 μg/m^3	24-Hour	NEPM (allows five exceedances per year)
$PM_{2.5}$	25 µg/m^3	24-Hour	NEPM Advisory Reporting Standard
	8 µg/m^3	Annual	NEPM Advisory Reporting Standard

Notes: μg/m^3 – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fallout relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 3.2**Table 3.2** shows the total and the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (**DEC, 2005**).

Table 3.2: EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level (cumulative)
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

4 EXISTING ENVIRONMENT

4.1 Existing Air Quality

4.1.1 Introduction

Air quality standards and goals refer to pollutant levels that include the contribution from specific projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals (see **Section 3**) it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which the proposed modification is likely to contribute to these levels. It is also important to note that the existing air quality conditions (that is, background conditions) will be influenced to some degree by the existing mining operations and other sources.

Dust deposition and dust concentration (TSP and PM_{10}) are monitored in the vicinity of the Ravensworth East Mine as part of the Mt Owen Complex monitoring program. The locations of the monitoring sites are shown in **Figure 2.1**. Airbourne dust concentrations can be measured either intermittently or continuously, and both methods have been used in the area of the Mt Owen Complex. A network of High Volume Air Samplers (HVAS) measures both TSP and PM_{10} 24-hour average concentrations on a six day cycle, while five Tapered Element Oscillating Microbalance instruments (TEOMs) continuously measure PM_{10} concentrations. The Mt Owen Complex has a total of 25 dust deposition gauges which measuring the monthly average of deposited dust. The following sections discuss the TSP, PM_{10} and dust deposition monitoring results.

4.1.2 Dust Concentration

The current monitoring results include emission sources in the vicinity of the proposed modification, including any contribution from surrounding mines and localised activities. Sources of particulate matter in the vicinity of the proposed modification include mining activities, traffic on unsealed roads, local building and construction activities, farming, and animal grazing and to a lesser extent traffic from the other local roads and other sources such as wood-burning fires.

A summary of the annual average PM_{10} concentration from 2002 to 2011 is shown in **Table 4.1**. **Figure 4.1** shows the past four years of monitoring data in more detail, while the 24-hour average and rolling annual average PM_{10} concentration is shown in **Figure 4.2**.

Table 4.1: Annual average PM_{10} conentrations measured at each site (µg/m^3)

	PM_{10}-1[a]	PM_{10}-2 [a]	PM_{10}-3iii[b]	PM_{10}-4	PM_{10}-3ii	TEOM1 SX8	TEOM2 SX9	TEOM3 SX10	TEOM4 SX13	TEOM5 SX14
Criterion	***30***	***30***	***30***	***30***	***30***	***30***	***30***	***30***	***30***	***30***
2002	-	-	-	26	**31**	-	-	-	-	-
2003	-	-	-	25	**38**	-	-	-	-	-
2004	16	18	-	23	**36**	-	-	-	-	-
2005	21	19	-	25	30	-	-	-	-	-
2006	17	19	20	22	27[c]	-	-	-	-	-
2007	21	25	24	25	24	-	-	-	-	-
2008	24	26	25	25	22	-	-	-	-	-
2009	28	29	22	28	27	-	-	-	25	30
2010	22	24	21	22	20	-	-	-	18	23
2011	20	25	20	26	21	18[d]	22[d]	20[d]	18	20

[a] *Monitoring commenced May 2004*
[b] *Monitoring commenced May 2006*
[c] *No monitoring data for the period of April 2006 to August 2006*
[d] *No monitoring data available prior to July 2011*

From **Table 4.1** it can be seen that the majority of the annual average PM_{10} concentrations for each monitoring station were below the EPA criteria of 30 µg/m^3. There were three exceptions to this at PM_{10}-3ii. In 2002, 2003 and 2004 the annual average PM_{10} concentration at monitor PM_{10}-3ii was 31 µg/m^3, 38 µg/m^3 and 36 µg/m^3, respectively. The cause of the high PM_{10} concentrations at monitor PM_{10}-3ii in 2002, 2003 and 2004 is difficult to determine due to only two HVAS being in operation at the time. Given that monitor PM_{10}-3ii is downwind of the dominant wind directions (see **Figure 4.3**), it likely that Mt Owen Complex wide operations contributed to the measured PM_{10} concentrations at that location. However, levels have generally declined in recent years across the network.

These monitoring data are also plotted in **Figure 4.1** and **Figure 4.2** and show a seasonal trend in the 24-hour average PM_{10} concentrations at all PM_{10} monitoring locations. In general, the highest PM_{10} concentrations are experienced during summer and the lowest during winter. The measured 24-hour average PM_{10} concentrations have been above the 50 µg/m^3 criterion on a number of occasions at all sites, particularly in the later part of 2009 when there was a severe and widespread dust storm across eastern Australia and a number of bushfires in NSW.

A summary of the annual average TSP monitoring results for each of the four TSP HVAS monitors are presented in **Table 4.2**. The annual average TSP concentrations have remained below the EPA criterion of 90 µg/m^3 for all years, except at monitor TSP-3 in 2009. The highest TSP concentration at monitor TSP-3 in 2009 was 265 µg/m^3 on 8 December. Concentrations at all four TSP monitors were above the EPA criterion on this day. This day corresponds with severe weather conditions experienced in the Hunter region, for example, dust storms and bushfires as discussed above.

Table 4.2: Annual average TSP concentrations at HVAS sites - µg/m^3

	TSP/1	TSP/2[a]	TSP/3[b]	TSP/4[c]
Criterion	***90***	***90***	***90***	***90***
2002	79	-	-	-
2003	70	-	28	-
2004	47	50	64	-
2005	50	45	60	-
2006	50	50	69	66
2007	64	69	79	64
2008	63	76	70	63
2009	80	84	**98**	73
2010	62	79	84	63
2011	62	71	82	65

*NOTE: Exceedances of the Air Quality criterion shown in **bold**.*
[a] Monitoring commenced May 2004
[b] Monitoring commenced December 2003
[c] Monitoring commenced October 2006

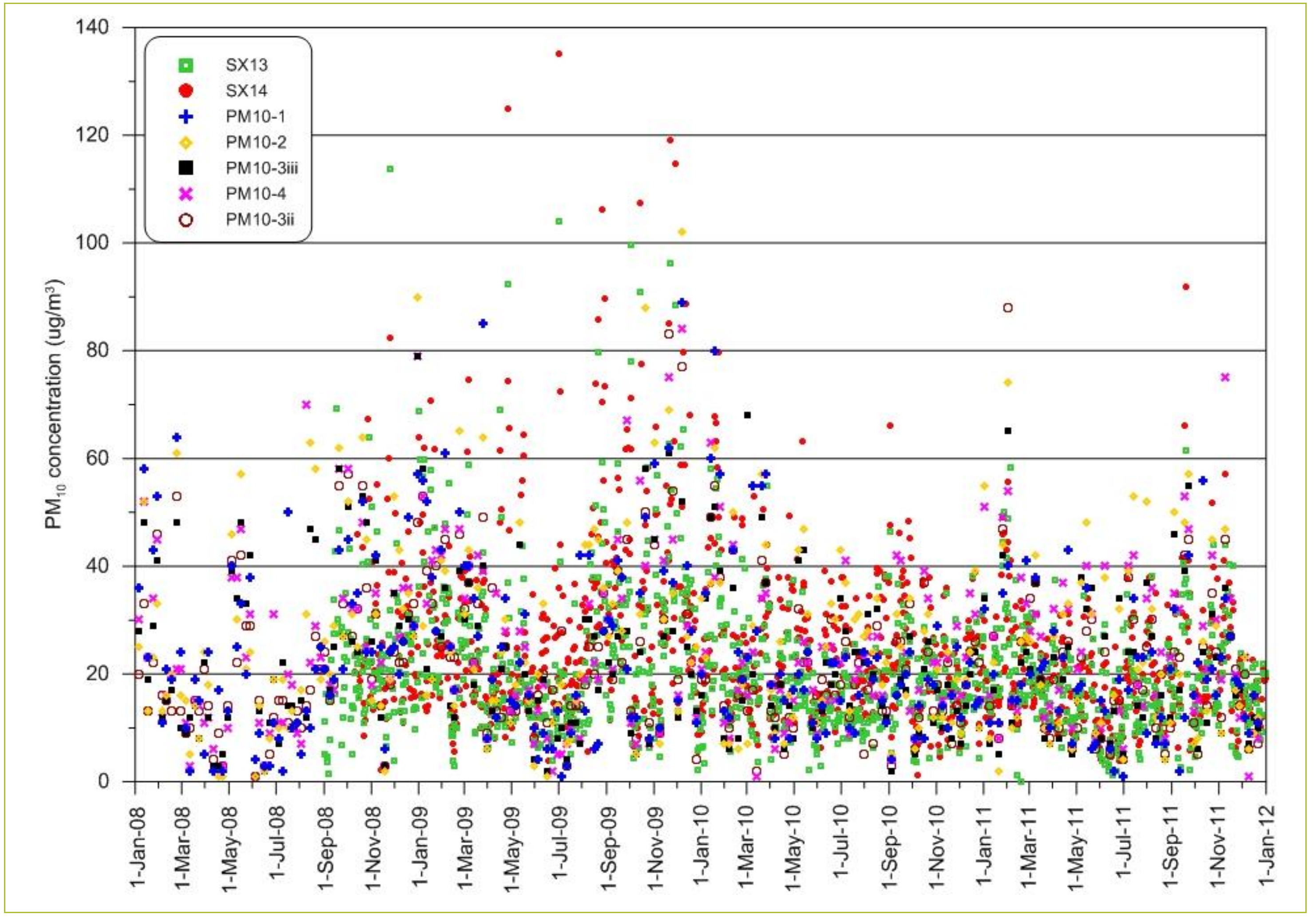


Figure 4.1: 24-hour average PM_{10} monitoring data for 2008 – 2011

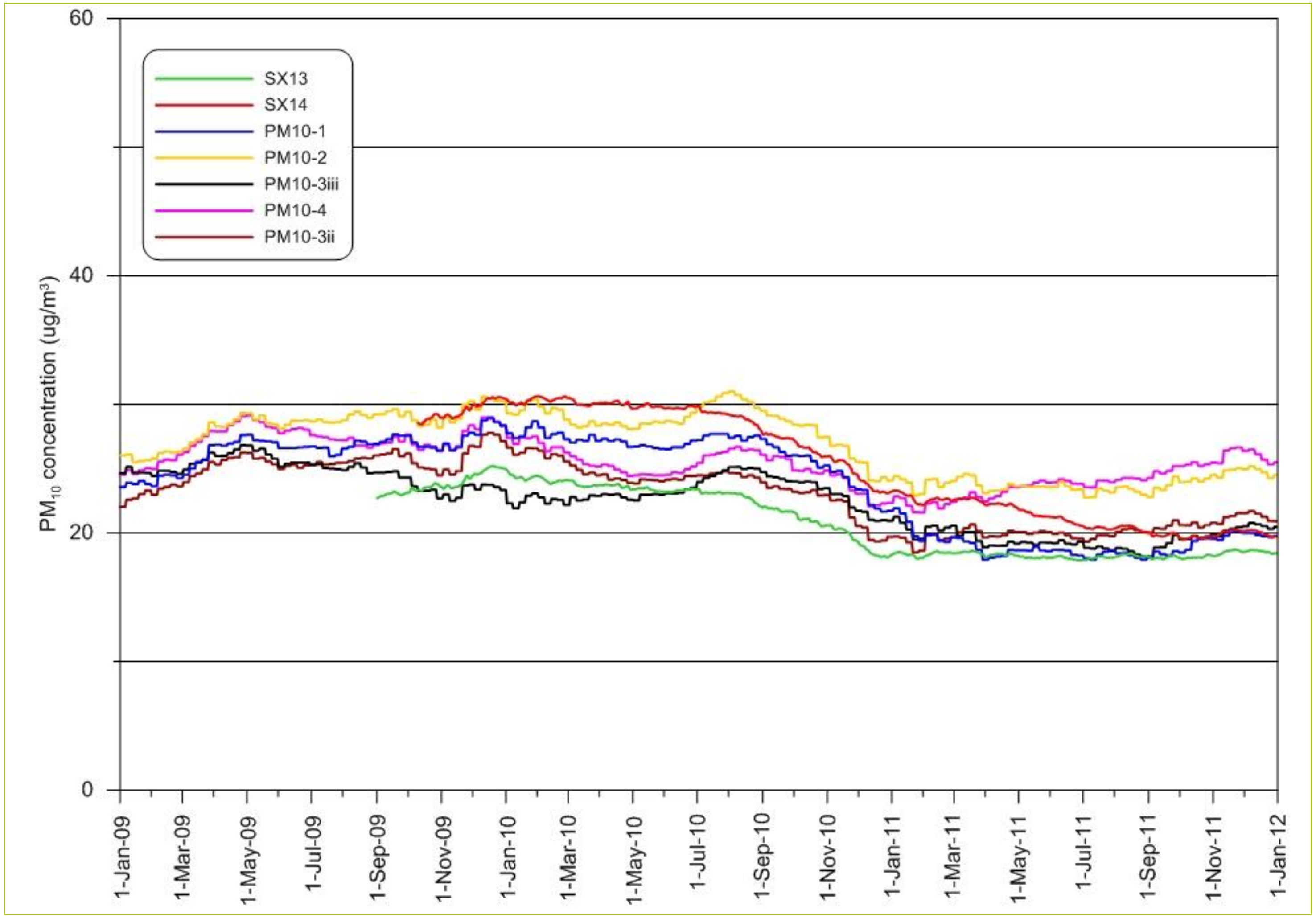


Figure 4.2: Running annual average PM_{10} values

4.1.3 Dust Deposition

Figure 2.1 shows the locations of the 25 dust deposition gauges analysed in this assessment. The annual averages (excluding contaminated data[d]) are summarised in **Table 4.3**.

Since 2004, all dust gauges with the exception of DD2, DD5, DD8 and DD11 have recorded annual average deposition levels lower than the EPA annual average assessment criterion of 4 g/m^2/month for insoluble solids. These observations also include the effects of existing operations from other mines in the surrounding area as well as all other sources of particulate matter (for example, traffic, and emissions from industrial and domestic activities).

As shown in **Figure 2.1**, DD8 is very close to Mt Owen operations, and levels have been increasing in recent years as mining progresses towards that monitoring location. This location, as well as DD11, lies along the northwest-southeast axis of predominant wind directions in the area. DD2 and DD5 also lie close to existing mining operations.

[d] Contaminated data include those samples which had an excessive amount of bird droppings (for example) or had been vandalised or were in some other way unable to be accurately measured.

Table 4.3: Annual average Dust deposition data (insoluble solids) – 2004 to 2011 ($g/m^2/month$)

	2004	2005	2006	2007	2009	2010	2011	Average
Criterion = 4 $g/m^2/month$								
DD1/DG1	2.2	1.8	1.8	1.5	1.6	2.7	3.1	2.2
DD2	**6.1**	**5.5**	3.6	3.7	**4.5**	3.6	3.0	**4.1**
DD3	3.5	2.4	3.1	2.6	3.7	3.3	3.9	3.2
DD4	3.3	2.3	2.4	2.0	1.8	3.2	2.8	2.5
DD5	3.4	**4.5**	3.0	1.8	1.9	3.1	2.7	2.9
DD6	3.3	0.9	1.8	1.6	1.3	1.5	1.2	1.6
DD7/DG2	1.0	1.5	1.6	1.6	1.8	2.8	2.3	1.9
DD8	**4.8**	**4.1**	3.7	3.3	**6.2**	**5.7**	**7.0**	**5.3**
DD9	3.8	2.5	2.6	2.5	2.5	3.7	3.9	3.1
DD10	-	-	-	2.6	2.3	2.0	2.9	2.4
DD11	**5.6**	**4.3**	2.8	2.5	3.0	3.3	**4.3**	3.6
DD12	2.0	2.3	2.1	1.8	1.9	2.6	2.7	2.2
DD13	1.7	1.7	2.7	2.5	2.3	3.1	2.9	2.5
DD14	-	-	-	1.1	1.5	2.1	1.5	1.5
DD15/DG4	2.0	2.1	2.1	1.9	2.6	2.9	2.8	2.6
DD16	-	-	2.0	1.9	1.6	2.2	1.8	1.9
DG3	-	-	-	1.1	1.5	-	2.0	2.0
DG5	-	-	-	3.0	2.9	-	2.5	2.8
DG6	-	-	-	2.6	2.6	-	3.2	2.8
DG7	-	-	-	2.0	2.2	-	2.3	2.1
DG8	-	-	-	2.5	2.7	-	3.0	2.8
DG9	-	-	-	2.8	3.8	-	2.5	3.1
DG10	-	-	-	2.8	3.2	-	3.5	3.2
DG11	-	-	-	1.9	2.4	-	3.7	2.7
DG12	-	-	-	2.5	2.2	-	3.7	2.8

Note: bold indicates exceedances above EPA annual average assessment criterion

4.2 Meteorology

4.2.1 Wind speed and direction

Seasonal and annual windroses from the SX13 weather station for 2010 are presented in **Figure** 4.3. The location of the SX13 and SX8 weather stations are shown in **Figure 2.1**. The data available for the SX8 site are limited and are therefore not presented in this section. However, the data that are available from the SX8 site have been used in the CALMET model (described in **Section 5.2.2**).

On an annual basis, winds are predominantly from the north-northwest, northwest, southeast and south-southeast directions. Spring and autumn also reflect this pattern. The predominant wind direction in summer is from the south-southeast and southeast while winter shows more prominent winds from the northwest and north-northwest. On an annual basis the percentage of calms is 3.3%.

4.2.2 Local Climatic Conditions

The nearest Bureau of Meteorology (BoM) site to collect climatic information in the vicinity of the proposed modification is Jerry's Plains. A range of climatic information collected from Jerry's Plains (Post Office), located approximately 19 km from the Ravensworth East Mine, are presented in **Table 4.4** (**BoM, 2012**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced at Jerrys Plains are 25.2°C and 10.6°C respectively. On average January is the hottest month, with an average maximum temperature of 31.7°C. July is the coldest month, with average minimum temperature of 3.8°C.

The annual average relative humidity reading collected at 9 am from the Jerry's Plains site is 70% and at 3 pm the annual average is 47%. The month with the highest relative humidity on average is June with a 9 am average of 80%. The months with the lowest relative humidity are October, November and December with a 3 pm average of 42%.

Rainfall data collected at Jerry's Plains shows that January is the wettest month, with an average rainfall of 76.7 mm over 7.9 rain days. The average annual rainfall is 645 mm with an average of 87.2 rain days.

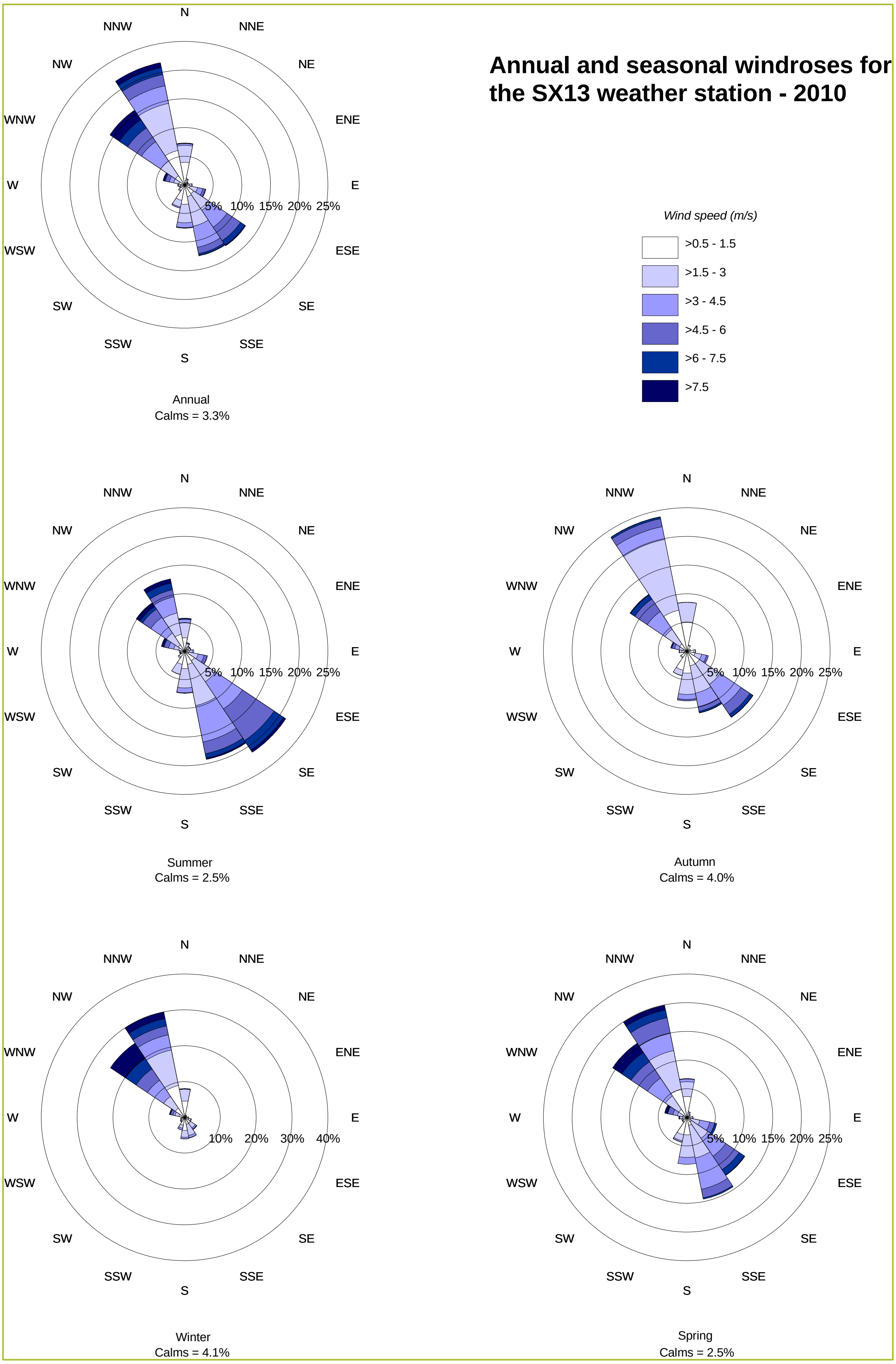


Figure 4.3: Wind Roses for SX13 weather station, 2010

Table 4.4: Climate Information for Jerry's Plains

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean maximum temperature (°C)	31.7	30.9	28.9	25.3	21.3	18	17.4	19.4	22.9	26.2	29.1	31.3	25.2
Mean minimum temperature (°C)	17.1	17.1	15	11	7.5	5.3	3.8	4.4	7	10.3	13.2	15.7	10.6
Mean rainfall (mm)	76.7	72.8	58.4	44.5	40.9	48.1	43.5	36.5	42	52.2	61.1	67.9	645
Mean number of days of rain	7.9	7.5	7.4	6.4	6.6	7.7	7.1	7	6.6	7.6	7.7	7.7	87.2
Mean 9am temperature (°C)	23.4	22.7	21.2	18	13.6	10.6	9.4	11.4	15.3	19	21.1	23	17.4
Mean 9am wet bulb temperature (°C)	19.3	19.3	17.9	15	11.6	9	7.7	9	11.9	14.5	16.3	18.1	14.1
Mean 9am relative humidity (%)	67	72	72	72	77	80	78	71	65	59	60	61	70
Mean 3pm temperature (°C)	29.8	28.9	27.2	24.1	20.1	17.1	16.4	18.2	21.2	24.2	26.9	29	23.6
Mean 3pm wet bulb temperature (°C)	21.1	21.1	19.6	17.1	14.6	12.2	11.2	12.1	14.1	16.2	18	19.7	16.4
Mean 3pm relative humidity (%)	47	50	49	49	52	54	51	45	43	42	42	42	47

Source: BOM (2012)

Climate averages for Station: 061086; Commenced: 1884, Last record: 2012; Latitude: 32.50 °S; Longitude: 150.91 °E, elevation 90m.

5 MODELLING APPROACH

The assessment follows a conventional approach commonly used for air quality assessment in Australia and outlined in the Approved Methods (**DEC, 2005**).

5.1 Modelling System

The CALMET/CALPUFF modelling system was chosen for this study. CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the 3-dimensional (3D) meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region. CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al.*, 2000**). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff, and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

In March 2011 the EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (**TRC, 2011**). The model set up for this study has been conducted in consideration of these guidelines.

5.2 Model Set Up

5.2.1 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided in other documentation. The Technical Paper by **Hurley (2005)** describes technical details of the model equations, parameterisations, and numerical methods. A summary of some verification studies using TAPM is also given in **Hurley *et al.* (2005)**.

TAPM utilises fundamental fluid dynamics and scalar transport equations to predict meteorology and (optionally) pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analysis.

For the proposed modification, TAPM was set up with 4 domains, composed of 25 grids along both the x and the y axes, centred on -32°25′ Latitude and 151°6′ Longitude (approximately 321.270 km Easting, 6415.410 km Northing (UTM Zone 56 S)). Each nested domain had a grid resolution of 30 km, 10 km, 3 km and 1 km respectively.

TAPM was used to generate gridded prognostic data (3D.dat) for the CALMET modelling domain.

5.2.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model.

CALMET was run with an outer domain covering a 50 km x 50 km area, with the origin (SW corner) at 297 km Easting and 6389 km Northing (UTM Zone 56 S). This consisted of 50 x 50 grid points, with a 1 km resolution along both the x and y axes.

Observed hourly surface wind speed, wind direction, temperature and relative humidity data from the two weather stations at the Mt Owen Complex (SX8 and SX13) were used as input for CALMET. The nearest cloud amount and cloud height data were sourced from observations at the Williamtown RAAF station and sea level pressure were sourced from the Burea of Meteorology (BoM) Cessnock Airport Automatic Weather Station (AWS).

Together, the surface and three-dimensional data file generated by TAPM were used as input to CALMET to create a coarse resolution three-dimensional meteorological field for the region.

Four inner grids were run to take into account the change in terrain as mining operations progress. The outer grid was incorporated into the runs for the inner grids to provide finer resolution closer to the site. The origin for the inner domain was 312 km Easting and 6403 km Northing (UTM Zone 56 S). This consisted of 100 x 100 grid points, with a 0.2 km resolution along both the x and y axes. Land use for the domain was determined from aerial photography.

Terrain for this area was derived from 90 m DEM data sourced from NASA. These data were used in conjunction with more detailed terrain for the proposed modification in 2016 and for the currently approved Mt Owen and Glendell pits in the years that most closely represent operations in 2016.

Observed data used as input for CALMET was the same as for the outer grid. Upper air data were also extracted from TAPM to provide the necessary upper air files. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to generate a fine resolution three-dimensional wind field for the region. A fine resolution three-dimensional wind field was then generated to represent 2016.

5.2.2.1 Atmospheric Stability

An important aspect of plume dispersion is the level of turbulence in the atmosphere near the ground. Turbulence acts to dilute or diffuse a plume by increasing the cross-sectional area of the plume due to random motion. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits diffusion and is a critical factor in causing high plume concentrations downwind of a source. Turbulence is related to the vertical temperature gradient, the condition of which determines what is known as stability, or thermal stability. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe the dispersion conditions in the atmosphere.

The best known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, such as those that commonly occur under clear skies at night and in the early morning, especially during the cooler months. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are closely associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

The CALMET-generated meteorological data can be used to extract stability class for the site and the frequency distribution of estimated stability classes is presented in **Figure 5.1**. The data show a large proportion of class F conditions (~35% of hours), and a total of 47.9% of hours with either E or F class. It is noted that a turbulence based scheme within CALPUFF was used in the modelling and the P-G stability class frequency is shown for information only. The use of turbulence based dispersion coefficients is recommended (**TRC, 2010**) and the US EPA has replaced P-G-based dispersion with a turbulence-based approach in their regulatory model (AERMOD) and is in accordance with best science practice and model evaluation studies.

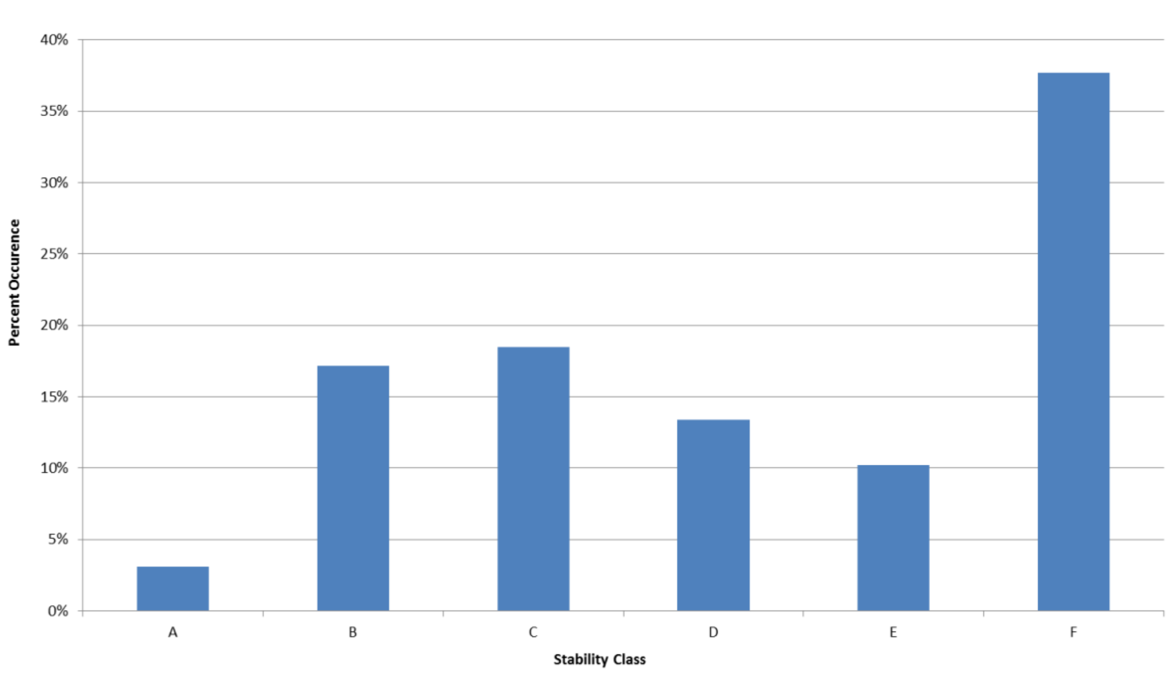


Figure 5.1: Stability class frequency (CALMET 2010)

5.2.2.2 Mixing Height

Mixing height is defined as the height above ground of a temperature inversion or statically stable layer of air capping the atmospheric boundary layer. It is an important parameter within air pollution meteorology as vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motion.

It is often associated with, or measured by, a sharp increase in temperature with height, a sharp decrease of water-vapour, a sharp decrease in turbulence intensity and a sharp decrease in pollutant concentration. Mixing height is variable in space and time, and typically increases during fair-weather daytime over land from tens to hundreds of metres around sunrise, up to 1-3 km in the mid-afternoon, depending on the location, season and day-to-day weather conditions. Sea breezes may, however, introduce complexities to the mixing height. The onset of a sea breeze at a particular location will often bring a reduction in the mixing height.

Mixing heights show diurnal variation and can change rapidly after sunrise and at sunset. Diurnal variation in the minimum, maximum and average mixing depths, based on the CALMET-generated meteorological data for the proposed modification, is shown in **Figure 5.2**. As expected, mixing heights begin to grow following sunrise with the onset of vertical convective mixing with maximum heights reached in mid to late afternoon. The median, highest and lowest mixing heights for each hour are represented by the horizontal lines. The vertical bars represent the lower quartile and upper quartile of mixing heights.

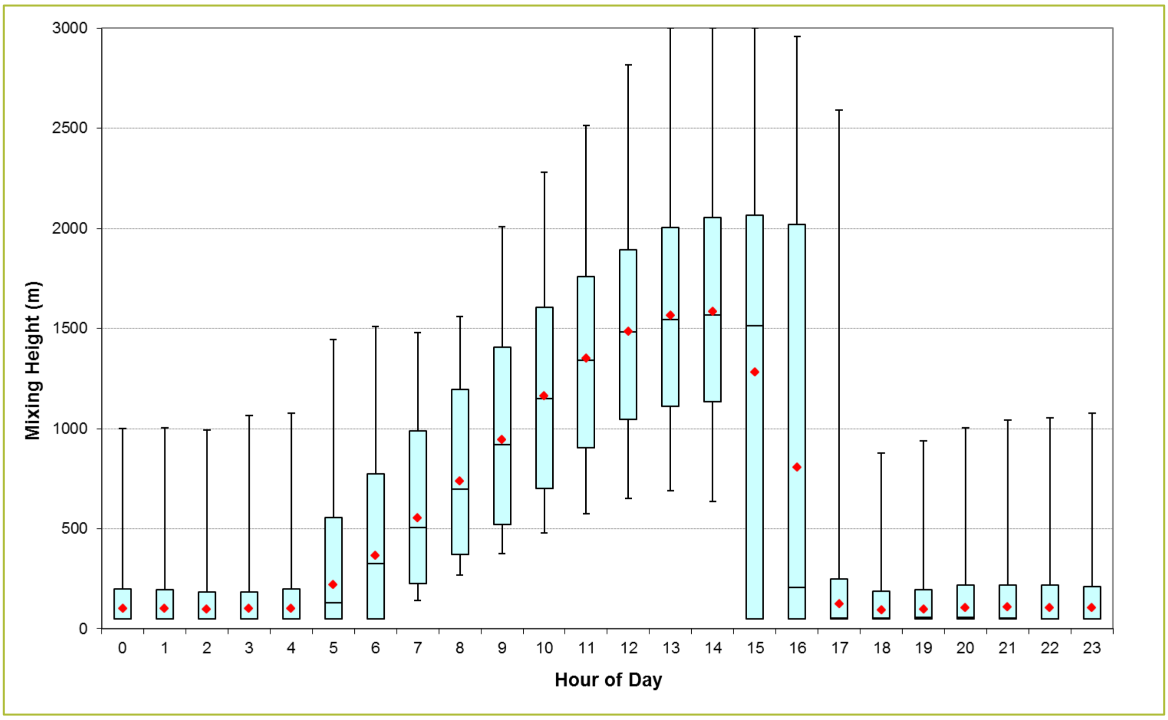


Figure 5.2: Average daily diurnal variation in mixing layer depth (CALMET 2010)

6 EMISSIONS ESTIMATES OF PARTICULATE MATTER

6.1 Particle Size Categories

The modelling for this assessment has been based on the use of three particle-size categories (0 to 2.5 µm - referred to as fine particles [FP] or $PM_{2.5}$, 2.5 to 10 µm - referred to as coarse matter [CM], and 10 to 30 µm - referred to as the [Rest]). The distribution of particles in each particle size range is as follows (**SPCC (1986)**):

- $PM_{2.5}$ (FP) is 0.0468 of the TSP
- $PM_{2.5-10}$ (CM) is 0.3440 of TSP
- PM_{10-30} (Rest) is 0.6090 of TSP

Emission rates of TSP in 2016 have been calculated using emission factors developed both locally and by the US EPA. Modelling was undertaken for each of the size fractions which are assumed to emit according to the distribution above and deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mass mean of the particle size range.

The resultant predicted concentrations are then combined as follows to determine the concentrations of each size fraction:

- $PM_{2.5}$ = FP
- PM_{10} = FP + CM
- TSP = FP + CM+ Rest

6.2 Dust Control on Haul Roads

Preliminary emissions estimations indicated that of the potential dust sources associated with the proposed modification, emissions from the hauling of overburden and ROM coal contributes more than any other source group to short-term PM_{10} impacts. Historically, modelling assessments for mine sites apply a haul road control level of 75% (representing control via Level 2 watering). In accordance with the modelling scenarios presented in this report, an additional level of control on hauling (85% control) has been applied to emissions estimations.

This level of control is supported by **Buonicore and Davis (1992)** who state that a level of control of 90% is expected to be achieved by increasing the application rate of water and/or through the use of dust suppressants. The study states that 90% control can only be maintained provided the moisture content of the surface material is approximately 8% (refer to **Figure 6.1**). The 85% control level is also supported by **Sinclair Knight Merz (2005)** who derived an equation that shows control benefits for increased watering up to 95%.

The above observations are further reinforced within **US EPA, 2006**. **Figure 6.2** (after **US EPA, 2006**) presents the relationship between the instantaneous control efficiency due to watering and the resulting increase in surface moisture. The moisture ratio "M" (shown on the x-axis) is calculated by dividing the surface moisture content of the watered road by the surface moisture content of the uncontrolled road.

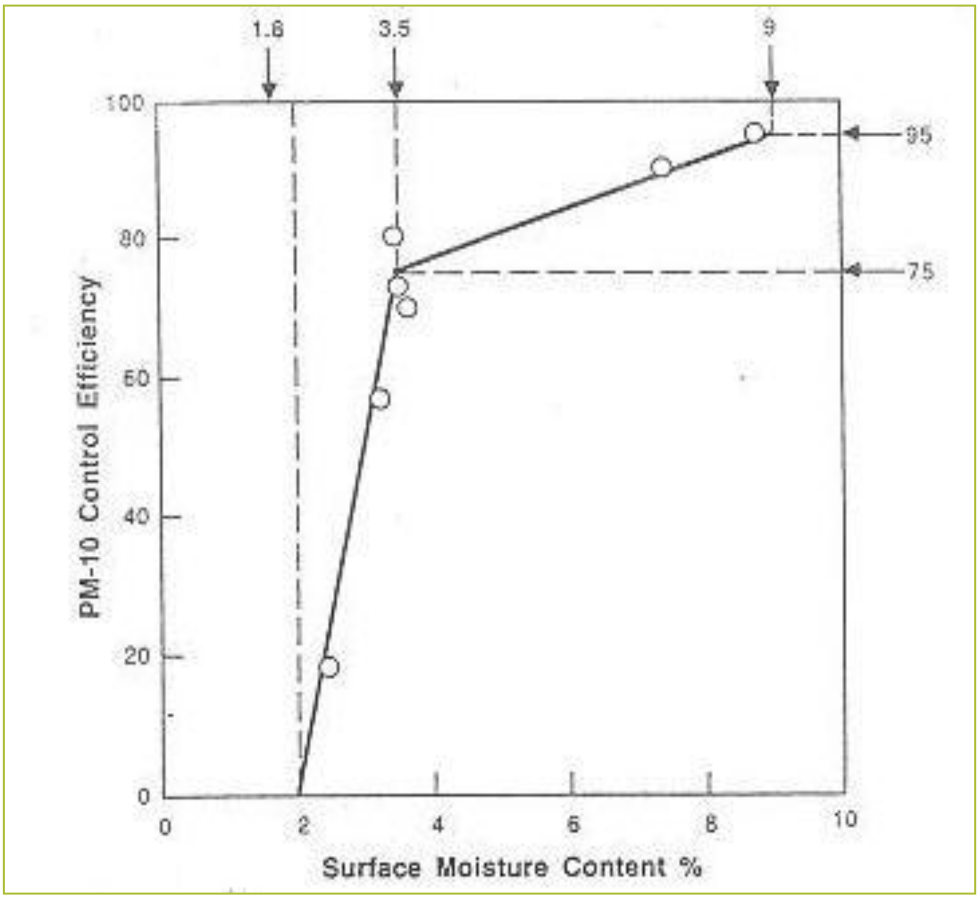


Figure 6.1: Watering Control Effectiveness for Unpaved Roads (Buonicore and Davis, 1992)

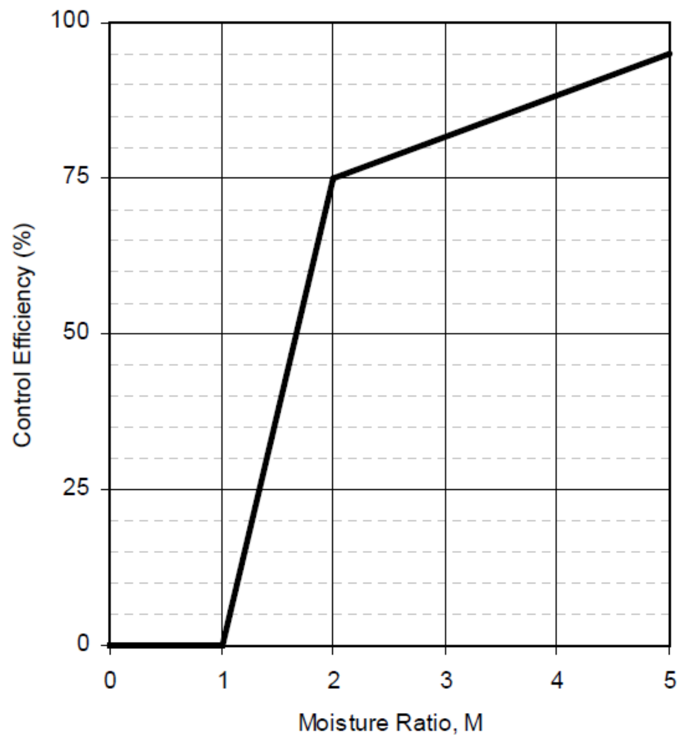


Figure 6.2: Watering Control Effectiveness for Unpaved Travel Surfaces (US EPA, 2006)

US EPA, 2006 states that as the watered surface dries, both the ratio M and the predicted instantaneous control efficiency (shown on the y-axis) decrease. The figure shows that between the uncontrolled surface moisture content and a value twice as large, a small increase in moisture content results in a large increase in control efficiency. Beyond that, control efficiency grows slowly with increased moisture content. For example, if the uncontrolled surface moisture content was 2%, and the addition of water increased this to 4%, a 75% reduction in emissions could be expected. However, increasing the surface moisture content further to 6% would only result in an additional 5% control.

Notwithstanding the above, it is clear from **Figure 6.2**, that while returns diminish beyond 75% control, theoretical control efficiencies from the application of water alone may reach up to 95%. In the absence of any site specific testing at the proposed modification site, a conservative assumption of 85% has been made, rather than assuming the full 95%.

6.3 Emissions from the Proposed Modification

Table 6.1 presents the emission estimates for 2016 for the proposed modification. Detailed emission estimates and calculations are provided in **Appendix A**.

There are a number of control measures in place which have been taken into account when developing the emissions inventory. The treatment of unsealed haul routes has already been discussed, and the results presented are based on 85% dust control, achieved with regular use of water carts and chemical dust suppressants. Silt samples from haul roads have also been collected and found to be approximately 2% on average. The details of this analysis can be found in **Appendix B**.

Other control factors include:

- Water sprays at ROM coal stockpiles and hoppers.
- Blast hole drilling rigs fitted with dust collection and suppression systems including dust curtains and water infection into the drill hole.
- Premanent rehabilitation of overburden emplacement areas which are to be inplace for more than 3 years.
- Restricting vehicle access or the application of wet or chemical suppression to overburden emplacement areas which are to be in place for less than 12 months.

Table 6.1: Summary of estimated TSP emissions from the proposed modification (kg/y)

Activity	2016
OB - Drilling	2,993
OB - Blasting	34,354
OB - Dozers in pit	27,044
OB - FEL loading OB to haul truck	37,646
OB - Hauling to waste dump	389,230
OB - Unloading at waste dump	37,646
OB - Dozers on waste dumps	216,354
CL - Dozers ripping coal in pit	38,642
CL - FELs Loading ROM to trucks	87,819
CL - Hauling ROM to ROM pad	23,571
CL - Unloading ROM at ROM pad	43,910
CL - FELs Loading ROM to trucks/hopper	43,910
CL - Loading product to stockpiles	119
WE - OB dump area	80,329
WE - Exposed pit area	55,714
WE – Active rehab areas	44,676
Grading roads	30,227
Loading product to trains	239
TOTAL	**1,194,423**

Figure 6.3 shows the general position of mine pit areas, overburden dumping areas and rehabilitation areas for 2016. The marked locations represent dust generating sources assumed in the modelling and include haul roads.

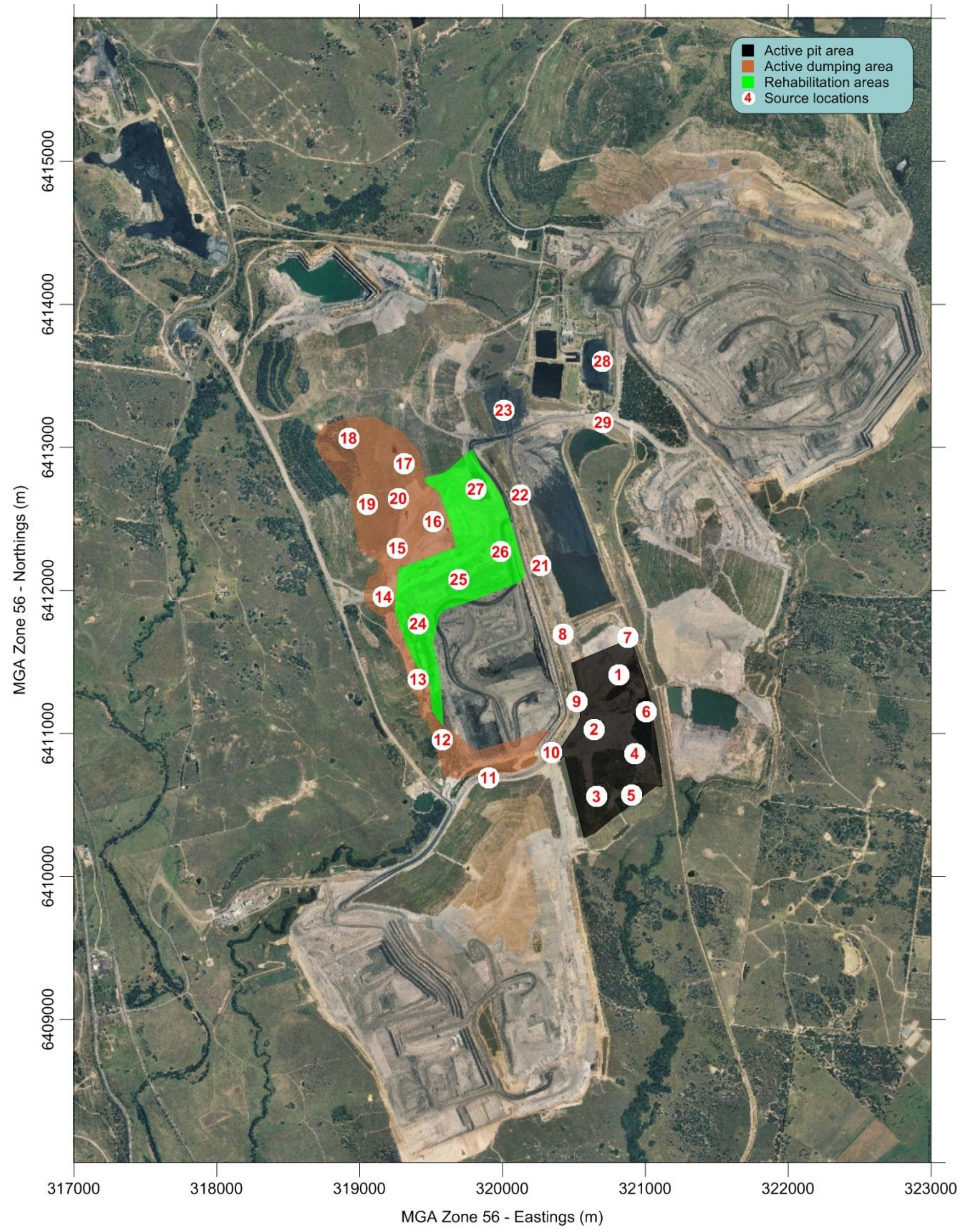


Figure 6.3: Modelled source locations for the proposed modification in 2016

6.4 Emissions from Neighbouring Mines

In addition to the proposed modification, estimated emissions for 2016 from other nearby mining complexes have been taken from Environmental Assessments (EAs) for those mines.

It should be noted that only those mines which are currently approved to be operating in 2016 have been included in this assessment. This includes the following mines:

- Mt Owen North Pit (**HAS, 2003**)
- Glendell Mine (**HAS, 2007**)
- Liddell Colliery (**HAS, 2006**)
- Ravensworth Operations (**PAEHolmes, 2010**)
- Ashton South East Open Cut (assumed to start in 2013, therefore Year 4 assumed to occur in 2016) (**PAEHolmes, 2009a**)
- Ashton surface facilities for underground workings (**PAEHolmes, 2009a**)
- Integra Mine Complex (**URS, 2009**), which includes North Open Cut, Western Extension and Underground operations

There are other mines to the southwest but they are outside the modelling domain and not included in this part of the assessment. They are classified as 'distant mines' and are discussed further in **Section 6.5**.

Each mine has been treated as a set number of volume sources located at the apparent points of major emission, as estimated from the locations of pits, dumps and other major dust sources shown in the EAs.

With the exception of Mt Owen, Glendell and the Ashton surface facilities, sources have been considered in three classes covering all dust emission sources for which there are emission factor equations for open cut mines. These classes are:

- Wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed
- Loading and dumping operations where emissions vary with the wind speed raised to the power of 1.3
- All other sources where emissions are assumed to be independent of wind speed

The proportion of emissions in each of these categories has been assumed to be:

- 0.732 for emissions independent of wind speed
- 0.135 for emissions that depend on wind speed (such as loading and dumping)
- 0.133 for wind erosion sources

These factors are based on a detailed analysis of mine dust inventories undertaken as part of the Mt Arthur North EA (**URS, 2000**), and have subsequently been accepted as appropriate and routinely applied in subsequent air quality impact assessments for mining operations.

In the case of Mt Owen and Glendell, source locations and emission estimates for each activity were taken from their EAs for the year which most closely represented 2016 (Year 10 for Mt Owen and Year 9 for Glendell). For Ashton surface facilities, there were only a small number of emission sources and their origin was clear, so they were able to be allocated directly to wind erosion and wind speed dependent sources.

Table 6.2 presents the emission estimates for Mt Owen North Pit, Glendell, Liddell, Ravensworth Operations, Ashton and Integra for 2016. Where data were not available for the precise years of the proposed modification, the closest modelling year was taken. For Integra Underground, the maximum TSP emissions listed in the EA were assumed to occur for future years.

Table 6.2: Summary of estimated TSP emissions from other mining operations (kg/y)

Mine	2016 (or closest year)
Mt Owen North Pit	4,407,886
Glendell Mine	2,568,288
Liddell Colliery	5,618,526
Ravensworth Operations	8,148,991
Ashton South East Open Cut	2,094,321
Ashton Coal (surface facilities)	72,075
Integra Mine Complex	
Western Extension	1,917,799
North Open Cut	1,064,309
Underground Operations	198,024

6.5 Emissions from Distant Mines and Other Sources

In addition to the mines identified in **Section 6.4**, distant mines and other sources will contribute to PM_{10} and TSP concentrations and to dust deposition in the area surrounding the proposed modification. Estimating the background allowance for distant mines and other sources (collectively referred to as non-modelled) is difficult and depends on local land use and the associated emission sources, as well as climate, soil type etc.

Historically, the approach taken has been to compare the predicted impacts due to the proposed modification and other mines to nearby monitoring locations. From this, an estimate of the contribution by non-modelled sources was made and a single figure estimate of annual average background PM_{10} and TSP concentrations was added to all the predicted impacts.

However, it is recognised that in reality, there is spatial variation in the contribution that non-modelled sources make to the ambient concentrations where open cut mines are located, compared with areas where open cut mining is not active.

For this assessment, a grid of annual average PM_{10} and TSP concentrations due to non-modelled sources has been created to make allowance for the spatial variability that occurs in the PM_{10} and TSP concentrations due to sources that are not explicitly included in the modelling.

The approach taken was to model the actual operations that took place at Mt Owen, Glendell and Ravensworth East, as well as other nearby mines in 2010 (see **Appendix C** for a summary of these emissions) in combination with the meteorological data for the same year. Annual average PM_{10} and TSP predictions were made at all the HVAS monitoring sites and TEOM sites SX13 and SX14[e], as discussed in detail in **Section 4**.

[e] Data from the remaining three sites were unavailable.

- PM_{10}-1/TSP-1 – Picton
- PM_{10}-2/TSP-2 – Cramps
- PM_{10}-3iii – Middle Falbrook Road
- PM_{10}-4/TSP-3 – Ravensworth Farm
- PM_{10}-3ii/TSP-4 – Hardy
- TEOM4/SX13
- TEOM5/SX14

The difference between the predicted and measured annual average concentrations was taken to be the contribution of any distant mines and other sources which were not included explicitly in the model. This difference is then taken to represent the background level to be added to the modelled impacts at those locations.

Table 6.3 and **Table 6.4** present the measured, predicted and background PM_{10} and TSP concentrations, respectively. Monitoring data for 2010 were used to coincide with contemporaneaous modelling predictions and meteorology.

Table 6.3: Predicted and measured PM_{10} concentrations for 2010

Monitor ID	Measured conc^{n}s (µg/m^3)	Predicted conc^{n}s (µg/m^3)	Background conc^{n}s (µg/m^3) (measured – predicted)
SX13	18	16	2
SX14	23	31	-8[f]
PM_{10}-1	22	6	15
PM_{10}-2	24	8	16
PM_{10}-3iii	21	7	14
PM_{10}-4	22	12	11
PM_{10}-3ii	20	15	5

Table 6.4: Predicted and measured TSP concentrations for 2010

Monitor ID	Measured conc^{n}s (µg/m^3)	Predicted conc^{n}s (µg/m^3)	Background conc^{n}s (µg/m^3) (i.e. measured – predicted)
TSP-1	62	16	46
TSP-2	79	22	58
TSP-3	84	30	54
TSP-4	62	17	45

The monitoring locations are sparsely located so in order to create a grid of spatially varying concentrations to add to the predicted impacts due to combined operations at the proposed modification and other distant mines, it was assumed that the annual average PM_{10} concentrations at the northern and eastern edges of grid are 15 µg/m^3, where there will be little contribution from nearby mines. To the southwest and northwest, where there are larger non-modelled mining sources (such as HVO North and South, Drayton and Mt Arthur), the annual average PM_{10} non-mining source levels have been assumed to be 20 µg/m^3. The corresponding annual average TSP concentrations used are 30 µg/m^3 and 40 µg/m^3.

[f] This negative value indicates an over prediction by the model at TEOM site SX14, which is not unusual close to mining operations. For the purposes of developing the spatially varying background grid, the difference has been given a nominal value of 1 µg/m^3.

Figure 6.4 and **Figure 6.5** show the grids created for PM_{10} and TSP. These demonstrate that closer to the mine the majority of the measured PM_{10} and TSP concentrations are due to the operations at the Mt Owen Complex, with small contributions from other mines and non-mining sources. Further away from these operations, this contribution to the total measured concentrations increases and the contribution from the Mt Owen Complex decreases, as would be expected.

The approach taken for deposited dust has not been revised. The annual average quantity of deposited dust contributed by these other sources has been set conservatively at 1 g/m^2/month.

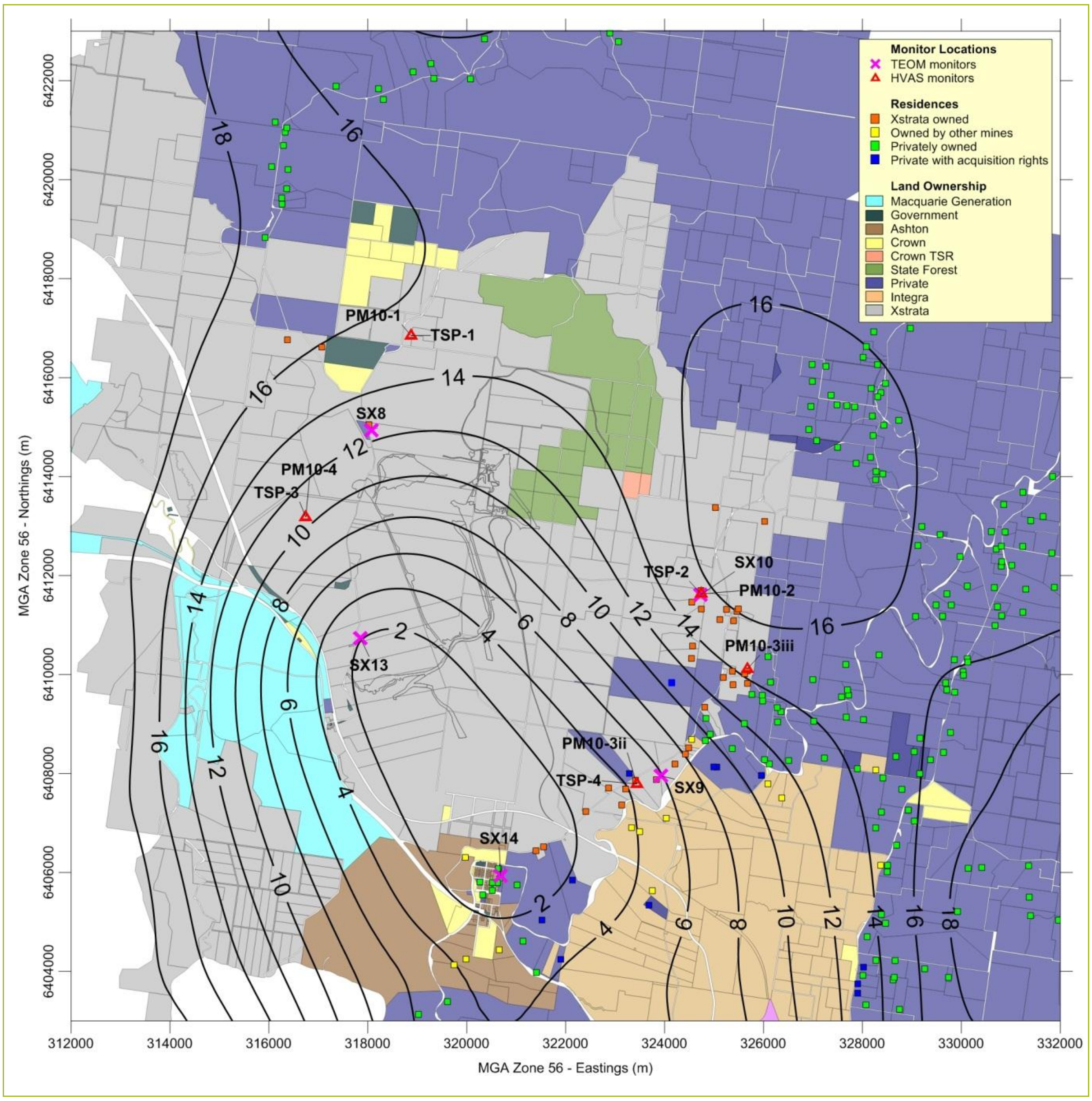


Figure 6.4: Estimated annual average PM_{10} concentrations due to non-modelled sources ($\mu g/m^3$)

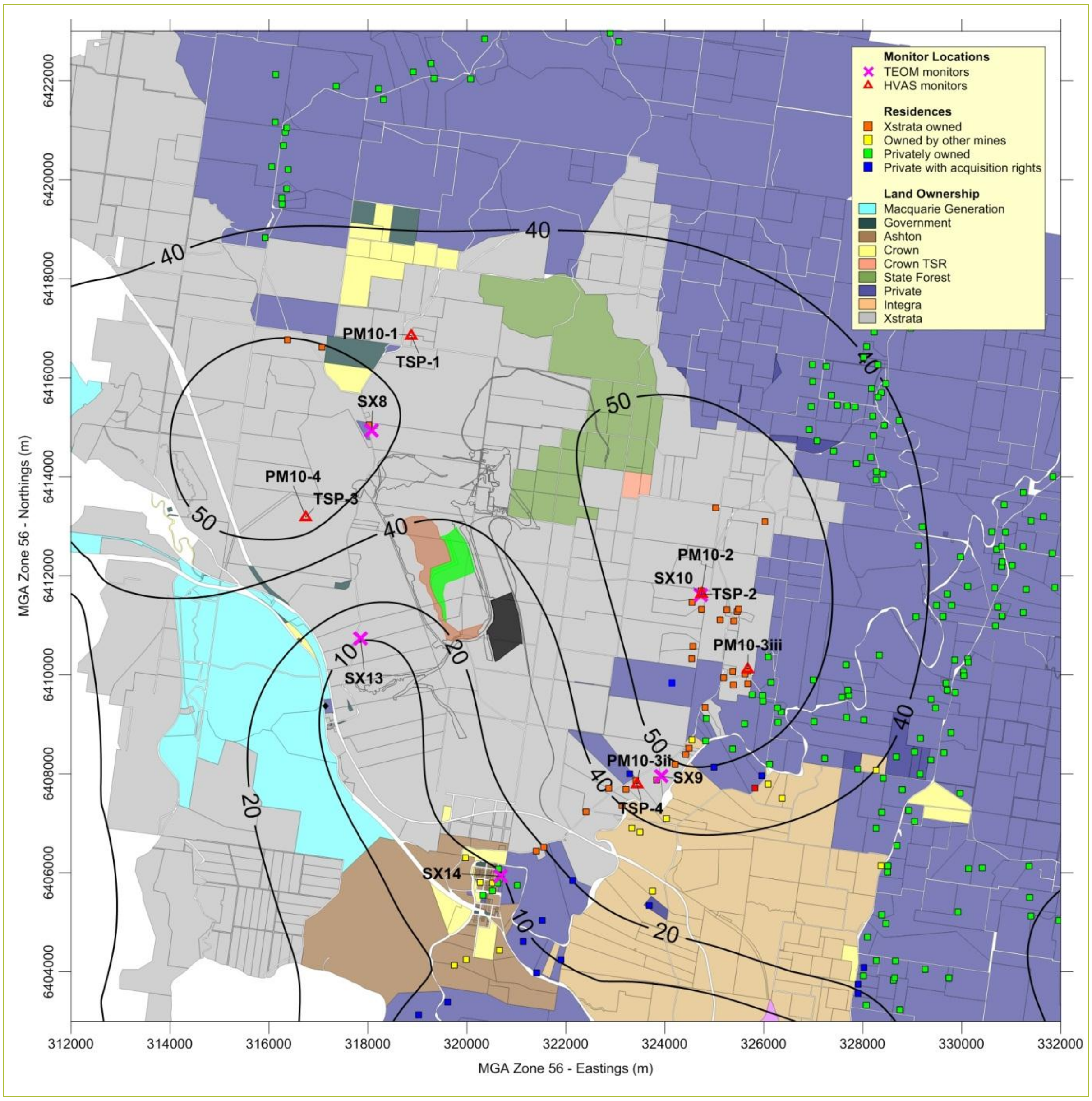


Figure 6.5: Estimated annual average TSP concentrations due to non-modelled sources (µg/m³)

7 ASSESSMENT OF IMPACTS

7.1 Introduction

The air quality criteria used for identifying which residences are likely to experience air quality impacts are those specified in EPA's Approved Methods (**Section 3**). These have been applied in the assessment process following the practices used in contemporary approvals for mining projects in NSW. It should be noted that these criteria apply to the cumulative impacts resulting from emissions from the proposed modification together with surrounding approved mines and non-modelled sources. Cumulative results are discussed in **Sections 7.3** and **7.4**.

Results for 2016 are presented and discussed in **Section 7.2**, and relate to the RERR Project alone. The annual average cumulative results (**Section 7.3**) include both neighbouring and distant mines, using the spacially-varying background grid as described in **Section 6.5**. This approach also accounts for non-modelled sources using monitoring information and results can be compared directly to air quality criteria.

Results for the 24-hour average cumulative impact assessment are assessed differently and are discussed in **Section 7.4**.

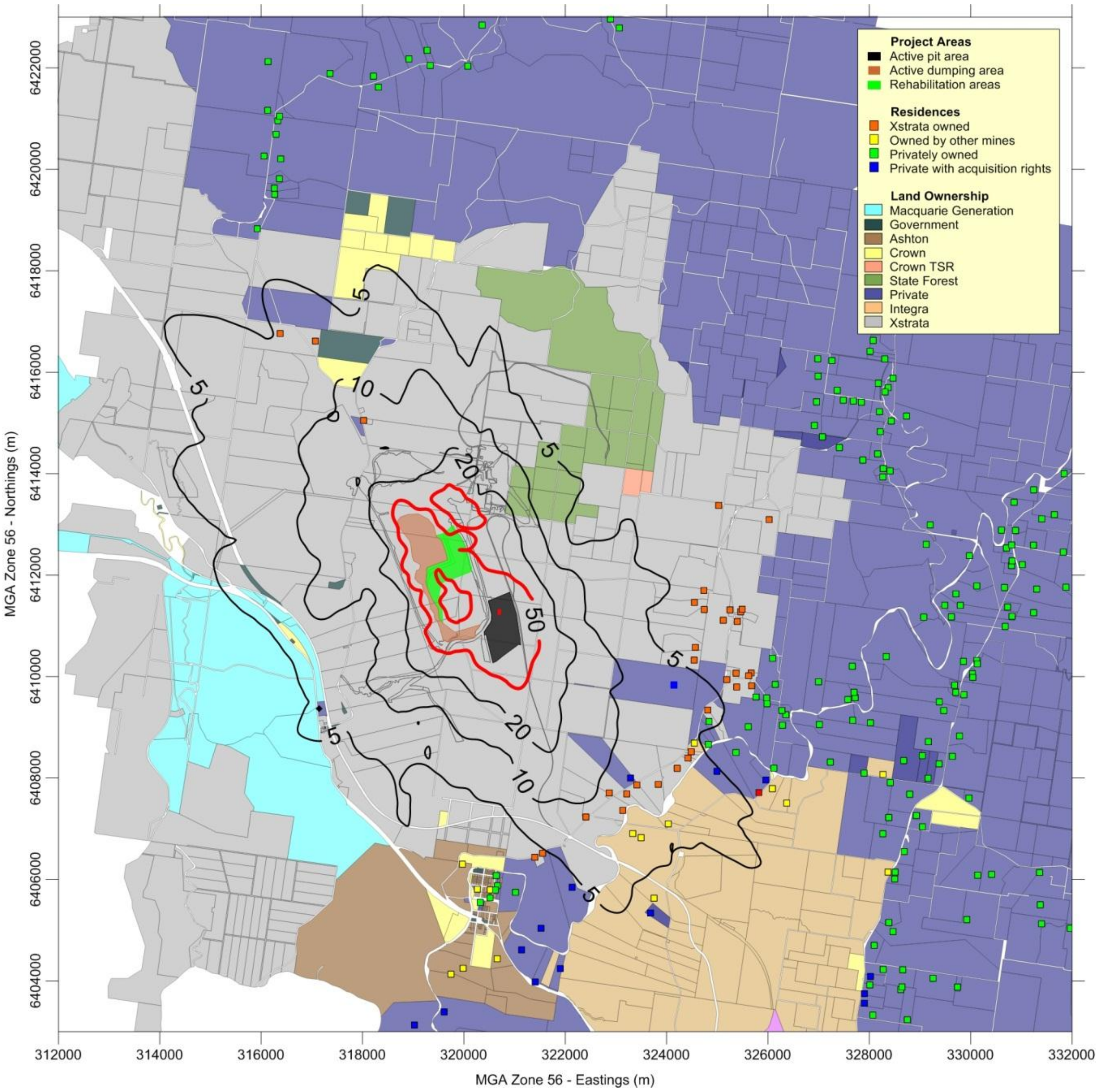
7.2 Impacts from Proposed Modification

Figure 7.1 to **Figure 7.4** presents contour plots for the predicted maximum 24-hour average PM_{10}, annual average PM_{10} and TSP concentrations and dust deposition levels for the proposed modification only for 2016.

The 24-hour average PM_{10} contours presented do not represent a single worst case day, but rather the potential worst case 24-hour average PM_{10} concentration that could be reached at any particular location across the entire modelling year.

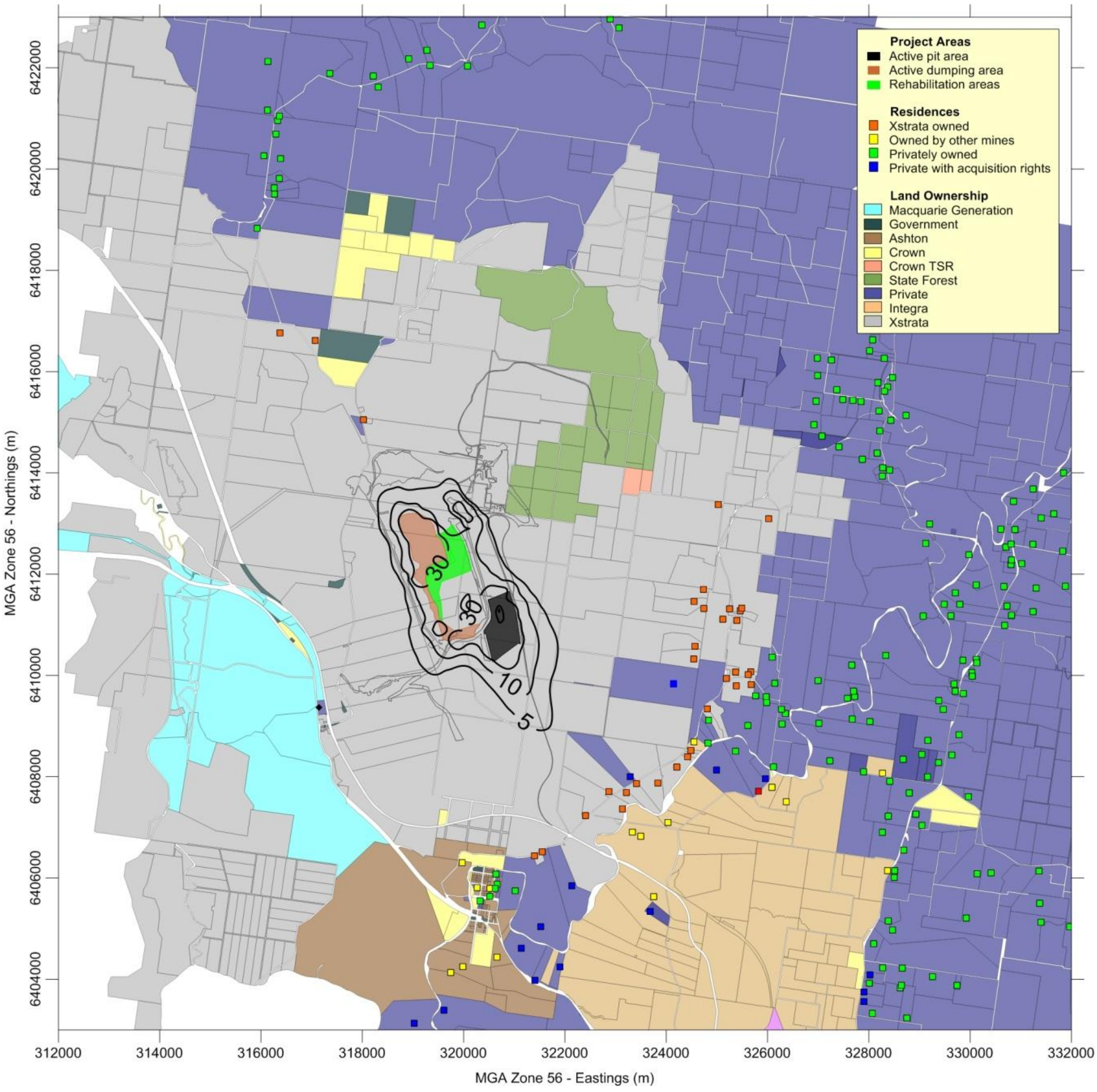
As shown, the impacts of the proposed modification are minimal. The highest predicted 24-hour average PM_{10} concentration at a private residence, is approximately 5 µg/m^3, and no residences (either privately or mine owned) are predicted to experience 24-hour average PM_{10} levels of more than 15 µg/m^3.

Annual average predictions are also very low for the proposed modification only, for both PM_{10} and TSP concentrations as well as deposition levels, and will have minimal contribution to the local airshed.



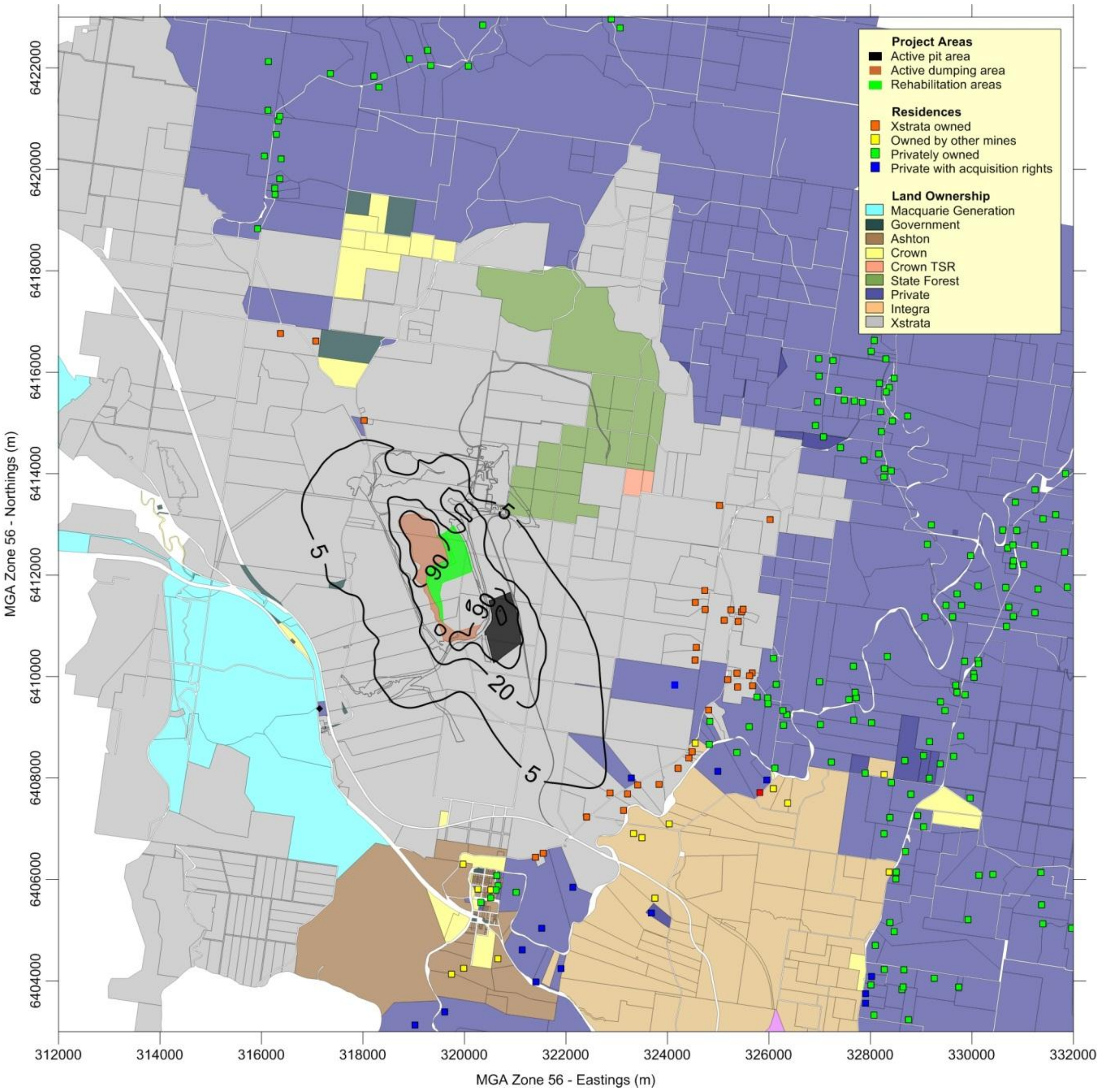
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Ravensworth East	2016 (RERR only)	Maximum	24-hour
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	µg/m³	N/A	CALMET	J. Barnett

Figure 7.1: Predicted 24-hour average PM_{10} concentrations due to emissions from the RERR Project only – 2016



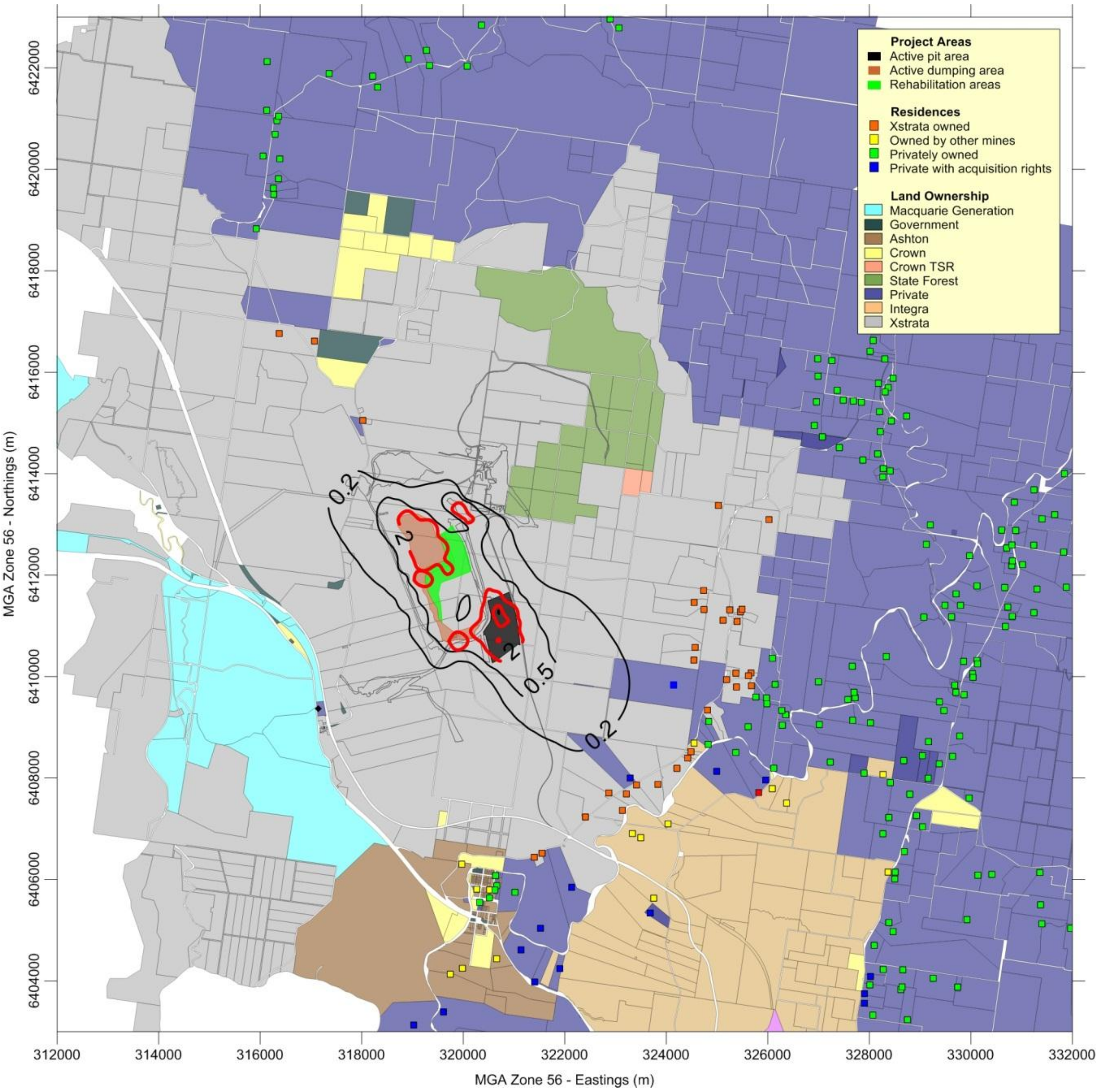
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Ravensworth East	2016 (RERR only)	Maximum	Annual
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	µg/m³	N/A	CALMET	J. Barnett

Figure 7.2: Predicted annual average PM_{10} concentrations due to emissions from the RERR Project only – 2016



Species: TSP	Location: Ravensworth East	Scenario: 2016 (RERR only)	Percentile: Maximum	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Criterion:** N/A	**Met Data:** CALMET	**Plot:** J. Barnett

Figure 7.3: Predicted annual average TSP concentrations due to emissions from the RERR Project only – 2016



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Deposition	Ravensworth East	2016 (RERR only)	Maximum	Annual
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	$g/m^2/month$	2 (Project only)	CALMET	J. Barnett

Figure 7.4: Predicted annual average dust deposition due to emissions from the RERR Project only – 2016

7.3 Cumulative Annual Average Impacts

Figure 7.5 to **Figure 7.7** presents contour plots for the predicted cumulative annual average PM_{10} and TSP concentrations and dust deposition levels. These results include contributions from the RERR project, nearby and distant mines, as well as other non-mining sources. The bold red contour lines represent the relevant air quality criteria.

In **Figure 7.5**, the model results indicate that predicted ground level concentrations may exceed annual PM_{10} criteria at residences 145, 147, 148 and 111 (144a is also shown but this is a dairy and not a residence). Further analysis of the relative contributions at those residence locations show that the predicted ground level concentrations are predominantly due to Ashton South East Open Cut and Integra operations. It should also be noted that these residences are subject to acquisition rights either by Ashton (145, 147 and 148) or Integra (111). Existing background levels are also estimated to contribute more than those from the proposed modification. **Table 7.1** summarises the relative contributions to the predictions at these four residents.

Table 7.1: Annual PM_{10} contributions to predicted ground level concentrations (µg/m^3)

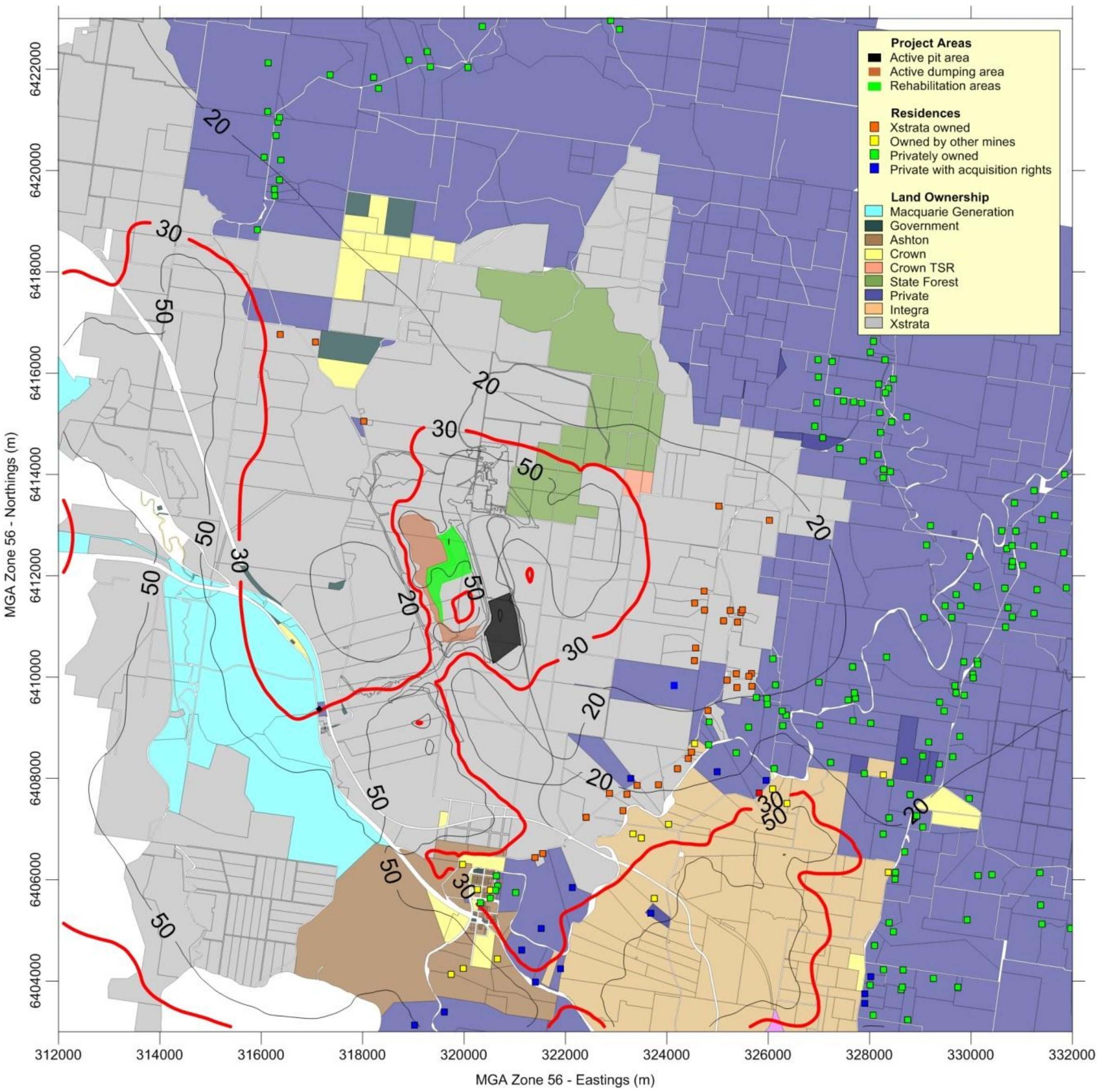
Mine/source	111	145	147	148
Proposed modification (RERR)	0.6	0.1	0.2	0.2
Mt Owen Complex	5	0.5	0.5	0.5
Distant mines and other sources	5	5	4	4
Nearby mines	28*	>200	29$^+$	29$^+$

* Predominantly Integra Operations

$^+$ Predominantly Ashton SEOC Operations

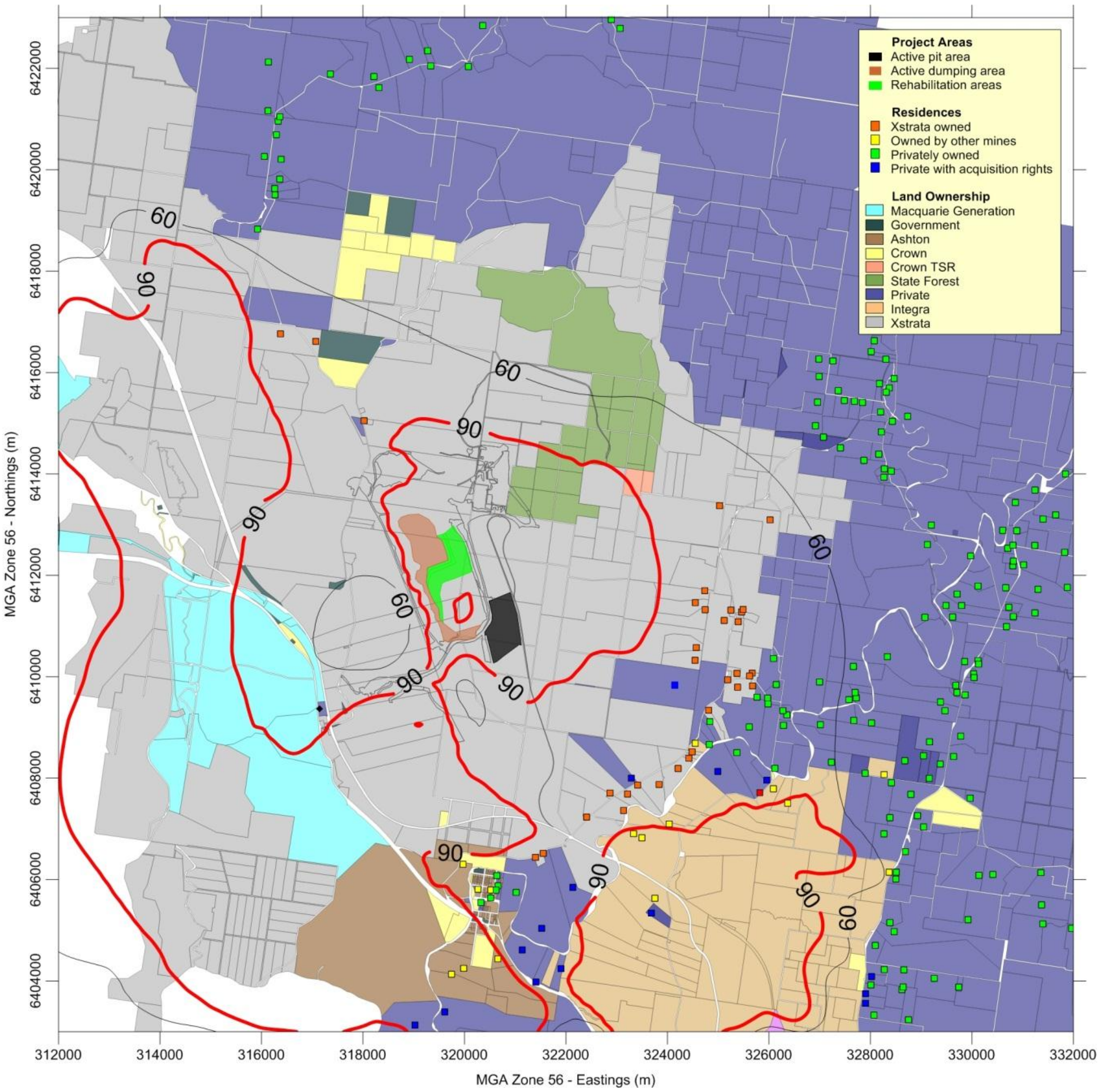
It is therefore unlikely that the proposed modification will have any measureable impact on annual PM_{10} concentrations at those residences.

Predicted cumulative PM_{10}, TSP and dust deposition levels are well below their relative criteria at all other privately owned residences as shown in **Figure 7.5**, **Figure 7.6** and **Figure 7.7**.



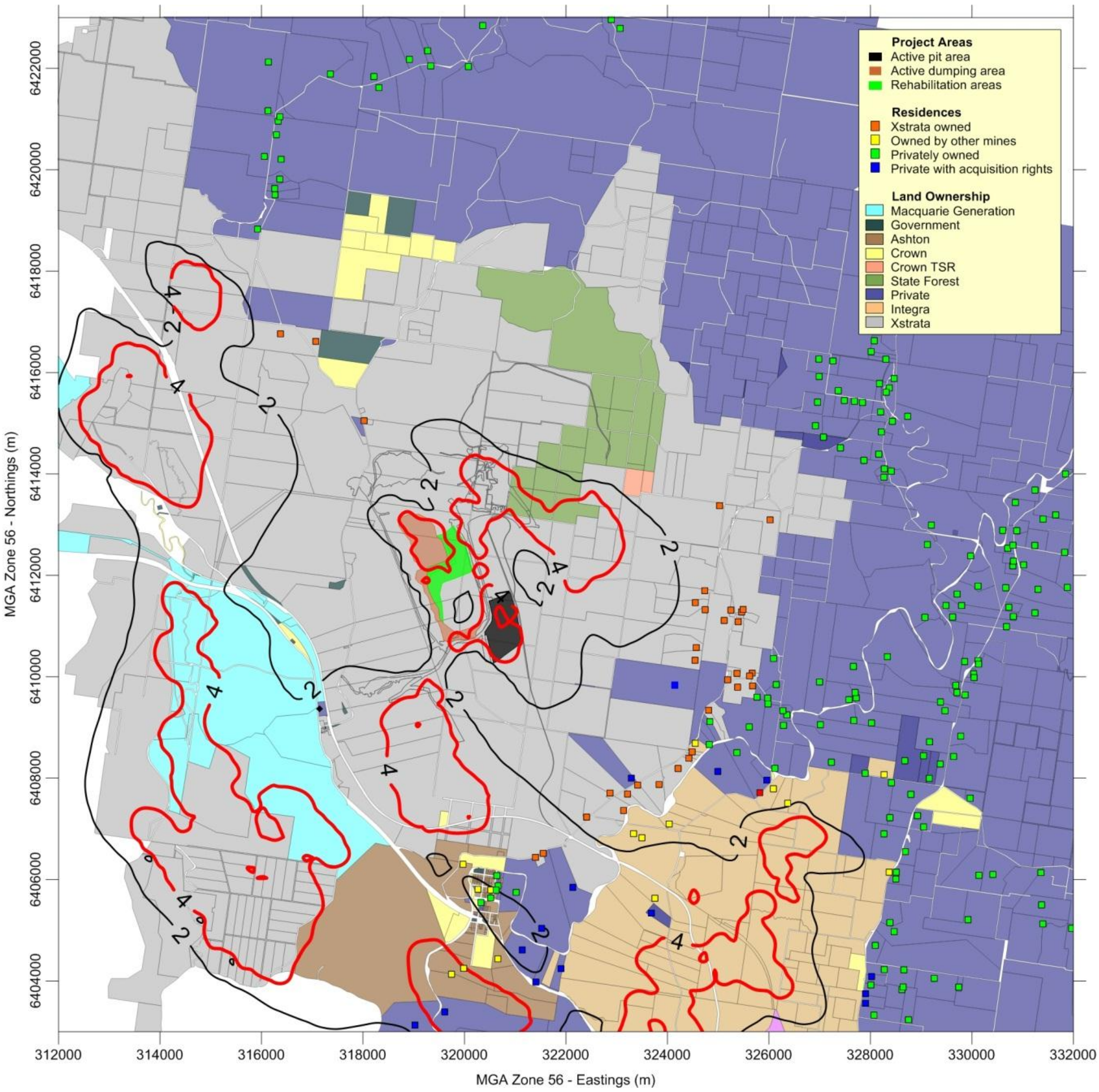
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Ravensworth East	2016 (cumulative)	Maximum	Annual
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	µg/m³	30	CALMET	J. Barnett

Figure 7.5: Predicted annual average cumulative PM_{10} concentrations – 2016



Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Ravensworth East	2016 (cumulative)	Maximum	Annual
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	µg/m³	90	CALMET	J. Barnett

Figure 7.6: Predicted annual average cumulative TSP concentrations – 2016



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
Deposition	Ravensworth East	2016 (cumulative)	Maximum	Annual
Model Used:	**Units:**	**Criterion:**	**Met Data:**	**Plot:**
CALPUFF	g/m^2/month	4	CALMET	J. Barnett

Figure 7.7: Predicted annual average cumulative dust deposition – 2016

7.4 Cumulative 24-hour average PM_{10} Impacts

7.4.1 Introduction

It is difficult to accurately predict cumulative 24-hour average PM_{10} concentration using dispersion modelling due to the difficulties in resolving (on a day to day basis) the varying intensity, duration and precise locations of activities at mine sites, weather conditions at the time of the activity, or a combination of activities.

Difficulties in predicting cumulative 24-hour average impacts are compounded by the day to day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity, for example, agricultural activity, or uncontrolled event such as bushfires, and so on, and including mining in the future. Experience shows that in many cases the worst-case 24-hour average PM_{10} concentrations are strongly influenced by other sources in an area, such as bushfires and dust storms, which are essentially unpredictable. The variability in 24-hour average PM_{10} concentrations can be clearly seen in the data collected at the HVAS and TEOM monitors located surrounding the RERR mining area (see **Section 4.1.2**).

Due to the difficulties outlined above, cumulative air quality impacts have been evaluated using a statistical approach (Monte Carlo Simulation). This approach has been provided to achieve the objectives of a Level 2 Assessment (see Section 11.2 of [**DEC, 2005**]). The cumulative assessment focuses on representative receptors in key areas in the vicinity of the RERR mining area.

Three resident locations were selected for cumulative analysis based on their proximity to proposed operations, and they are shown in **Figure 7.8**.

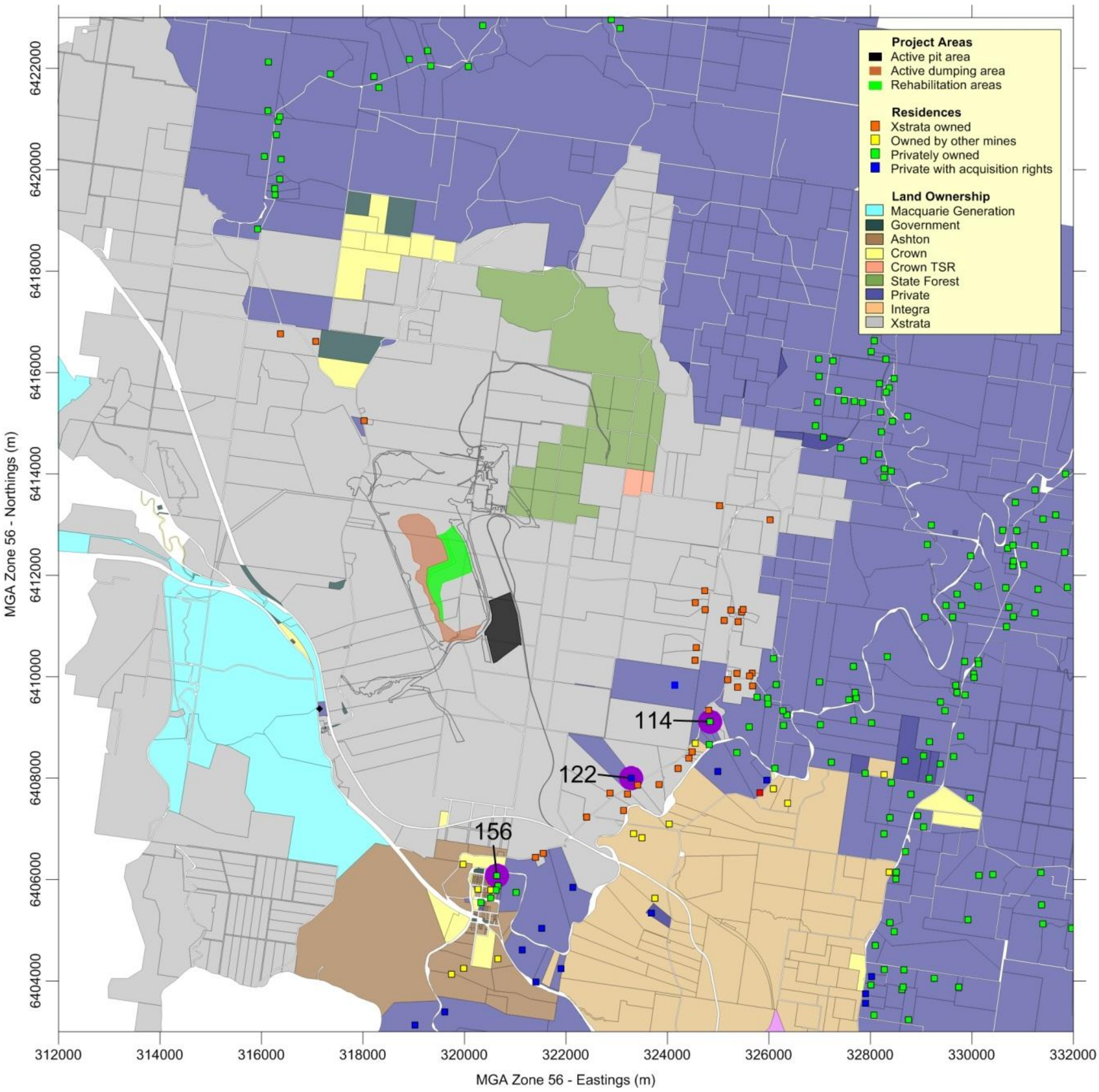


Figure 7.8: Selected receptors for Monte Carlo simulation

7.4.2 Cumulative assessment based on Monte Carlo Simulation

The Monte Carlo Simulation is a statistical approach that combines the frequency distribution of one data set (in this case background 24-hour average PM_{10} concentrations) with the frequency distribution of another data set (modelled impacts at a given residence). This is achieved by repeatedly randomly sampling and combining values within the two data sets to create a third, 'cumulative' data set and associated frequency distribution.

Receptors (residence numbers) 114, 122 and 156 were chosen to represent groups of private residences. R122 represent the closest private residences within the current XMO acquisition zone, R156 to the south represents residences in Camberwell Village, and R114 represents the closest privately owned residence outside the XMO acquisition zone. PM_{10} data from the five TEOMs and five HVAS monitors surrounding the operations at the Mt Owen Complex were used to represent possible background values for each of the three residences.

Individual 24-hour average predictions for the proposed modification (2016) are added to a random value from the above data sets. This process is repeated many thousands of times yielding the 'cumulative' data set, which is then presented as a frequency distribution.

The process assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given 'modelled day'. Over sufficient repetitions, this yields a good statistical estimate of the combined and independent effects of varying background and Project contributions to total PM_{10}.

To generate greater confidence in the statistical robustness of the results, the Monte Carlo Simulation was repeated 250,000 times for each of the three receptors. In other words, the same 1-year set of predicted (modelled) 24-hour average PM_{10} concentrations due to the RERR project were added to 250,000 variations of the randomly selected background concentrations at each residence (a different random background concentration is selected each time).

The results of this analysis are presented graphically in **Figure 7.9**. The plot shows the statistically estimated number of days that 24-hour average PM_{10} concentrations might exceed 50 $\mu g/m^3$ and also compares the cumulative probability with the measured background.

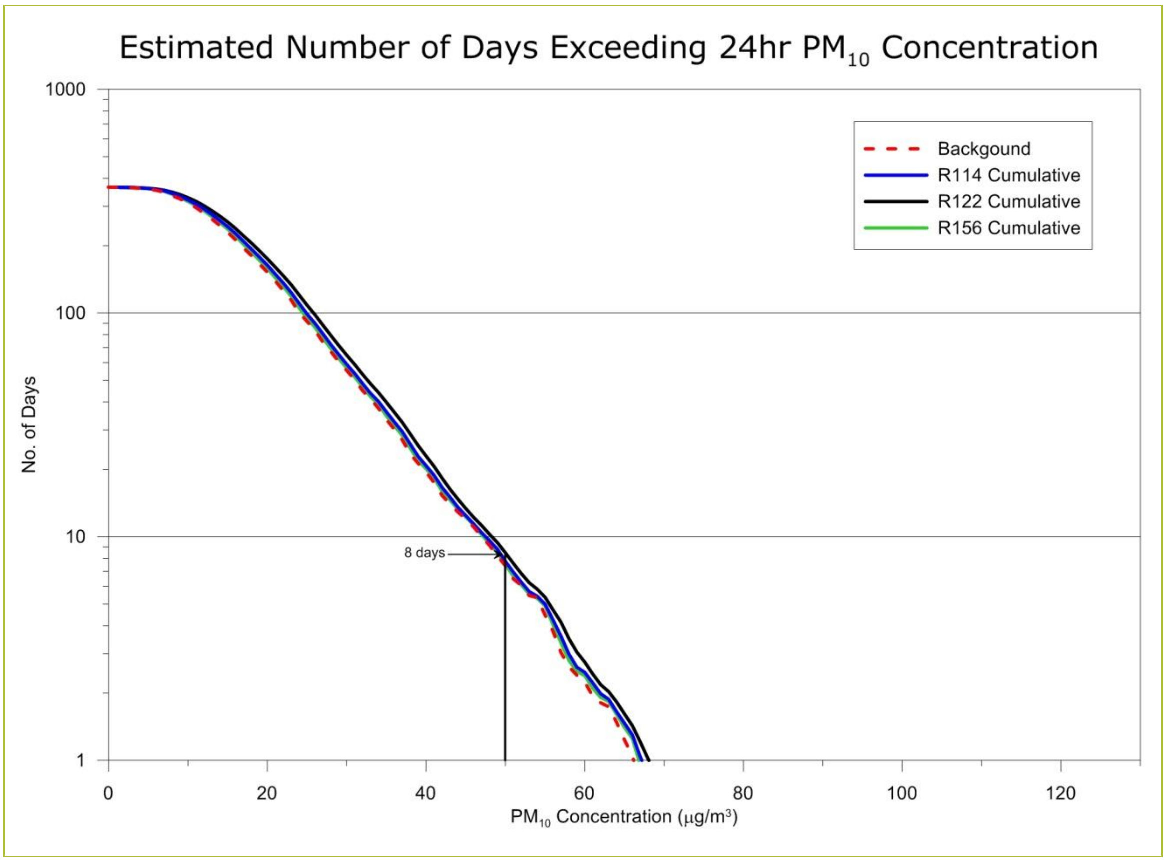


Figure 7.9: Residences 114, 122 and 156 – statistical estimate of number of days exceeding 24-hr PM_{10} average concentrations following Monte Carlo simulation

Figure 7.9 shows that existing activities, rather than the proposed modification, are the main contributors to PM_{10} concentrations. This is shown by the fact that the background is estimated to exceed 50 µg/m^3 approximately 7 days per year. These exceedances will be due, in part, to existing mining operations in the region, but also other sources such as farming and regional dust events all of which are captured in the TEOM and HVAS monitoring data. The Monte Carlo analysis has shown that due to the proposed modification, there may potentially be 8 days at these closest private residences when 50 µg/m^3 is exceeded, that is, an additional 1 day more than existing conditions which include existing mining and regional dust events contributions inherent in the background data.

Another way of looking at these results is to say that the probability of the background (monitoring) levels exceeding 50 µg/m^3 is approximately 2%, and the cumulative effect of the proposed modification increases this probability to 2.2% for the chosen residences.

It should also be noted that residences 114, 122 and 156 showed maximum PM_{10} 24-hour average Project only predictions of 5 µg/m^3, 8 µg/m^3 and 3 µg/m^3, respectively (**Section 7.2**). For the majority of the year the proposed modification is predicted to contribute less than 1 µg/m^3 at 114, 122 and 156. It is clear then, that the proposed modification is by no means a significant contributor to PM_{10} levels in the area.

As the cumulative results are created from random pairings of background and modelled concentrations, it is not possible to determine meteorological conditions on particular days of exceedance.

8 CONCLUSIONS

PAEHolmes has completed an Air Quality Impact Assessment for the continuation of mining operations at Ravensworth East Mine.

The mining plans for the proposed modification in 2016 have been analysed and a detailed emissions inventory has been prepared for predicted worst-case operations. Dispersion modelling was conducted to predict the ground level concentrations for all relevant particulate matter and deposited dust emissions.

Cumulative impacts were also considered, taking into account the approved neighbouring mines as well as distant mines and other non-mining sources.

The modelling indicates that no privately owned residences, not currently subject to acquisition rights from previous mining approvals, are predicted to experience 24-hour or annual average impacts above the criteria, due to emissions from the proposed modification alone.

There are no privately owned residences, not currently subject to acquisition rights from previous mining approvals, which are predicted to experience annual average TSP or PM_{10} concentrations, or deposition levels above the assessment criteria, due to emissions from the proposed modifcaiton and other sources.

There is a 2% chance of an exceedance of the 24-hour average PM_{10} impact assessment criterion, but this is due predominantly to other mines and existing background levels and the probablility remains very small.

The proposed modification should not result in unacceptable air quality impacts in the local area.

9 REFERENCES

Buonicore and Davis (1992)

"Air Pollution Engineering Manual", Air and Waste Management Association. Edited by Anthony J. Buonicore and Wayne T. Davis.

Chow (1995)

"Measurement methods to determine compliance with ambient air quality standards for suspended particles", J. Air & Waste Manage. Assoc. 45, 320-382, May 1995.

DoP (2010)

"Major Project Assessment: Integra Open Cut Project (08_102)" NSW Department of Planning November 2010. Available from: http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=2701 accessed 31 May 2011.

Holmes Air Sciences (2006)

"Air Quality Assessment: Liddell Open Cut - Proposed Modifications" prepared for Umwelt (Australia) Pty Ltd, December 2006.

Holmes Air Sciences (2009)

"Air Quality Impact Assessment: Integra open Cut Project" 16 June 2009. Prepared for URS Australia Pty Ltd on behalf of Integra Coal.

Hurley, P. (2005)

The Air Pollution Model (TAPM) Version 3. Part 1, Technical Description, CSIRO Atmospheric Research Technical Paper No. 71, CSIRO Division of Atmospheric Research, Melbourne.

Hurley, P. et. al (2005)

The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies, CSIRO Atmospheric Research Technical Paper No. 72, CSIRO Division of Atmospheric Research, Melbourne. Hurley, P., Physick, W.L., Luhar, A.K. & Edwards M. 2005.

NSW DEC (2005)

"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW", August 2005.

PAEHolmes (2009a)

"Air Quality Impact Assessment for Ashton South East Open Cut" prepared for Wells Environmental Services on behalf of Ashton Coal Operations Limited, October 2009.

PAEHolmes (2009b)

"Air Quality Assessment for Narama Extended Project" prepared for Umwelt (Australia) Pty Ltd, June 2009.

PAEHolmes (2010)

"Air Quality Impact Assessment for Ravensworth Operations Project", prepared for Umwelt (Australia) Pty Ltd, January 2010.

URS (2000)

"Mount Arthur North Coal Project" EIS produced for COAL Australia Pty Ltd by URS Australia Pty Ltd, Level 22, and 127 Creek Street, Brisbane, Queensland 4000.

URS (2009)

"Environmental Assessment: Integra Open Cut Project" prepared by URS Australia Pty Ltd, June 2009.

APPENDIX A: Emission Inventories For 2016

The dust emission inventories have been prepared using the operational description of the proposed modification.

Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below. Activities have generally been modelled for 24 hours per day.

Dust from wind erosion is assumed to occur over 24-hours per day, however, wind erosion is also assumed to be proportional to the third power of wind speed. This will mean that most wind erosion occurs during the day when wind speeds are highest.

Drilling overburden

The emission factor used for drilling has been taken to be 0.59 kg/hole (**US EPA, 1985 and updates**).

Drilling will occur on overburden only in years 1 and 2 and will be used on both overburden and coal in each proceeding modelled year.

A control factor of 70% has been applied for drilling to include the use of water sprays and sut curtains.

Blasting overburden

TSP emissions from blasting were estimated using the **US EPA (1985 and updates)** emission factor equation given in **Equation 1**.

Equation 1

$$E_{TSP} = 0.00022 \times A^{1.5} \qquad \text{kg/blast}$$

Where,
A = area to be blasted in m^2

Loading material / dumping overburden

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. **Equation 2** shows the relationship between these variables.

Equation 2

$$E_{TSP} = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right) \quad \text{kg/t}$$

Where: k = 0.74 for TSP
U = wind speed (m/s)
M = moisture content (%)
(where $0.25 \leq M \leq 2.8$)

A value of 2% was used for the moisture content of overburden.

Hauling material / product on unsealed surfaces

The emission estimate of wheel generated dust is based the US EPA AP42 emission factor for unpaved surfaces at industrial sites shown below in **Equation 3**.

Equation 3

$$E_{TSP} = 0.2819 \times \left[4.9 \times \left(\frac{s}{12}\right)^{0.7} \times \left(\frac{\frac{W}{1.1023}}{3}\right)^{0.45} \right] (kg|VKT)$$

Where:

E_{TSP} = TSP emission factor from wheel generated dust

s = silt content of road surface (2% as measured)

W = mean vehicle weight

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip.

A control factor of 85% has been applied for watering and the use of chemical suppressants on unpaved roads.

Dozers working on overburden

Emissions from dozers on overburden have been calculated using the US EPA emission factor equation given in **Equation 4** (**US EPA, 1985 and updates**).

A value of 10% has been used for the silt content of overburden, and 2% for the moisture content. This results in an emission factor of 16.7 kg/h.

Equation 4

$$\mathrm{E_{TSP}} = 2.6 \times \frac{\mathrm{s}^{1.2}}{\mathrm{M}^{1.3}} \ \mathrm{kg/hour}$$

Where:

S = silt content (%)

M = moisture (%)

Dozers working on coal

The **US EPA (1985 and updates)** emission factor equation has been used. It is given below in **Equation 5**.

Equation 5

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{M^{1.4}} \quad (kg|hour)$$

Where,

s = silt content (%), and

M = moisture (%)

Values of 5% for silt content and 6% for moisture content of ROM coal, resulting in an emission factor of 23.9 kg/h.

Loading/unloading coal

The **US EPA (1985 and updates)** emission factor equation has been used. It is given below in **Equation 6**.

Equation 6

$$E_{TSP}\ \left(\frac{kg}{t}\right) = \frac{0.580}{M^{1.2}}(kg|t)$$

Where,

M = moisture (%)

A moisture content of 6% was used for ROM coal and 9.8% for product coal. A control factor of 50% has been applied to include water sprays at the ROM pad.

Wind erosion

The default emission factor of 0.1 kg/ha/h (**US EPA, 1985 and updates**) has been used to estimate TSP emissions for wind erosion on exposed surfaces.

Grading roads

Estimates of TSP emissions from grading roads have been made using the **US EPA (1985 and updates)** emission factor equation shown in **Equation 7**.

Equation 7

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad \text{kg/VKT}$$

Where,

S = speed of the grader in km/h (taken to be 8 km/h)

The following table presents the calculated emissions for 2016 of the proposed modification which correspond to the sources allocations as represented in **Figure 6.3**.

The abbreviations used in the tables are as follows:

- OB - overburden related activities
- CL - coal related activities
- WE - wind erosion emissions

Table A1: Emissions inventories for Ravensworth East Resource Recovery Project – 2016

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units
Ravensworth East Resource Recovery Project																	
OB - Drilling	2,993	16,912	holes/y	0.177	kg/hole											70	% control
OB - Blasting	34,354	85	blasts/y	404	kg/blast	15,000	Area of blast in square metres										
OB - Dozers in pit	27,044	1,616	h/y	16.7	kg/h	2	moisture content in %	10	silt content								
OB - FEL loading OB to haul truck	37,646	23,040,000	t/y	0.00163	kg/t	1.380	average of (wind speed/2.2)^1.3 in m/s	2.0	moisture content in %								
OB - Hauling to waste dump	389,230	23,040,000	t/y	0.017	kg/t	224	payload (tonnes)	272	Average vehicle mass (tonnes)	8.8	km/return trip	2.87	kg/VKT	2	% silt content	85	% control
OB - Unloading at waste dump	37,646	23,040,000	t/y	0.00163	kg/t	1.380	average of (wind speed/2.2)^1.3 in m/s	2.0	moisture content in %								
OB - Dozers on waste dumps	216,354	12,928	h/y	16.7	kg/h	2	moisture content in %	10	silt content								
CL - Dozers ripping coal in pit	38,642	1,616	h/y	23.9	kg/h	6	moisture content in %	5	silt content								
CL - FELs Loading ROM to trucks	87,819	1,300,000	t/y	0.06755	kg/t	6	moisture content in %										
CL - Hauling ROM to ROM pad	23,571	1,300,000	t/y	0.018	kg/t	165	payload (tonnes)	224	Average vehicle mass (tonnes)	7.6	km/return trip	2.62	kg/VKT	2	% silt content	85	% control
CL - Unloading ROM at ROM pad	43,910	1,300,000	t/y	0.03378	kg/t	6	moisture content in %									50	% control
CL - FELs Loading ROM to hopper	43,910	1,300,000	t/y	0.03378	kg/t	6	moisture content in %									50	% control
CL - Loading product to stockpiles	75	845,000	t/y	0.00009	kg/t	1.380	average of (wind speed/2.2)^1.3 in m/s	9.8	moisture content in %							50	% control
WE - OB dump area	80,329	91.7	ha	0.1	kg/ha/h	8,760	h/y										
WE - Exposed pit area	55,714	63.6	ha	0.1	kg/ha/h	8,760	h/y										
WE - Active rehab area	44,676	51.0	ha	0.1	kg/ha/h	8,760	h/y										
Grading roads	30,227	49,112	km	0.62	kg/km	8	speed of graders in km/h										
Loading product to trains	149	845,000	t/y	0.00018	kg/t	1.380	average of (wind speed/2.2)^1.3 in m/s	9.8	moisture content of coal in %								

APPENDIX B: Analysis results for silt sampling on haul roads

SGS Muswellbrook
3 Blakefield Rd
PO Box 748
Muswellbrook, NSW, 2333
Ph: (02) 6542 0000
Fax: (02) 6541 4966

ANALYTICAL REPORT

CARBON BASED ENVIRONMENTAL
ROAD WAY DUST SAMPLES

ATT: Mr Colin Davies — **MONTH:** Mar-11

OUR REF: HM10161 — **DATE** 30-Mar-11

Sample Description: **GLENDELL MEGA RAMP**
Mass Sample (a.r.): 793.1 g
Total Moisture (a.r.): 3.3 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	98.1	24.7	24.7
8.0	**4.0**	76.5	19.2	43.9
4.0	**1.00**	121.6	30.6	74.5
1.00	**0.600**	29.5	7.4	81.9
0.600	**0.106**	62.5	15.7	97.6
0.106	**0.075**	4.9	1.2	98.8
0.075		4.7	1.2	100.0
	Total Mass (g)	397.80		

Sample Description: **GLENDELL NORTH RAMP 1**
Mass Sample (a.r.): 2801.5 g
Total Moisture (a.r.): 1.3 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	127.2	32.0	32.0
8.0	**4.0**	48.8	12.3	44.3
4.0	**1.00**	74.3	18.7	63.0
1.00	**0.600**	24.7	6.2	69.3
0.600	**0.106**	100.5	25.3	94.6
0.106	**0.075**	11.8	3.0	97.6
0.075		9.7	2.4	100.0
	Total Mass (g)	397.00		

Sample Description: **GLENDELL NORTH RAMP 2**
Mass Sample (a.r.): 3040.9 g
Total Moisture (a.r.): 1.1 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	61.5	15.5	15.5
8.0	**4.0**	51.2	12.9	28.5
4.0	**1.00**	92.6	23.4	51.9
1.00	**0.600**	31.6	8.0	59.8
0.600	**0.106**	130.4	32.9	92.8
0.106	**0.075**	19.0	4.8	97.6
0.075		9.6	2.4	100.0
	Total Mass (g)	395.90		

APPENDIX C: 2010 Emission Estimates for Neighbouring Mines

Emission estimates from 2010 Mt Owen Complex operations and neighbouring mines

Detailed information was available on the mining operations at the Mt Owen Complex for 2010. With this information it was possible to model these and nearby mining 2010 operations and compare those results with contemporaneous monitoring data, in order to estimate the contributions from non-modelled sources, as described in **Section 6.5**.

Mt Owen Complex operations

The Mt Owen, Glendell and Ravensworth East mining operations for 2010 were analysed and detailed emissions inventories were prepared for that year. These estimates are listed by activity in **Table C1**.

Table C1: Summary of estimated TSP emissions from 2010 operations (kg/y)

Activity	Mt Owen	Glendell	Ravensworth East
Drilling	29,927	14,984	9,163
Blasting	70,862	33,329	16,434
OB - Dozers in pit	407,656	202,899	135,958
OB - FEL loading OB to haul truck	153,200	76,708	46,909
OB - Hauling to waste dump	1,110,586	622,723	308,280
OB - Unloading at waste dump	153,200	76,708	46,909
OB - Dozers on waste dumps	373,081	208,154	125,515
CL - Dozers ripping coal in pit	340,476	242,235	242,235
CL - FELs Loading ROM to trucks	453,093	187,578	134,225
CL - Hauling ROM to ROM Pad	230,836	145,090	67,893
CL - Unloading ROM at ROM pad	80,701	33,410	23,907
CL - FELs Loading ROM to hopper	453,093	187,578	134,225
CL - Loading product to stockpiles	912	357	270
CL - Dozers on product	168,609	168,609	168,609
WE - OB dump area	840,960	297,840	280,320
WE - Exposed pit area	525,600	245,280	192,720
WE - Tailings Dams	10,512	0	0
Grading roads	4,044	4,044	4,044
TOTAL (kg/y)	**5,407,346**	**2,747,526**	**1,937,616**

Other Neighbouring mines

Mining production rates as well as pit, dump and haulage locations for 2010 were also analysed for each of the nearby mines operating at that time. These mines/pits included Liddell Colliery opencut, Ravensworth/Narama, Integra West open cut, North open cut and Underground, and Ashton Northeast open cut. Emission estimates for these nearby mines were obtained from the estimates made in their individual EAs, and are summarised in **Table C2**.

Modelling sources for these mines have been located at the apparent points of major emission, as estimated from the locations of major dust sources shown in the EAs.

Table C2: Estimated TSP emissions from nearby modelled mines in 2010

Mine/Pit	TSP emissions for 2010 (kg/y)
Liddell Colliery open cut (**HAS, 2006**)	4,444,656
Ravensworth/Narama open cut (**PAEHolmes, 2009b**)	1,248,000
Integra Mine Complex (**URS, 2009**)	
Western Extension	1,917,799
North Open Cut	1,064,309
Underground Operations	198,024
Ashton Northeast open cut (**PAEHolmes, 2009a**)	2,738,318

APPENDIX 5

Groundwater Impact Assessment

SINCLAIR KNIGHT MERZ

SKM

Ravensworth East Resource Recovery (RERR) Project Groundwater Impact Assessment

For Umwelt (Australia) Pty Limited, on behalf of Xstrata Mt Owen (XMO) Pty Limited

- Final
- 11 December 2012

Ravensworth East Resource Recovery (RERR) Project Groundwater Impact Assessment

For Umwelt (Australia) Pty Limited, on behalf of Xstrata Mt Owen (XMO) Pty Limited

- Final
- 11 December 2012

Sinclair Knight Merz
ABN 37 001 024 095
100 Christie Street
NSW 2065 Australia
PO Box 164
St Leonards NSW 1590 Australia
Tel: +61 2 9032 2100
Fax: +61 2 9928 2224
Web: www.globalskm.com

Contents

Tables

Figures

LIMITATION: The sole purpose of this report and the associated services performed by Sinclair Knight Merz Pty Ltd (SKM) is to undertake a groundwater assessment for the RERR project in accordance with the scope of services set out in the contract between SKM and Umwelt. That scope of services, as described in this report, was developed with Umwelt.

In preparing this report, SKM has relied upon, and presumed accurate, certain information (or absence thereof) provided by the Client and other sources. Except as otherwise stated in the report, SKM has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

SKM derived the data in this report from a variety of sources. The sources are identified at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. SKM has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose of the project and by reference to applicable standards, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by SKM for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Kingsgate, and is subject to, and issued in connection with, the provisions of the agreement between SKM and Umwelt. SKM accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

Background

Sinclair Knight Merz Pty Limited (SKM) has been engaged by Umwelt (Australia) Pty Limited, on behalf of Xstrata Mt Owen (XMO) Pty Limited, to carry out a Groundwater Impact Assessment (GIA) for the Ravensworth East Resource Recovery (RERR) Environmental Assessment (EA) to enable XMO to continue open cut coal mining near Ravensworth in the Upper Hunter Valley region of New South Wales (**Figure 1-1**).

A regional numerical groundwater flow model has been developed as part of a broader investigation of groundwater impacts due to all Xstrata Coal NSW holdings in the Bowmans Creek area (*see* **Appendix A)**. This model has been developed to provide estimates of environmental impacts that may accompany further development of Xstrata Coal NSW (XCN) operations within the catchment and will provide estimates of the changes in groundwater heads that will occur as a result of mine dewatering operations and the associated changes to baseflow in the creeks draining to the Hunter River.

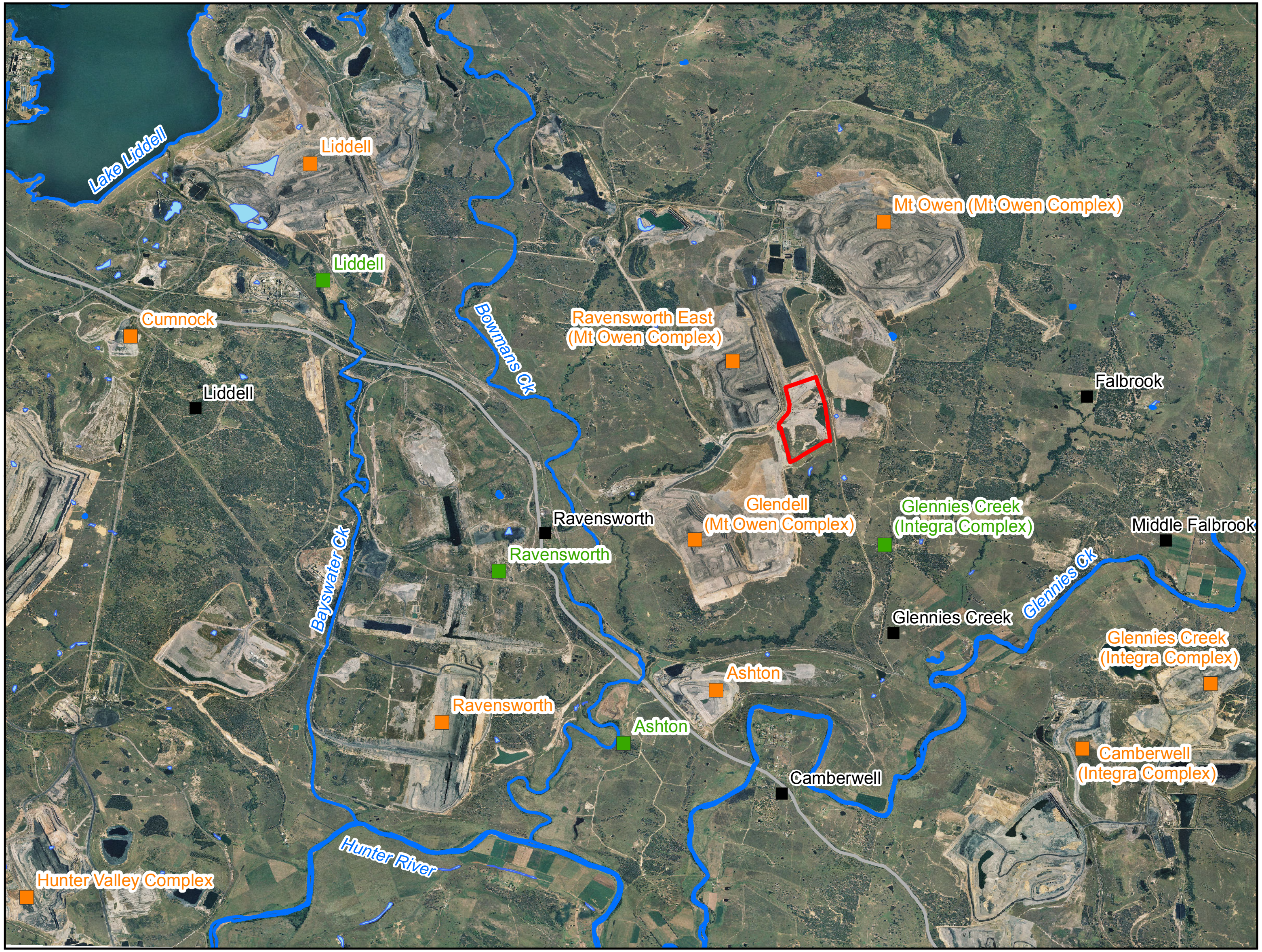
This regional model has been used to assess the impact of the proposed Ravensworth East Resource Recovery project and will also determine any impacts outside the lease area. A summary of the regional model development is provided in **Appendix A**. A summary of the results is provided here, with specific reference to Ravensworth East.

Ravensworth East Mine is part of the Mt Owen Complex, which consists of the Mt Owen, Ravensworth East and Glendell open cut mines. Mining in the area has occurred since the 1970s, initially at the Swamp Creek Mine (Pacific Power Pty Ltd) until mining ceased in 1991. The current development relates to Mining Leases (ML) 1415, 1475, 1476 and 1561. In 1999, a development application was lodged with Planning NSW (now the Department of Planning and Infrastructure (DP&I)) to continue operations at the mine. Development Consent DA 52-03-99 was granted by the Minister for Planning in 1999 for 20 years of continued mining operations at the re-named Ravensworth East Mine. The Ravensworth East DA boundary can be seen in **Figure 1-2**.

XMO is now seeking a modification under Section 75W of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) to allow XMO to continue mining within the RERR Mining Area to a depth of approximately 200m in an area previously the subject of a shallow open cut, known then as TP2. The proposed modification will be completed wholly within previously disturbed land (**Figure 1-3**) and will allow for efficient use of existing facilities and allow enhanced resource recovery by deepening current operations to target all coal plys from the Ravensworth Seam down to the Bayswater Seam within the Wittingham Coal Measures. This will allow extraction of an additional ~6Mt of coal.

The existing West Pit Overburden Emplacement Area will be used to emplace overburden from the RERR mining area.

Mines in the Ravensworth region



Mine locations

- Underground
- Open Cut
- RERR Mining Area
- Reservoir
- Stream
- Main road
- Locality

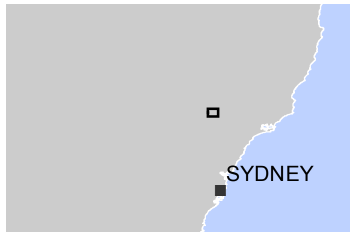
Sinclair Knight Merz does not warrant that this document is definitive nor freeof errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

[GDA 94]

A4 1:100,000

0 2

Kilometres



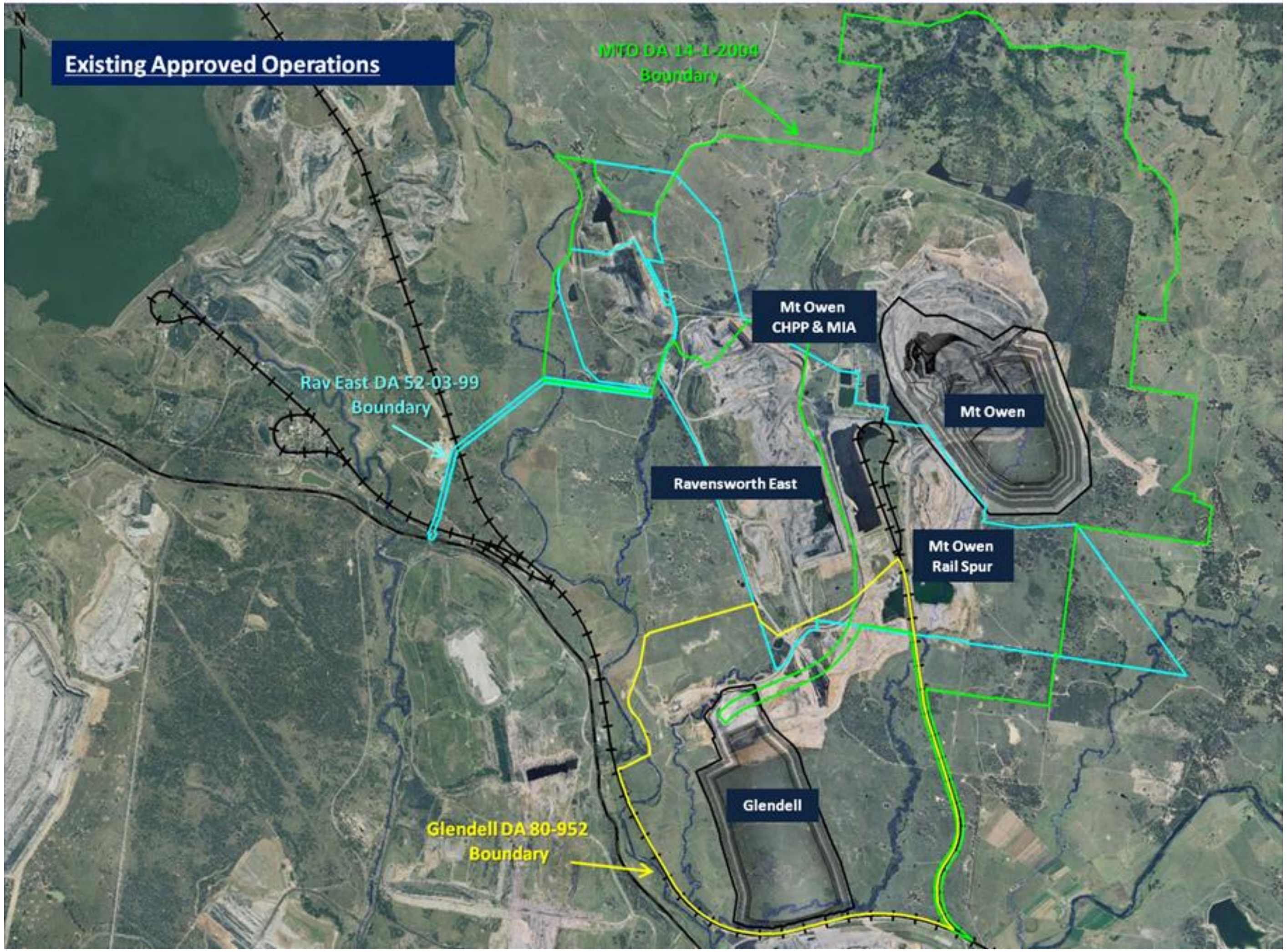
SINCLAIR KNIGHT MERZ

SKM

[FIGURE 1-1]

D:\Documents and Settings\landers\My Documents\Projects\Xstrata\GIS\Figures\RRER_005_rgc_v3.mxd

Prepared by : LA



- **Figure 1-2. Current development consents around Ravensworth East Mine (XMO, 2012)**

Ravensworth East Resouces Recovery Project

RERR Mining Area

Sinclair Knight Merz does not warrant that this document is definitive nor freeof errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

[GDA 94]

A4 1:18,851

0 0.5

Kilometres

SINCLAIR KNIGHT MERZ

SKM

[FIGURE 1-3]

This Report

This report collates the findings of the assessment of potential groundwater impacts associated with the proposed modification and includes an assessment of:

- groundwater inflow into the proposed open cut operations (RERR mining area), including possible water quality impacts;
- extent of depressurisation of the coal measures;
- impact on any aquifers (including alluvials);
- potential loss of water supply to local and regional users;
- the potential for, and degree of, connection between shallow and deep groundwater or between the mine and overlying streams;
- potential post-mining water level recovery; and
- potential impacts on groundwater dependent ecosystems.

The groundwater assessment also provides:

- an estimate of groundwater contribution to the operation's water balance;
- recommendations relating to the management of the groundwater resource, management of groundwater inflow in the operations and the impact groundwater may have on the operations water balance.

This report provides the necessary background and contextual information required to make an informed assessment of potential impacts to groundwaters (and any dependencies) in the region, in the context of the RERR proposed development.

Chapter 2 provides the legislative framework in which the mining operation exists.

Chapter 3 provides a summary of mining in the broader region surrounding the RERR area.

Chapter 4 gives a summary of the biophysical landscape and water regimes of the region, including the surface and groundwater observational data available to help inform our understanding of water dynamics in the vicinity of the RERR area and the broader region encompassed by the regional groundwater model.

Chapter 5 presented a summary of the numerical groundwater model including predictive results showing the potential groundwater drawdown that might occur under a projected climate sequence and the predicted groundwater contribution to pit inflows. Potential impacts to stream flow are also assessed. The assessment considers the potential impact from continued operations under the existing approved development and compares this to the proposed new development. The new development is also compared against the scenario where no mining was carried out.

Chapter 6 places the results within the context of an Environmental Impact Assessment, including assessment of water management practices. Chapter 7 summarises the findings of the groundwater assessment.

The numerical groundwater model is a fundamental tool to allow prediction of future potential impacts from proposed developments. It is, therefore, critical to attain a comprehensive understanding of the hydrogeological system of the region, including an assessment of all available hydrogeological data. The hydrogeological system is summarised using a conceptual hydrogeological model, which brings together and summarises all available hydrogeological data.

As understanding of the system advances there may be changes in the conceptual understanding of the mining strategy and consequent revisions to the regional model may be required. The regional groundwater model therefore must be seen as a continuously evolving tool that can be used to test understanding of the system and provide capacity to analyse predictive scenarios for future mine sequences.

Appendix A presents details of the numerical model.

Data Sources

Data used in preparing this report has been sourced from a number of locations. Detailed quantitative data available for this study is for the most part limited to Xstrata operations within the regional groundwater model extents (the “model extents”). That is, availability of data is predominantly associated with the Liddell, Mt Owen, Glendell and Ravensworth underground and surface operations. Summary data available in public reports for non-Xstrata operations within the model extents has been used where available**. Table 1-1** presents a summary of the data sources used in this report.

Table 1-1 - Summary of relevant data sources

Source	Related Mine Operation	Data Type	Timeframe
Aquaterra, 2009	Ashton Underground	• Piezometric elevations • Groundwater chemistry • Aquifer hydraulic properties • Alluvium leakage estimates	2006 – 2009
Beckett, 1987	Liddell: Hazeldene U/G Liddell U/G Foybrook O/C Swamp Creek O/C	• Alluvium leakage estimates • Mine inflow data	1987
MER, 1998	Ravensworth East Open Cut Mine	• Hydrochemistry • Hydraulic properties	1995-1997
MER, 2011a	Mt Owen Complex	• Piezometric elevations • Groundwater salinity • Aquifer hydraulic properties • Baseflow estimates (modelled)	2008 – 2010
MER, 2011b	Ravensworth Underground	• Piezometric elevations • Groundwater chemistry • Aquifer hydraulic properties • Baseflow estimates (modelled) • Alluvium leakage estimates (modelled) • Mine inflow estimates (modelled)	Pre-mining & 2010 - 2024 (modelled) and 2000 – 2011 (measured) 1980 - 2040 2005 - 2035
Probert & Stevenson, 1970	Liddell U/G	• Mine inflow data	1970
Umwelt, 1997	Ravensworth East Open Cut Mine	• Historical information	1972-1999
Umwelt, 2008a	Liddell Coal Operations	• Piezometric elevations • Groundwater quality	2002 – 2007
Umwelt, 2008b	Mt Owen Complex	• Piezometric elevations • Groundwater quality • Mine inflow data (modelled)	2005 – 2008 2008 - 2023
URS, 2009	Integra	• Piezometric elevations • Groundwater quality • Aquifer hydraulic properties • Mine inflow data (modelled) • Alluvium & creek leakage estimates (modelled)	2007 - 2009 2008 - 2040
Xstrata, 2011	Glendell	• Piezometric elevations • Groundwater quality	2008 – 2011

2. Legislative Framework

Water Management Act (2000) and Water Sharing Plans

The object of the *Water Management Act 2000* is the sustainable and integrated management of the state's water for the benefit of both present and future generations.

The *Water Management Act 2000* recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land. The main tool *the Act* provides for managing the State's water resources are Water Sharing Plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source.

Since the legislation was passed in 2000, some amendments have been necessary to better implement the new arrangements and also give effect to the ***National Water Initiative*** signed on 25 June 2004, including creation of perpetual or open-ended water licences. *The Act* was also amended in 2008 to strengthen compliance and enforcement powers in response to water theft.

The Act has been progressively implemented and since 1 July 2004 the new licensing and approvals system has been in effect in those areas of NSW covered by operational WSPs. These areas cover most of the State's major regulated river systems and therefore the largest areas of water extraction. As WSPs are finalised and commenced for the remainder of the state, the licensing provisions of *the Act* are introduced extending the benefits for the environment of defined environmental rules and for licence holders of perpetual water licences, including greater opportunities for water trading.

By the end of 2010, around 90 per cent of the water extracted in NSW was covered by the *Water Management Act 2000*.

Water Sharing Plans

WSPs are being progressively developed for rivers and groundwater systems across New South Wales. These plans protect the health of our rivers and groundwater while also providing water users with perpetual access licences, equitable conditions, and increased opportunities to trade water through separation of land and water. The Water Sharing Plan relevant to operations at Ravensworth East is *The Hunter Unregulated and Alluvial Water Sources Water Sharing Plan 2009*, which took effect in 2009. Under the WSPs, distinct water sources are identified as the primary unit of water management and are used to define and limit surface and groundwater allocations for a given area. Alluvial groundwater extracted from the formations in the area around Ravensworth East would be designated as from the Jerrys Management Area, or from the Jerrys Water Source.

The water sharing rules for licences in alluvial aquifers are based on the following principles:

- A recognition that in alluvial river reaches, the surface and groundwater is considered to be a single resource.
- Manage growth in use through a common set of available water determinations for both surface and groundwater users.
- Manage existing bores located within 40 metres of an unregulated river to surface water daily access rules (from year six of the plan), except access licences for stock and domestic, local water utility or food safety or essential dairy care purposes. These are not subject to access rule constraints.
- Prohibit new bores within 40 metres of a third order or higher stream except for bores as a result of a conversion of an unregulated river access licence or when:
  - They are drilled into the underlying non-alluvial material, and the slotted intervals of the production bore commence deeper than 30 metres.
  - The applicant can demonstrate that the bore will have minimal impact on base flows in the stream.
- Allow trading of groundwater licences.
- Manage the trade of alluvial groundwater licences with the same trading rules as the adjoining surface water. In effect, this would prohibit trading into areas identified as having high in-stream values, or are characterised as having high hydrological stress.
- Trade, where permitted between water sources, would only be from a river alluvial area to another river alluvial area.
- Manage to a combined long-term average annual extraction limit for the unregulated surface water and alluvial groundwater. This would be based on the sum of existing unregulated and alluvial groundwater entitlement, plus a basic landholder rights estimate, plus an allowance for exemptions such as water for Aboriginal Community Development or town water purposes (where these apply).
- Permit within water source licence conversion between licence categories, assignment or allocation of account water from unregulated river to alluvial groundwater licences but not the reverse (i.e. one way only).
- Minimise and manage any local impacts such as groundwater pollution or drawing down of the water table as a result of groundwater extraction.
- Protect groundwater dependant ecosystems.
- Apply the standard local impact rules for alluvial groundwater and standard provisions for identified Groundwater Dependent Ecosystems.

Access licences for groundwater extraction under these Plans have thus been subject to annual limits rather than daily management. When a plan commences, surface water licences in all unregulated water sources are subject to cease-to-pump rules (excluding licences held by local water utilities, licensed stock and domestic users, and licences used for food safety and essential dairy care). From year six of the plan these rules will also apply to any users extracting from any alluvial via a work located within 40 metres of the high bank of a river. This recognises the high degree of connectivity between alluvial aquifers and river flows and the potential impact that pumping from an aquifer can have on surface water flows. In instances where the existing cease-to-pump rule under the *Water Act 1912* is based on a higher flow rate than the rule proposed by the plan, the existing cease to pump rule will take precedence.

A Water Sharing Plan also sets out schedules of high priority (high conservation value) groundwater dependent ecosystems and actions to be undertaken to protect them. There are no listed groundwater dependent ecosystems that will be affected by this proposal.

Aquifer Interference Policy

In September 2012, the NSW Government released the policy for the licensing and approval of aquifer interference activities (NSW Office of Water, 2012). The *Water Management Act 2000* defines an aquifer interference activity as that which involves any of the following:

- The penetration of an aquifer.
- The interference with water in an aquifer.
- The obstruction of the flow of water in an aquifer.
- The taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.
- The disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

Any activity that results in a reduction in the groundwater resource pool of three megalitres per year or more, or at an instantaneous rate of greater than 5 litres per second will require a groundwater extraction and aquifer interference license. The primary potential interference posed by this project involves the obstruction of flow of water in an aquifer. Notwithstanding, if the activity occurs within a Water Protection Zone or Limited Intrusion Zone or on Biophysical Strategic Agricultural Land (BSAL), assessment of environmental impacts are required and minimal harm criteria thresholds needs to be met.

The alluvial systems of the Hunter River (including the tributaries of Bowmans and Glennies Creek) are listed as BSAL. These alluvial areas associated with Bowmans Creek, however, have undergone significant (approved) disruption in the course of previous and current mining activities as approved by the DP&I through previous Development Applications.   No BSAL will be impacted as a result of the proposed modification.

3. Mining Context

To place the Ravensworth East operations within the context of the regional mining operations, a summary of coal mining activities that are encompassed in the regional groundwater model extents are presented below. Critically, the operations of these mines must be evaluated through the regional groundwater model in order to evaluate the incremental impacts (if any) caused by the Ravensworth East operations, now and into the proposed future. Regional mine locations are shown on **Figure 1-1**. The geology of the region and stratigraphy of the coal seams are described in Appendix A2.

History of Mining in the Region

Ravensworth East is an existing open cut coal mine located approximately 25 km northwest of Singleton in the Upper Hunter Valley region of New South Wales. The region surrounding the Ravensworth East mine has been subject to extensive underground and open-cut coal mining since the early 20th century, which has disrupted the pre-mining surface water and groundwater systems.

Mt Owen Complex

The Mt Owen Complex (XMO) includes the Ravensworth East, Glendell and Mt Owen open cut mines. The Ravensworth East open cut commenced operations in 2000; the Mt Owen open cut commenced operations in 1993 and the Glendell open cut commenced in 2008. The Mt Owen Complex currently mines or has previously mined coal seams from the locally known Ravensworth seams (also known as the Mt Arthur, Piercefield, Vaux and Broonies seams elsewhere) down to Hebden at depths of more than 250m. Ravensworth East mines seams down to Bayswater and Glendell mines coal seams down to Barrett.

Liddell Coal Operations

The Liddell Colliery is located northwest of Ravensworth. Mining at Liddell has been continuous since the 1950s, prior to which operations were intermittent. Underground operations at Liddell commenced in 1923 and open cut operations in 1946 (NSW Department of Mineral Resources, 2010). The current open cut operations commenced in 1990 and as of 2011, the approved mining and dump footprint of Liddell is 1,207 hectares. (MER, 2011).

The Liddell open cut mine is currently progressing in a southeast direction, but will not extend beyond a buffer zone to the west of Bowmans Creek. The coal seams mined in 2010 were Lemington down to Barrett (NSW Department of Mineral Resources, 2010).

Historic Liddell underground operations are located within, and beyond, the southeast extents of the Liddell open cut. These operations were bord and pillar, followed by long-wall, and extracted coal from the Pikes Gully, Liddell and Barrett seams. Underground operations at Liddell have ceased and are being progressively intercepted in the open cuts (MER, 2011).

Ravensworth Surface and Underground Operations

The Ravensworth Open Cut and Underground operations are located to the south-west of Ravensworth East Mine. The old Ravensworth No. 2, Ravensworth South and the current Narama open cuts have historically extracted coal down to the Bayswater seam. These operations have left a continuous synclinal open cut shell over a north-south distance of more than 7 km, which is now mostly filled with spoil (excluding the Narama open cut and ramp), fly ash and tailings. Ravensworth underground mine is located beneath the old Ravensworth open cut workings, it extracts coal from the Pikes Gully seam. The long wall panels are mined in a southward direction. Future long walling will advance into the underlying Liddell and Barrett seams (MER, 2011).

Non-Xstrata workings

Other mining operations in the area include the Integra Complex, the Hunter Valley Complex and the Ashton open cut and underground workings.

Integra Complex

The Integra Complex, formed in 2006 through the integration of the former Glennies Creek Colliery and Camberwell Coal Mine, consists of Integra underground and open cut workings. The open cut workings include the original North Pit, where mining was undertaken between 1991 and 1999. This open cut has since been backfilled with waste rock. The open cut workings also include the South Pit, the North Pit and the South Pit extension (Western Extension). Mining within the South Pit started in 1991 and ceased in March 2011. Backfilling and rehabilitation is now taking place. The Western Extension commenced in February 2011. All open cut operations have targeted seams from Arties through to the Hebden seam (R. W. Corkery & Co. Pty. Limited, 2011).

The Integra longwall underground operations target the Middle Liddell seam and are progressing northwards from Longwall 11. Integra underground commenced in 1999 and has a projected life extending into the 2030s. Future mining is proposed in the deeper Hebden coal seams.

Ashton

Ashton Coal open cut and underground operations are located southeast of Ravensworth East Mine. The open cut operations commenced in 2004 and mine coal from the Pikes Gully seam down to the Barrett seam. The underground operations extract longwall panels from the Pikes Gully seam.

The Hunter Valley Complex

The Hunter Valley Complex is located southwest of the Ravensworth East Mine and consists of the West Pit (Previously Howick Pit), the North Pit, Carrington Pit, Cheshunt and Riverview Pits and the Lemington South Pit. The West Pit is one of the oldest open cuts in the Hunter Valley and first commenced production in 1952. It mined seams from Bayswater down to the Barrett seam. The North Pit commenced in 1979 and ceased in 2003 with rehabilitation due to be finished by 2020. The

Carrington Pit, which sits on the western boundary of the North Pit, commenced operations in November 2000. This open cut mines seams from Broonies down to the Bayswater seam. The Cheshunt Pit incorporates the former Lemington North Pit with a new strip alignment that commenced in 2001. The seams mined in the Cheshunt Pit are Warkworth down to Vaux. However, a recent approval means that as of early 2011 all seams down to Bayswater will be mined. The Riverview Pit commenced in 1991 using dragline operations extracting coal from Woodlands Hill down to Bowfield coal seams. The Lemington South Pit, which commenced production in 1971, has currently suspended operations but mined coal seams down to and including the Piercefield seam (Coal and Allied Operations Pty Limited, 2010).

4. Regional Setting

Climate

The climate of the region can be described as temperate, with hot summers and cool winters. The average daily maximum temperature ranges from around 32 °C in January to 17 °C in July. Rainfall data from two nearby Bureau of Meteorology weather stations (Ravensworth station (Hillview) located just southwest of Ravensworth East and Bowmans Creek station located 24 km north) and evaporation data from the BOM Scone SCS weather station, located approximately 45 km north of Ravensworth East, are presented in **Table 4-1**. Rainfall at Ravensworth averages 660 mm/yr with summer months having the highest rainfall. Rainfall data from the Bowmans Creek weather station, located in the upper parts of the Bowmans Creek catchment to the northeast of the proposed modification, shows an annual rainfall some 32% higher than Ravensworth at 871 mm/yr. This is probably a result of increased rainfall at the higher elevations on the flanks of the Hunter Valley. Average evaporation rates exceed average rainfall rates in almost every month of the year (**Table 4-1**).

- **Table 4-1 - Rainfall averages (mm) adjacent to (Ravensworth) and north of (Bowmans Creek) Ravensworth East Mine (source: Bureau of Meteorology)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall Ravensworth (Hillview)	82.8	69.9	59.8	54.7	50.3	47.4	41.8	35.5	40.7	49.3	55.2	66.1	**660**
Rainfall Bowmans Creek	108.0	94.3	92.4	58.1	61.5	67.9	47.3	47.2	57.3	68.7	84.1	85.0	**871**
Evaporation	220	174	155	105	68	48	56	84	117	155	183	220	**1585**

Rainfall data: Ravensworth (Hillview) (BOM Station 061028 – 1911-1979);
Bowman's Creek (BOM Station 061270 – 1969-2012)
Evaporation: Scone SCS (BOM Station 061089)

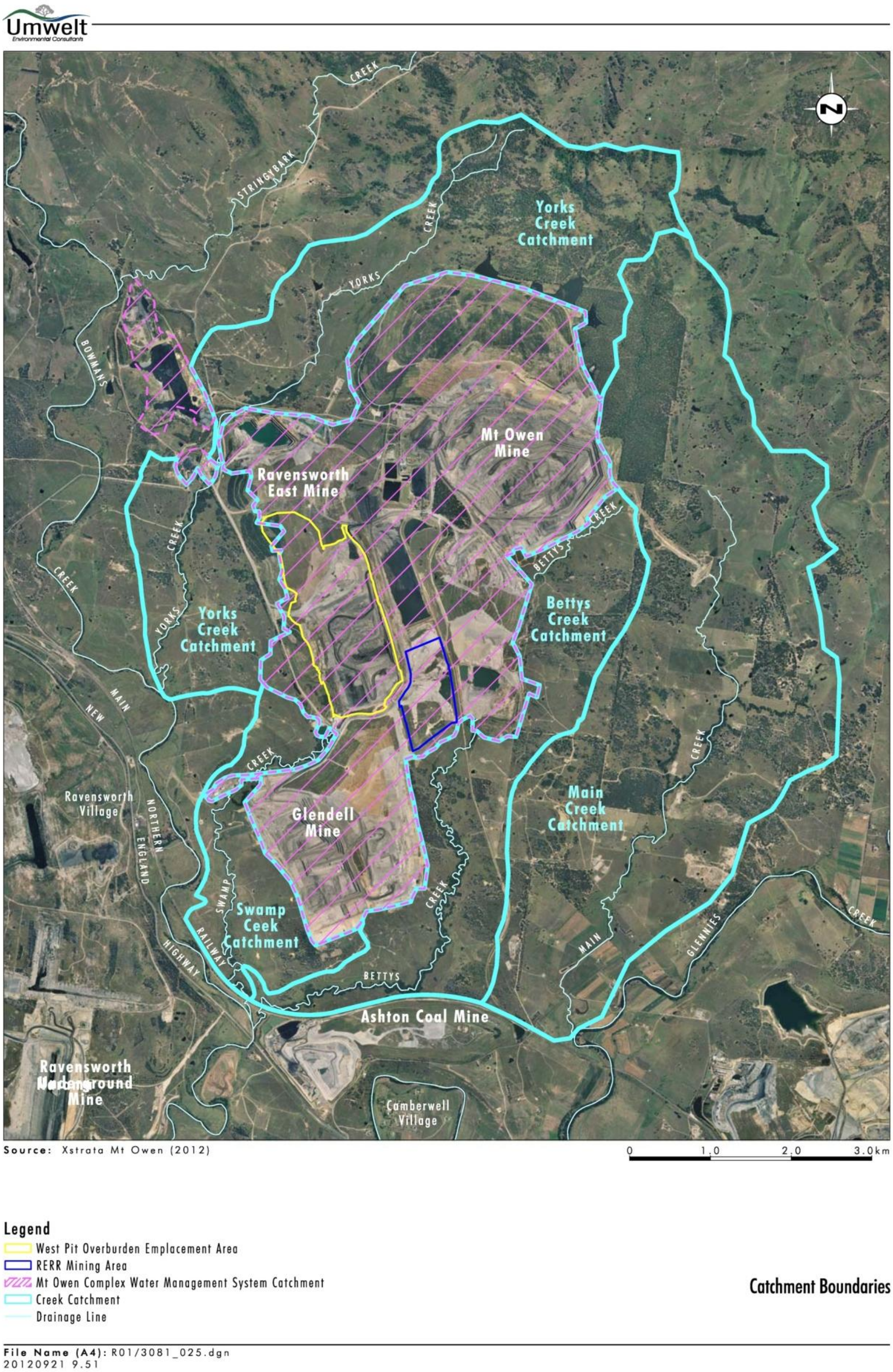
Topography and Surface Drainage Systems

The topography of the broader region in which Ravensworth East Mine sits can be defined in two parts:

1) gently undulating plains associated with the flats of the Hunter River Valley and its major tributaries, and
2) elevated rangeland associated with the tributaries on the northern flank of the Hunter Valley.

Ground elevations generally range around 100 to 150 mAHD within the region, decreasing towards 50 m AHD in the south towards the Hunter River. A northwest to southeast trending range line defines the northern flank of the Hunter River Valley and approaches an elevation of 550 mAHD north of the Mt Owen Complex. This is associated with outcropping Carboniferous-age rocks. The

Hunter River crosses 8 km to the south of Ravensworth East Mine and several tributaries to the Hunter River drain from the range to the north and east. Prominent among these is Bowmans Creek, which drains southward between the Mt Owen Complex to the east and Ravensworth Underground and Liddell Operations to the west. Ravensworth East Mine is situated across three tributaries to Bowmans Creek: York Creek to the north; Bettys Creek to the south and Swamp Creek has been diverted by the mine operations (**Figure 4-1**). These are ephemeral tributaries and completely cease to flow during extended periods of drought.



■ **Figure 4-1 Drainage catchments surrounding the Ravensworth East Mine (Umwelt, 2012)**

Groundwater - Surface Water Interaction

NSW Office of Water stream gauge records have been evaluated and indicate that the streams in the region are naturally variably losing and gaining, depending on the particular reach of stream being assessed and its location in the landscape. That is, while particular reaches are more likely to be gaining (receiving discharged groundwater) and others more likely to be losing (leaking beneath the river bed), these reaches are not consistently so, and may change depending on climatic conditions and local weather conditions. All creeks immediately adjacent to the RERR mining area are ephemeral and more generally represent losing streams.

With regard to groundwater implications, gaining streams indicate that groundwater levels are (at least for a portion of time) at or above the level of the stream bed. The contribution groundwater makes to stream flow is referred to as baseflow and this can be modelled using appropriate constraints in the groundwater model. Where streams are predominantly losing (leaking water to the sub-surface), a buffer zone between the stream and the water table exists which will expand (deepen) and contract (groundwater comes closer to the surface) depending on the amount of deep drainage reaching the water table to become recharge. These processes can operate on small as well as large scale and are critically constrained (spatially and temporally) by the level of observational data that can be used to calibrate the model.

A stream gauge was constructed on Yorks Creek (210049) in 1958 and remained in operation to 1968, providing a useful pre-mining record of stream flow (refer to **Figure 4-2** for streamflow record). The Creek's location can be seen in **Figure 4-1**. The flow duration curve for this Creek (**Figure 4-3**) shows it to be a highly ephemeral creek (75% no flow).

Yorks Creek is similar in form to Bettys Creek and is probably indicative of flow in that catchment also. The highly ephemeral nature of these creeks also suggests that there is no groundwater interaction (baseflow) with these creeks.

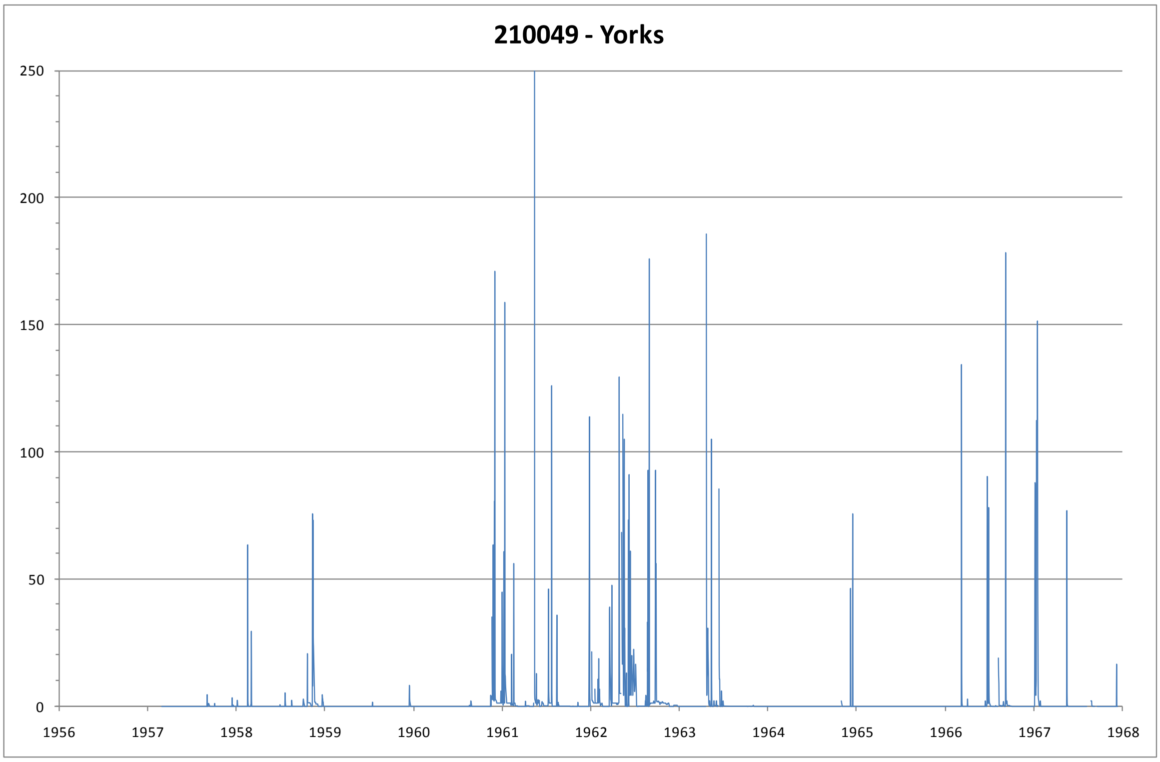


Figure 4-2 Stream flow record for stream gauge 210049, established on Yorks Creek between 1958 and 1968

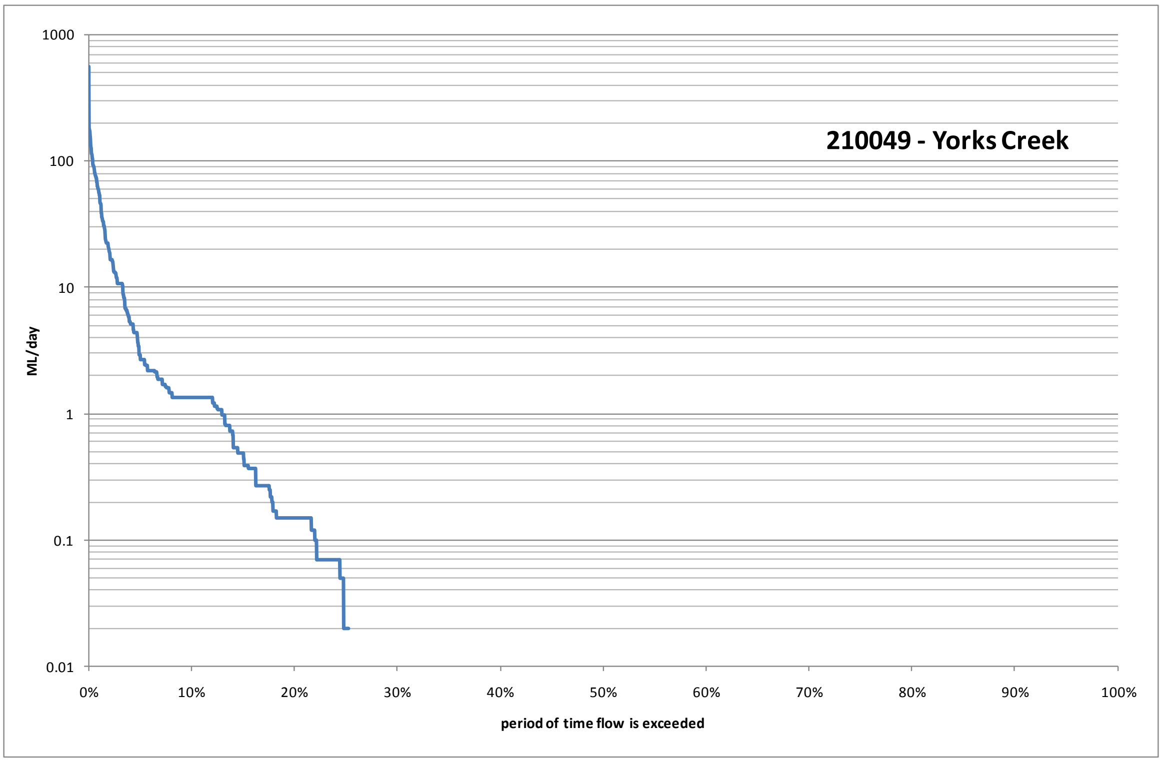


Figure 4-3 Flow duration curve for stream gauge 210049, established on Yorks Creek between 1958 and 1968

Hydrogeological Setting

Hydrostratigraphy

In terms of the groundwater systems of the region, there are two geological units of interest which form the main aquifers:

- the coal seams of the Wittingham Coal Measures; and
- alluvium of the Hunter River and its tributaries, including Bowmans Creek.

Previous investigations (e.g. Aquaterra, 2009) have identified minor perched groundwater within the weathered regolith overlying the Permian coal measures, although it is limited and not encountered in all boreholes.

Permian Coal Measures

The hardrock aquifer associated with the Permian coal measures exhibits varying levels of groundwater storage and transmissivity. Within the coal measures, the most permeable horizons are the coal seams themselves; non-coal interburden strata generally exhibit permeabilities that are one to two orders of magnitude less than the coal seams. Secondary porosity in the non-coal strata may be developed within fractures and joints, however, the degree to which this occurs is quite variable and generally unpredictable.

The coal seams represent the most permeable hardrock strata through the presence of cleating and jointing, although there is little evidence of structure-related fracturing. Horizontal permeabilities (i.e. parallel to bedding) are generally significantly higher than vertical permeabilities within the coal seams, although subsidence-related cracking may enhance vertical permeabilities of both coal seams and interburden strata in areas of underground workings. Regionally, the coal seam aquifers are generally confined above and below by the interburden strata.

Coal Seams Hydraulic Properties

The hydraulic properties of the coal measures in the region (coal seams and interburden) have historically been measured in a number of ways, generally as part of environmental investigations for various mining projects and include:

- airlift testing;
- packer testing; and
- laboratory core testing of non-coal interburden.

Very few measurements have been made for the shallow Burnamwood seams that constitute the targets for Ravensworth East. As part of the on-going works associated with the Mt Owen Complex, a new series of monitoring bores have been installed and are being tested for their hydraulic parameters. Once established, these will provide additional confidence in the conceptual understanding of the groundwater system and the representativeness of the groundwater model (**Appendix A**). Currently, model parameters for the upper seams are based on values of lower seams together with the few analyses carried out as part of the earlier Ravensworth East Development Application (MER, 1998).

Coal Seams Groundwater Quality

The groundwater quality of the coal seams and interburden is generally variable. Quarterly groundwater monitoring has been conducted for bores in the immediate vicinity of the RERR mining area since 2006. pH was found to range between 6.5 and 11, with high pH levels indicative of coal measures input. The electrical conductivity (EC = salinity) ranges up to 20,000 µS/cm, and the groundwaters in this part of Bowmans Creek catchment are among the most saline observed in throughout the catchment, though fresher zones are locally present at some locations including near the RERR mining area (e.g. NPZ4).

Following the hydrochemical province classification of Kellet et al. (1989), the coal seam groundwaters are designated WI2 (of Na-Cl type). The proportions of the major ions can generally be described as Na>Mg>>Ca and Cl>SO_4>HCO_3. The interburden groundwater quality is not monitored but often exhibits a greater proportion of HCO_3 (MER, 1998, 2011).

Alluvium

Previous investigations have shown that the Hunter River alluvium is deeper and generally more transmissive than the alluvium of the smaller tributaries such as Bowmans or Glennies Creeks. The basal coarse grained unit of the alluvial sequence forms the main aquifer of the alluvium and in places may be confined by the overlying fine grained terrace deposits. Hydraulic conductivity is known to vary significantly in each of the units of the alluvium, and appears to have been caused by palaeo-geomorphology and drainage conditions during deposition.

Alluvial Aquifer Hydraulic Properties

The hydraulic properties of the alluvium across the groundwater model extents have historically been measured in a number of ways, generally as part of environmental investigations for various mining projects:

- slug testing of groundwater wells
- pumping tests of groundwater wells.

Hydraulic testing data for the alluvium are generally much more limited than data for the coal measures. Table 4-2 and Table 4-3 present a summary of estimated hydraulic parameters for the alluvial aquifer.

Table 4-2 - Summary of hydraulic conductivity values for the alluvial aquifers (m/day)

Unit	Previous Studies within the regional groundwater model extents		
	MER, 2011a	MER, 2011b	Aquaterra, 2009
Bowmans Creek Alluvium	1.0×10^{-2} to 5.0×10^{1}	1.0×10^{1} (Kh and Kz)	7.0×10^{-1} (median Kh)
Glennies Creek Alluvium			6.0×10^{-1} (geometric mean Kh)
Hunter River Alluvium			5.0×10^{1}

Notes: Kh = horizontal hydraulic conductivity
Kv = vertical hydraulic conductivity

Table 4-3 - Summary of storage values for the alluvial aquifers

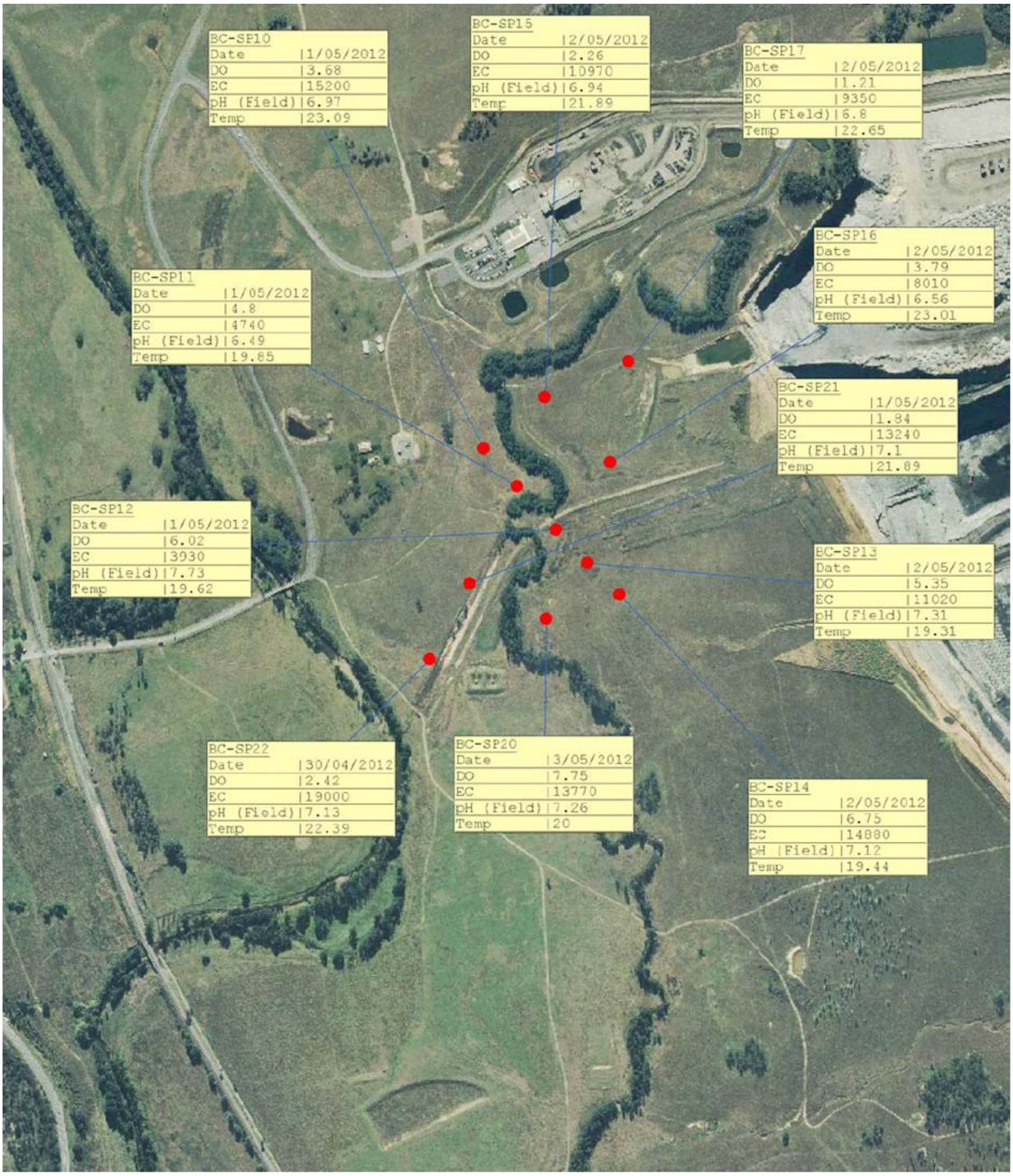
Unit	Previous Studies within the regional groundwater model extents		
	MER, 2011a	MER, 2011b	Aquaterra, 2009
Bowmans Creek Alluvium	Sy = 1.0×10^{-1} to 2.5×10^{-1}	Ss – 1.0×10^{-5} Sy – 5.0×10^{-2}	S = 1.0×10^{-4} Sy = 5.0×10^{-2}
Glennies Creek Alluvium			S = 1.0×10^{-4} Sy = 5.0×10^{-2}
Hunter River Alluvium			S = 1.0×10^{-4} Sy = 1.0×10^{-1}

Notes: S = confined storativity
Ss = specific storage (1/m)
Sy = unconfined specific yield

Alluvial Aquifer Groundwater Quality

The groundwater quality of the alluvial aquifer near the RERR mining area is variable. Bi-monthly groundwater monitoring was conducted for the period 2002 – 2007 and measured the pH to range between 3.2 and 9.6, and the EC to range between 648 and 5480 µS/cm. The major ionic composition can be described as Ca>Na>>Mg and HCO_3>Cl>SO_4 for the Hunter River alluvium; and Ca-Na>Mg and HCO_3>Cl>SO_4 for the minor drainages alluvium.

Recently, a new series of shallow monitoring bores has been installed near the confluence of Swamp and Bowmans Creek, just to the southwest of Ravensworth East Mine. These have been sampled and indicate that the salinity of the shallow groundwaters in the alluvium in this area is generally high ranging from 4,000 to 19,000 EC (Figure 4-4).



- **Figure 4-4 Field chemistry of samples from the recently (June 2012) installed standpipes on Swamp Creek where it joins the Bowmans Creek alluvium, south-west of the RERR area**

Hydrograph analysis

Data Sources and Frequency of Measurement

Groundwater data are available from monitoring networks associated with mines adjacent to Ravensworth East, such as the Xstrata operations at Glendell and Mt Owen, and the Integra and Ashton underground operations to the south. The monitoring networks consist of piezometers that have been installed at various depths in coal seams, interburden strata and alluvium associated with Bowmans Creek, Glennies Creek (and their tributaries) and the Hunter River.

The longest continuous monitoring period for bores around Ravensworth East Mine is from March 2005 until December 2011, with 9 bores having data available for this period. In the early stages of monitoring, three bores were measured on a monthly basis. However, since June 2006, all groundwater level measurements have been quarterly at most (March, June, September, and December). An additional 12 bores have quarterly data available for the period June 2006 to December 2011. The highest resolution of data is in the period September 2008 to March 2011, with an additional 8 bores having quarterly groundwater level monitoring data available.

Locations of bores used in this analysis are shown in **Figure 4-5** and hydrographs are presented in **Figure 4-6** and **Figure 4-7**. Bores designated “small” tap the alluvial aquifer; those labelled “large” extend to the coal measures.

Ravensworth groundwater monitoring bores

- Monitoring bore
- RERR Mining Area
- Stream
- Reservoir
- Main road
- Locality

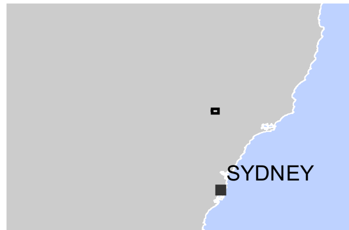
Sinclair Knight Merz does not warrant that this document is definitive nor freeof errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

[GDA 94]

A4 1:63,360

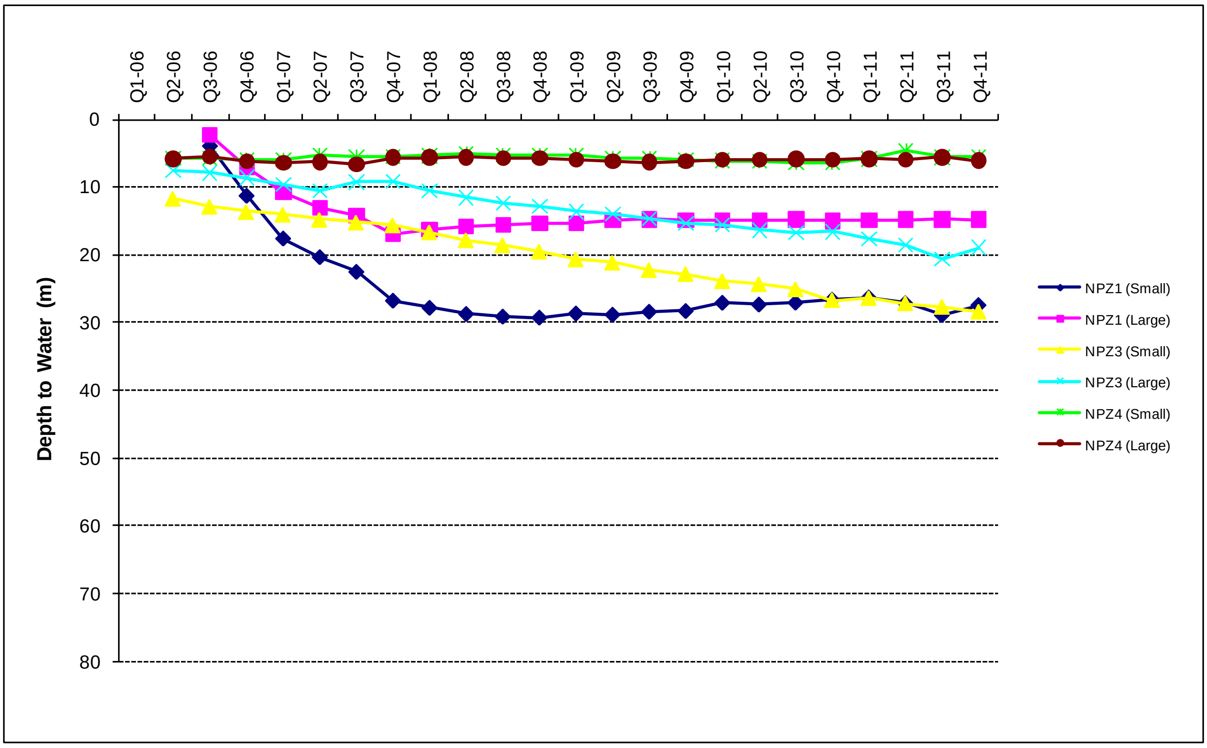
0 1.6

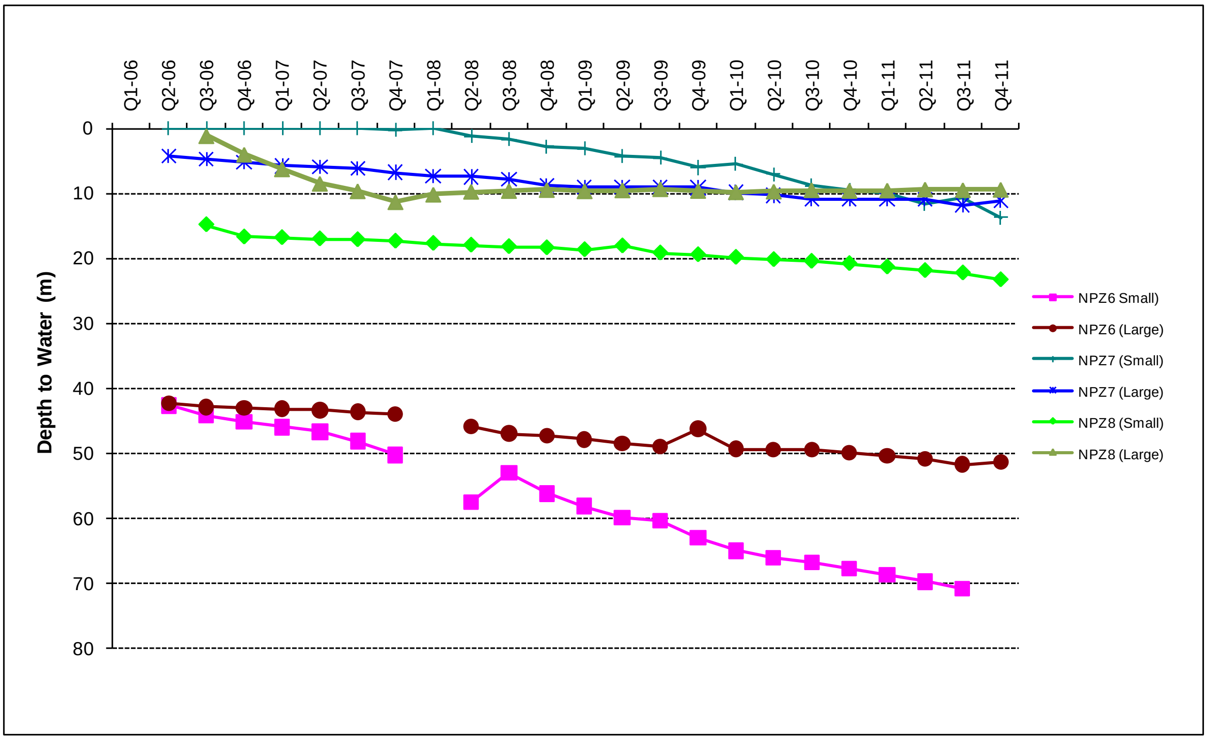
Kilometres



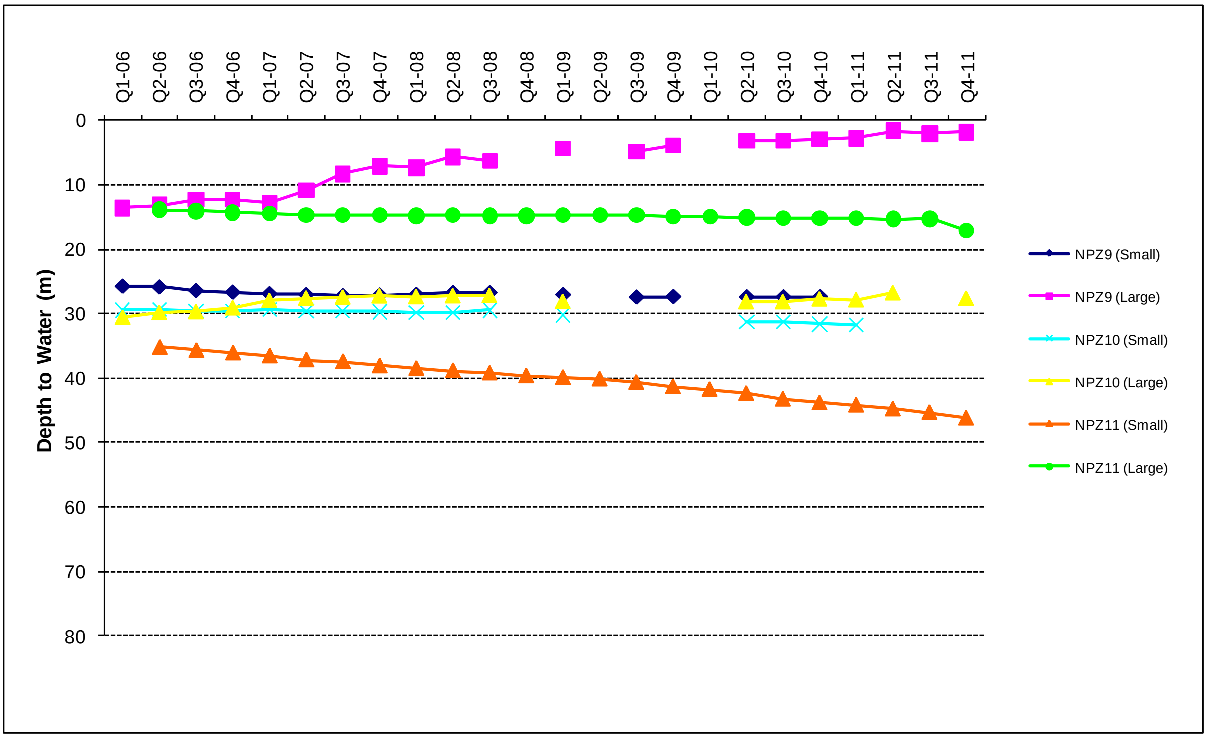
SINCLAIR KNIGHT MERZ SKM

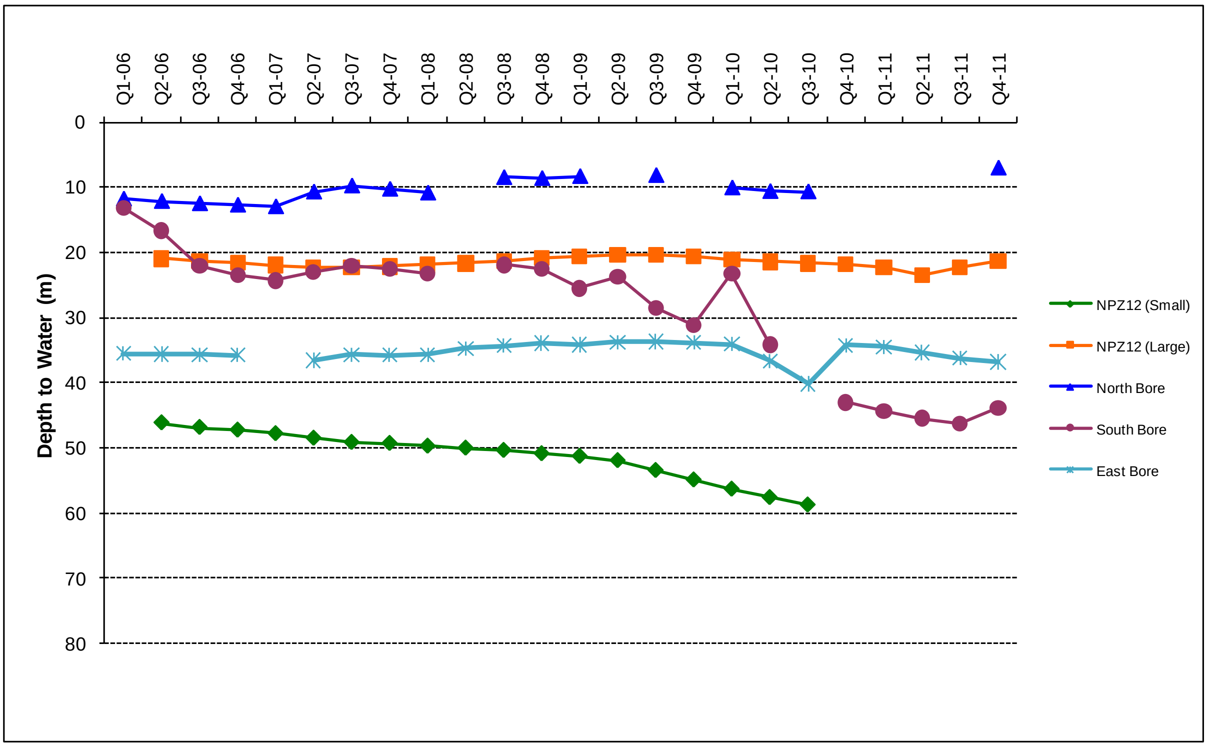
[FIGURE 4-5]





- **Figure 4-6 Depth to water table for bores in the vicinity of Ravensworth East**





- **Figure 4-7 Depth to water table for bores in the vicinity of Ravensworth East**

Alluvial Aquifer (NPZ Small)

Overall Trends

The majority of bores south of the Mt Owen and Ravensworth East open cuts display an overall decreasing trend in groundwater levels for the monitoring period (**Figure 4-6**, **Figure 4-7**). Exceptions include NPZ10, located in the vicinity of the tailings emplacement rail loop at the north-east corner of the RERR mining area, and South Bore, located along Betty's Creek. Another bore, NPZ15, recorded a single measurement with an increase in groundwater level, however, this value is much shallower than an otherwise declining trend at this bore and is considered anomalous.

Bores which do not have an overall declining trend include: North Bore and East Bore, to the east of the Mt Owen open cut; and NPZ4 located to the west of Mt Owen open cut. Groundwater levels in these bores appear to have a variable response to rainfall.

The only bore which has an overall increasing trend in groundwater levels is NPZ10. Umwelt (2008) proposed that the increasing trend up until that time in a nearby bore NPZ9 was attributed to the change of operation and continual filling of the tailings emplacement area adjacent to the rail loop. The same explanation may apply for NPZ10 for the current monitoring period.

Groundwater levels measured in bore NPZ1, located east of Mt Owen mine, display a sharp decreasing trend from 2006 to 2008, correlating with a declining trend in cumulative deviation from mean rainfall, followed by an increase, and then stabilisation at lower than previous levels.

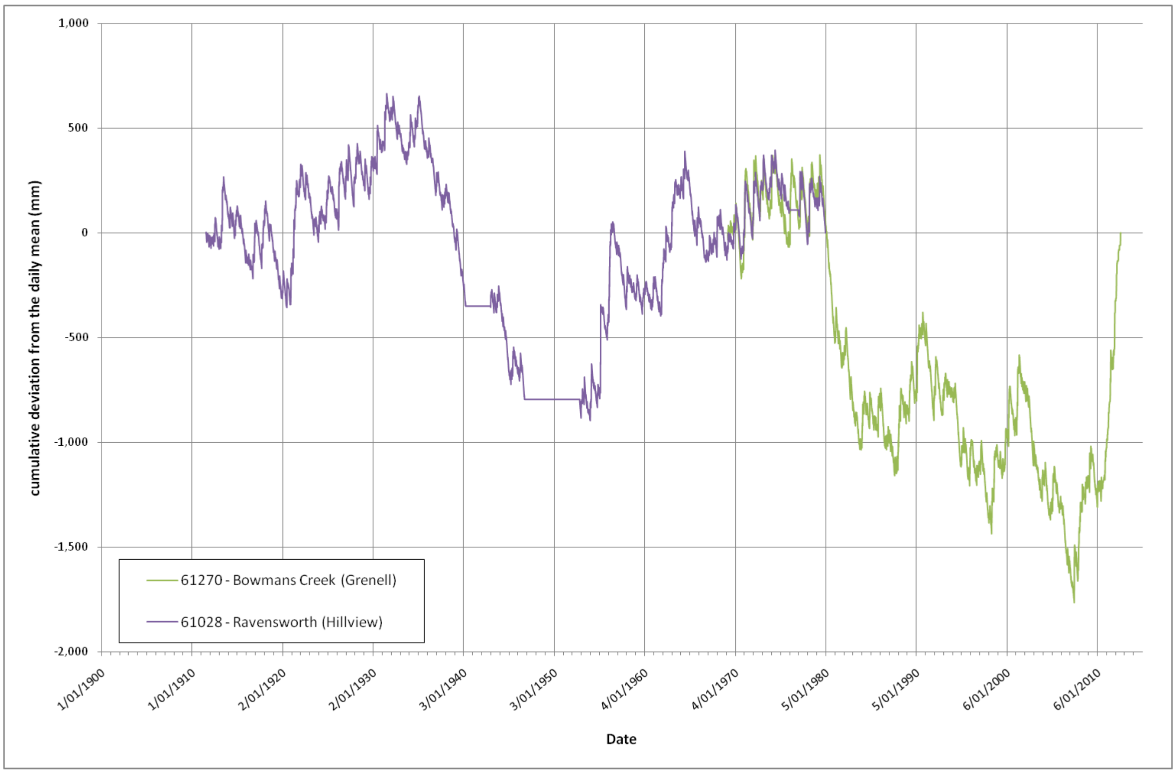
Response to Rainfall

The shallow bores should show a strong relationship to rainfall events and trends. This was analysed using cumulative deviation from daily mean rainfall charts for nearby rainfall data (**Figure 4-8**). The fastest apparent groundwater responses to rainfall (0 to 3 months) were observed in bores NPZ4, North Bore and GW2. All of these bores are located up gradient of the open cuts.

The slowest apparent groundwater responses to rainfall (9 to 15 months) were observed in bores NPZ6 and NPZ7, located down gradient of the open cuts. The groundwater in bore NPZ1, located southeast of Mt Owen open cut, is not responding strongly to rainfall and the hydrographs do not recover to the levels at the start of the monitoring period. This may reflect drawdown from mining activities.

Several bores do not display a visible response to rainfall and include: NPZ3, NPZ9, NPZ11, NPZ12, NPZ13, NPZ14, NPZ15, and NPZ16. Most of these bores are located adjacent to or down gradient of the Ravensworth East mine, which also may reflect the influence of mine related drawdown.

It is therefore possible that the effects of groundwater drawdown from mining activities are masking groundwater responses to rainfall. The bores up gradient of the Mt Owen complex recorded the fastest responses to rainfall; the intermediate bores recorded the slowest or muted responses to rainfall; and the bores down gradient recorded no response to rainfall.



- **Figure 4-8 Cumulative rainfall deviation from the daily mean for stations near Ravensworth East.**
  Note: Rising trends indicate wetter than average conditions; falling trends are drying periods

Water quality

All bores within the Ravenworth East Mine show a uniformly flat salinity and pH trend suggesting minimal impact on the chemistry of the groundwater and no discernible interaction between shallow and deep waters.

Hard Rock Aquifer (NPZ Large)

Overall Trends

The majority of bores south of the Mt Owen and Ravensworth mines and west of Bettys Creek, display a decreasing trend in groundwater levels for the monitoring period (**Figure 4-6** and **Figure 4-7**). Exceptions include NPZ9 and NPZ10, both located in the vicinity of the tailings emplacement rail loop at the north-east corner of the RERR area; and bores NPZ6 and NPZ7, located to the east of Betty's Creek.

Bores which do not have an overall declining trend include NPZ1, North Bore and East Bore, all to the east of the Mt Owen mine; NPZ4 located to the west of Mt Owen mine; and NPZ12 located to the west of the Ravensworth East West Pit. Groundwater levels in these bores appear to have a variable response to rainfall.

The only bores which have an overall increasing trend in groundwater levels are NPZ9 and NPZ10. Umwelt (2008) proposed that the increasing trend up until that time in bore NPZ9 was attributed to the change of operation and continual filling of the tailings emplacement area adjacent to the rail loop. The same explanation may apply for both NPZ9 and NPZ10 for the current monitoring period.

Groundwater levels measured in bores NPZ1 and NPZ8, located east of Mt Owen mine, display a sharp decreasing trend from 2006 to 2008, correlating with a declining trend in cumulative deviation from mean rainfall, followed by an increase, and then stabilisation at lower than previous levels.

Response to Rainfall

The fastest groundwater response to rainfall (0 to 3 months) was observed in bores NPZ4, South Bore and East Bore, of which only NPZ4 is located up gradient of the Ravensworth East mine. Bores NPZ3 and NPZ12, located southeast and southwest of the Ravensworth East mine respectively, also recorded apparent responses to rainfall of within 3 months.

The slowest apparent groundwater response to rainfall (up to 9 months) was observed in bore NPZ1, located down gradient of the Mt Owen mine. The groundwater in bore NPZ8, also located southeast of Mt Owen mine, does not appear to respond strongly to rainfall and the hydrographs do not recover to the levels observed at the start of the monitoring period. This may reflect drawdown from mining activities.

Several bores do not display a visible response to rainfall and include: NPZ11, NPZ13, NPZ14, NPZ15, and NPZ16. Most of these bores are located adjacent to, or down gradient of, the Mt Owen and Ravensworth East mines, again possibly reflecting the influence of mine-related drawdown.

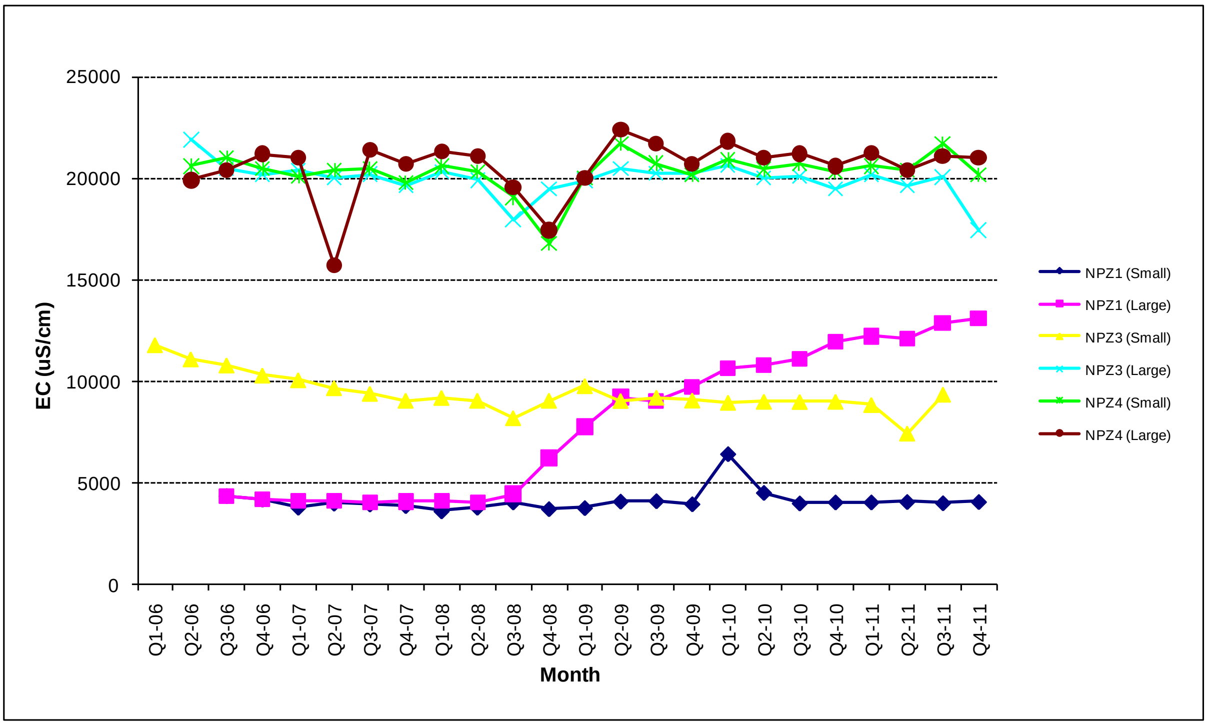
Groundwater data from the Integra underground mine indicate a complex groundwater system resulting from mining impacts. Significant depressurisation of the coal measures is reported in some areas, with reported piezometric elevations ranging from 70 mAHD north of the operation to -50 mAHD in the southern workings. Groundwater levels are reported to show a stable to slightly declining trend in the coal measures, suggesting that most of the groundwater depressurisation associated with the mine has already occurred.

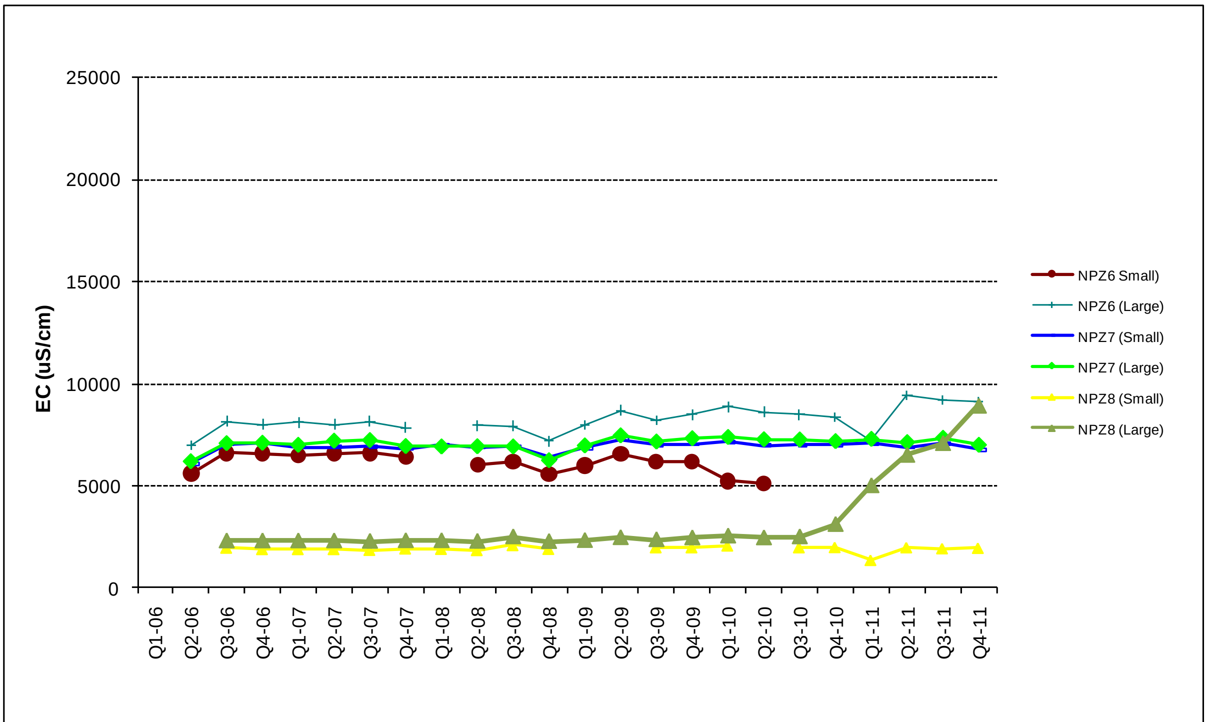
Further south, at the Ashton underground operation, groundwater monitoring data for the coal measures shows large and rapid groundwater depressurisation of up to 100 m in the coal seam targeted by mining operations from late 2006 (MER, 2011b). Initial groundwater elevations ranged around 50 to 60 mAHD and reduced to around -40 mAHD in the most extreme example. MER (2011b) reported that vibrating wire piezometer (VWP) data indicated that this depressurisation was somewhat slower and muted for coal seams located up to 50 m above the target seam with little observed response in other seams, indicating limited vertical connectivity within the coal measures. Although depressurisation within the targeted seam was noted to be large, groundwater drawdown contours indicated that the effects were localised, with steep gradients around the mining perimeter. Several piezometers showed partial recovery of groundwater pressures after initial drawdown from mining. Pre-mining VWP data showed the existence of an upwards gradient within the coal measures with groundwater elevations above natural ground surface in some cases.

Water Quality

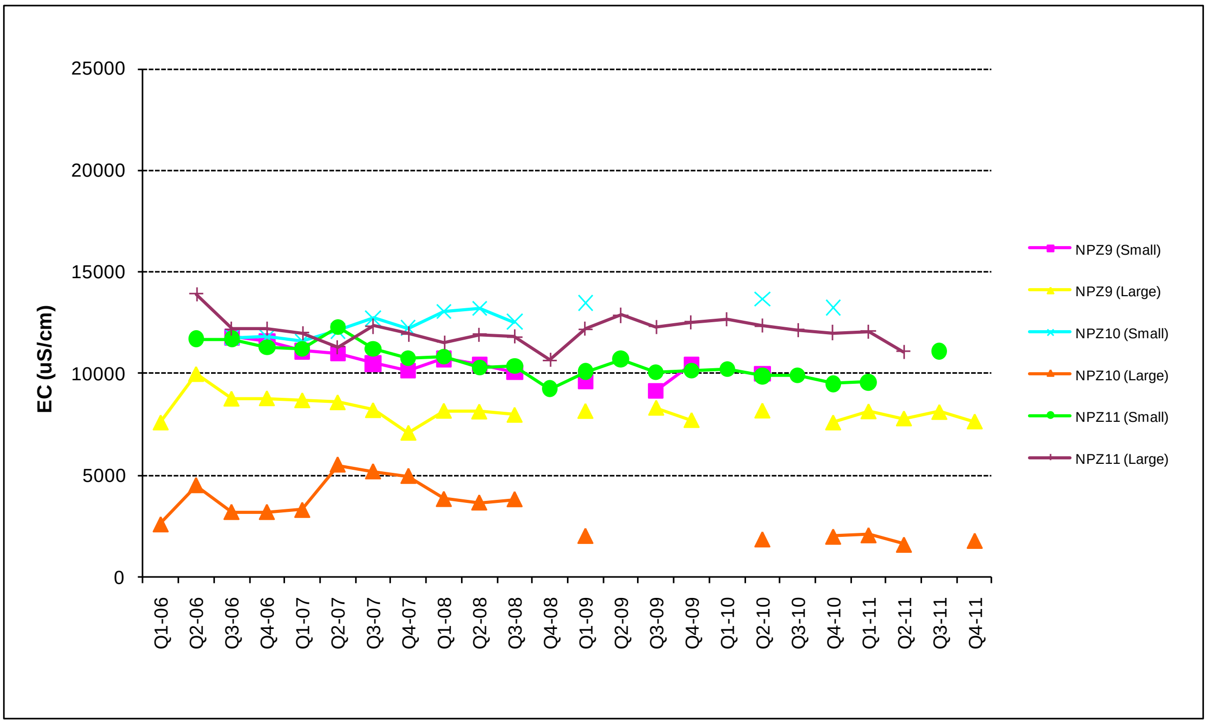
Water quality trends for most bores are flat for the last 5 years (**Figure 4-9** to **Figure 4-12**). A few bores 3 km to the east of the RERR mining area in ML 1355 (NPZ1, NPZ8, North, East, South) show either increasing or decreasing trends, but the bore closest to Ravensworth East Mine (NPZ10) exhibits a flat trend, indicating no impact on this bore from the past Ravensworth East mining operations.

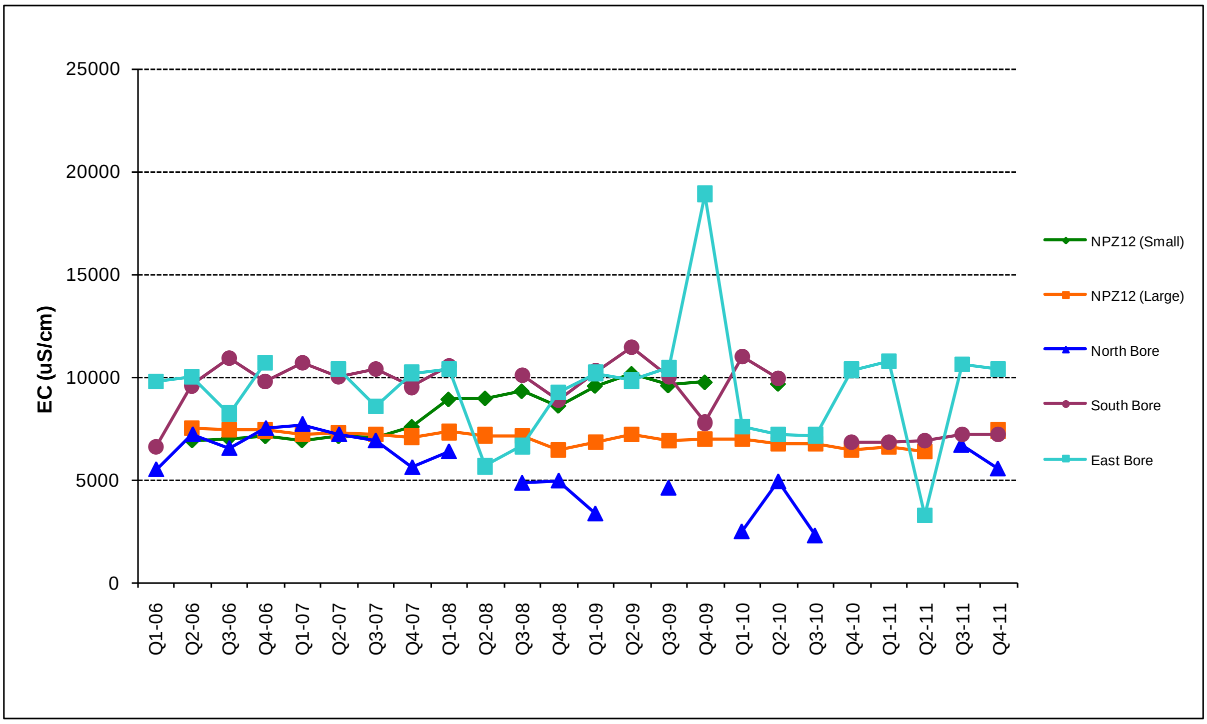
Groundwater salinity ranges from 2,000 to 22,000 EC and pH is slightly alkaline. These are typical values for groundwaters within coal measures.



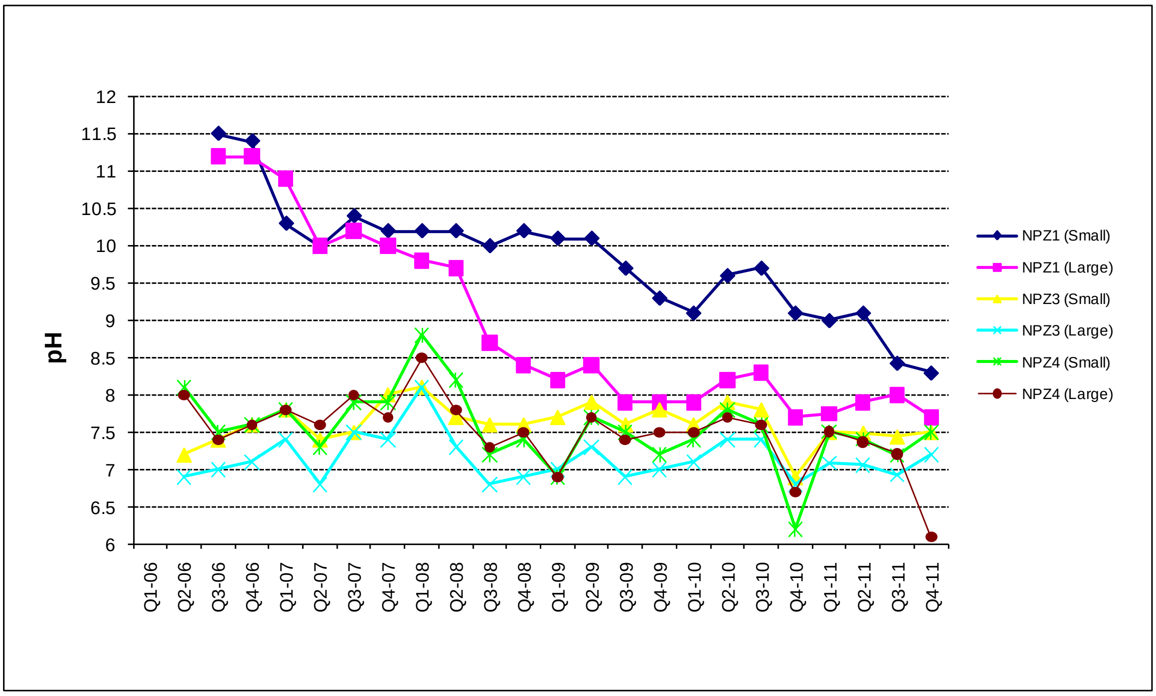


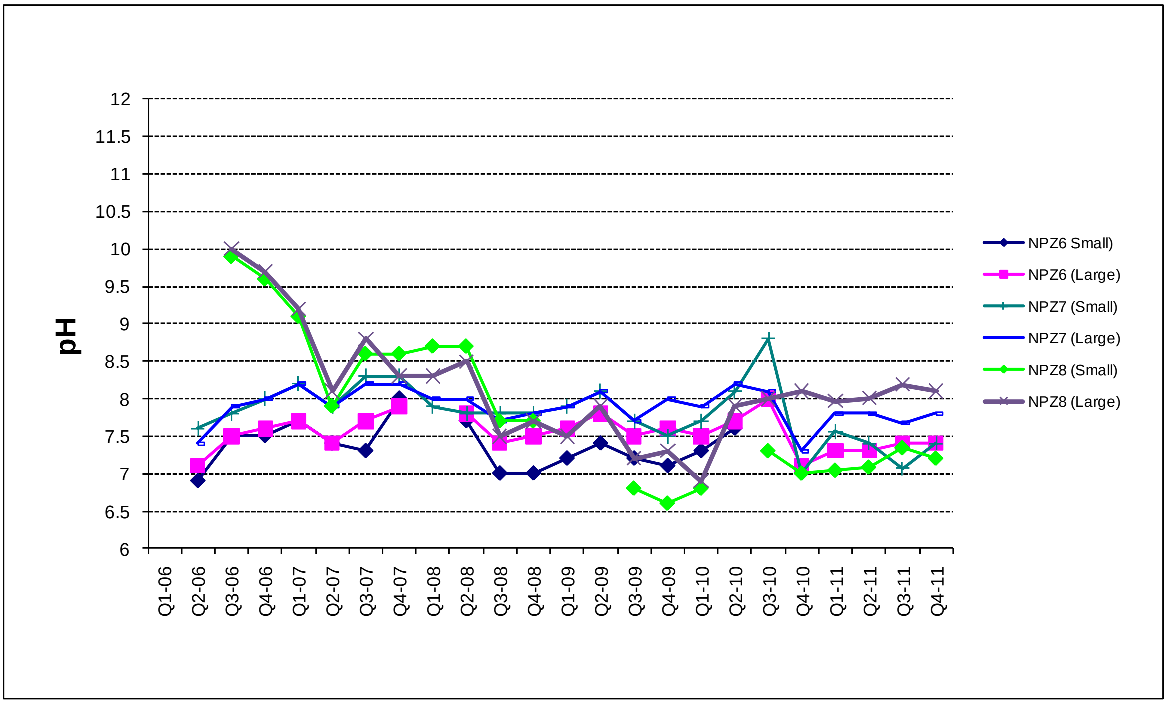
- **Figure 4-9. Salinity (measured as electrical conductivity) of groundwater around Ravensworth East Mine**



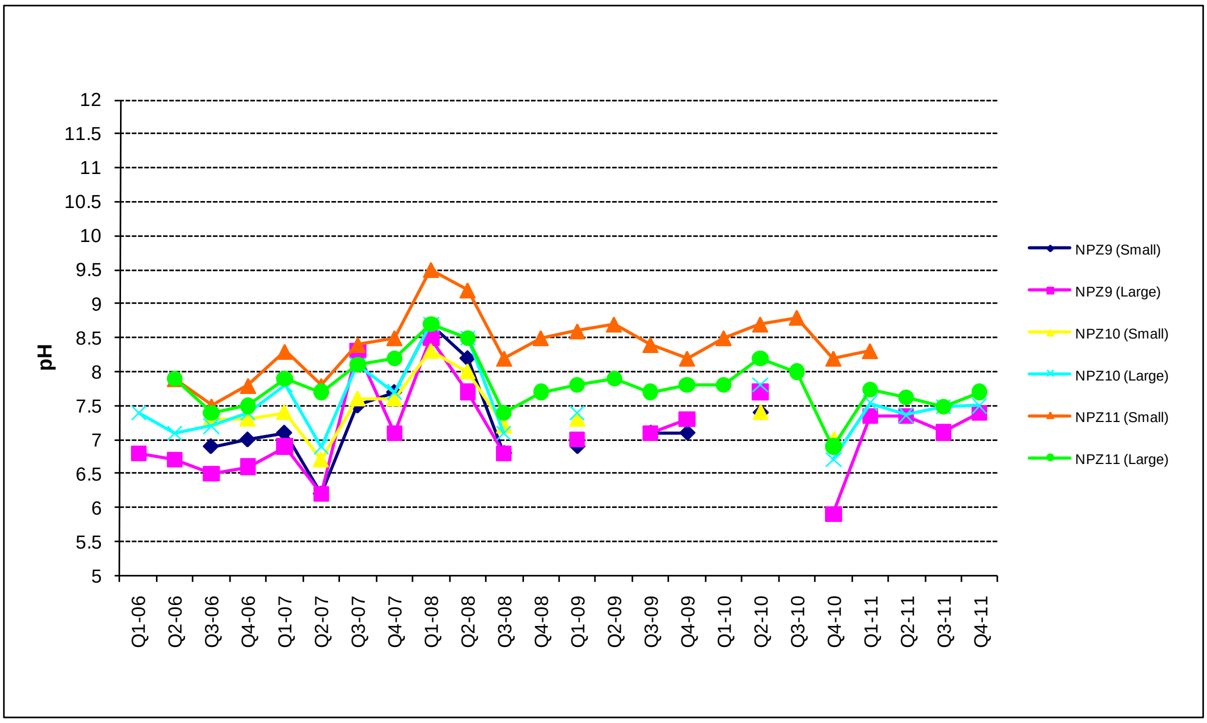


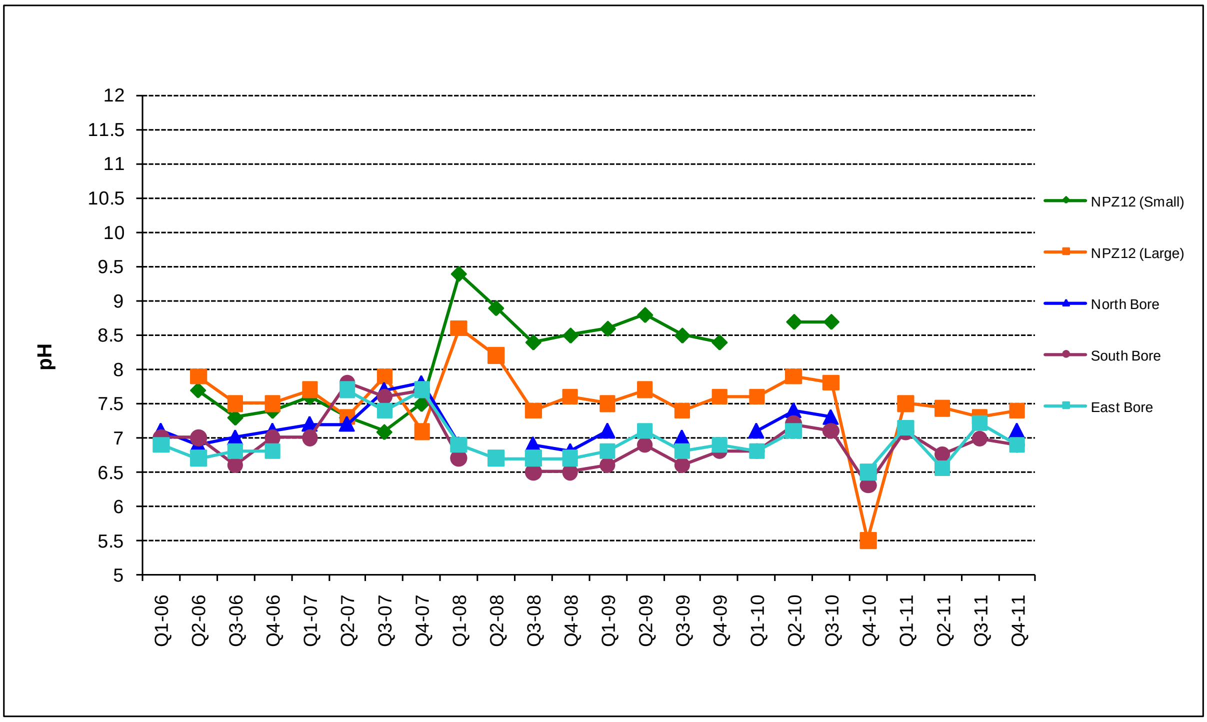
- **Figure 4-10. Salinity (measured as electrical conductivity) of groundwater around Ravensworth East Mine (continued)**





- **Figure 4-11. Acidity (pH) of groundwaters around Ravensworth East Mine**





■ **Figure 4-12. Acidity (pH) of groundwater around Ravensworth East Mine (continued)**

Existing Groundwater Users

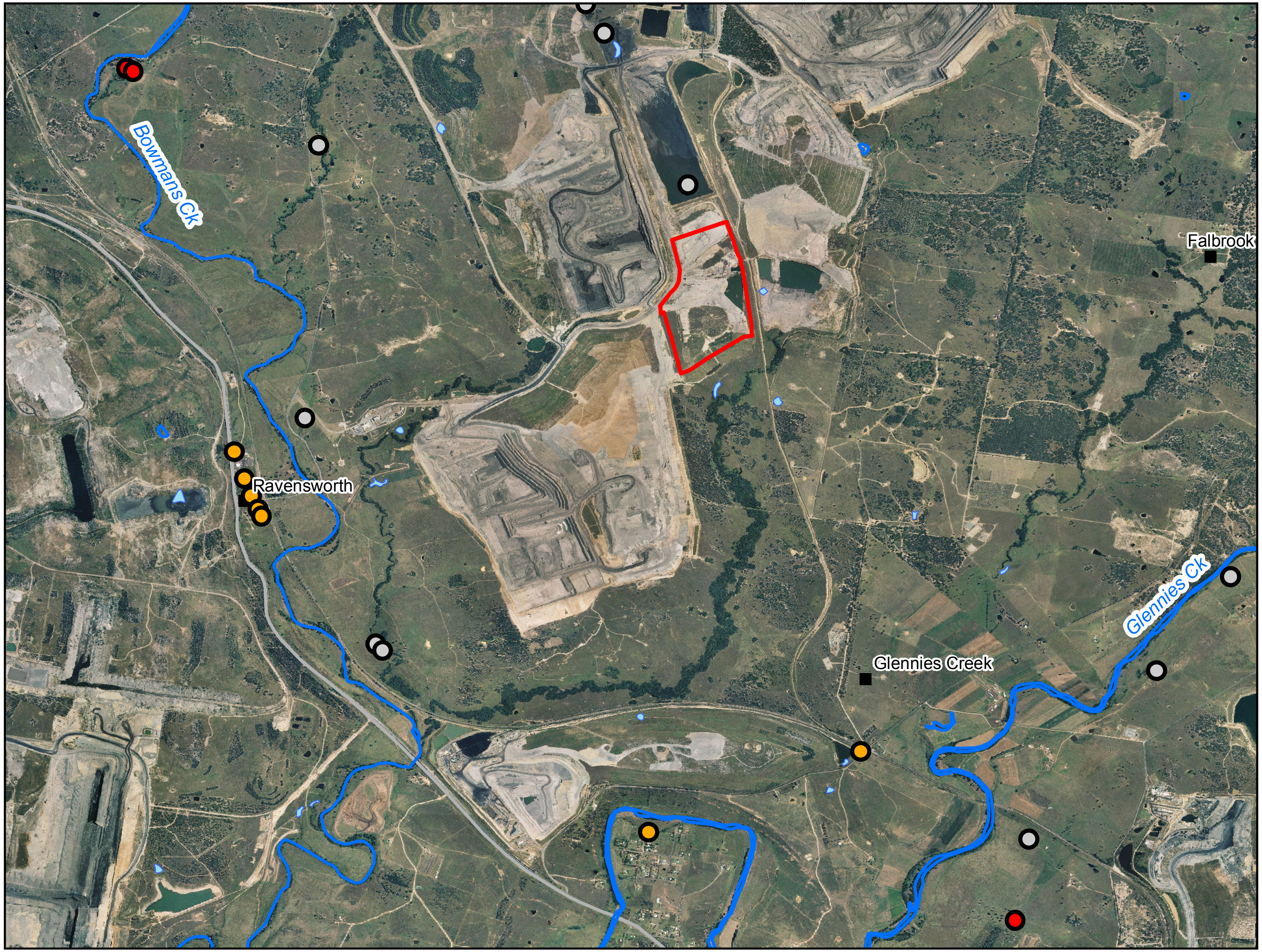
Previous investigations (e.g. MER 2008 and MER 2011) have interrogated the NSW Office of Water (NOW) database of registered bores and wells, and details of registered boreholes across the entire groundwater modelling extents have been recorded. The database includes exploration/test wells that may not have been completed as permanent infrastructure, observation/monitoring bores, and privately owned bores and wells that may be in use or abandoned.

These previous investigations have shown that there have been very few private bores or wells drilled within the predicted zones of mining impacts, most of which were in the alluvial aquifer. Many of the private bores in the regional groundwater model extents area are now owned by Xstrata or other coal companies. The current status of private bores in the area are shown in Figure 4-13

All potential groundwater user bore locations are four or more kilometres west or south of the existing Ravensworth East operations and are sited within shallow alluvium associated with Bowmans Creek (also known as Foy Brook) or Yorks Creek. These locations rely upon shallow recharge from creek runoff and would only be affected by mining operations if sustained dry periods occur and downward leakage from alluvium is initiated as a result of depressurisation of the coal measures. While such leakage is not expected, the existing XMO Surface Water and Groundwater Response Plan will be initiated at any location where loss of economic yield due to mine development can be demonstrated.

As noted earlier, no groundwater dependent ecosystems have been identified in the area.

Ravensworth private groundwater extraction bores



LEGEND

Private Bores

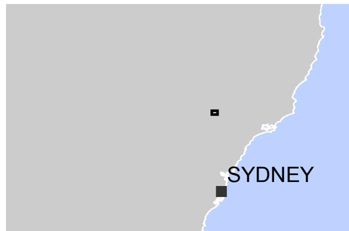
- Irrigation
- Domestic
- Stock
- Unknown
- RERR Mining Area
- Stream
- Reservoir
- Main road

Sinclair Knight Merz does not warrant that this document is definitive nor freeof errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

[GDA 94]

A4 1:56,067

0 1.4
Kilometres



SKM

D:\Documents and Settings\landers\My Documents\Projects\Xstrata\GIS\Figures\RERR_groundwater_monitoring_v1.mxd

Prepared by : LA

5. Numerical Groundwater Model

For the purposes of creating a groundwater model that replicates actual conditions, it is necessary to conceptualise a system that:

- provides sufficient detail to account for system variations and variability
- can input appropriate and available datasets
- output data sets that are meaningful and defendable
- is not more complicated than is necessary to describe the features and processes that are being assessed.

NOW requires that numerical groundwater models follow the principles in the National Guidelines for Groundwater Modelling. The Guidelines suggests a ranking according to confidence level classification. The ranking depends on the availability of data on which to develop the conceptualisation and to calibrate the model, the type of and accuracy of calibration and the manner in which the predictions are formulated (i.e. are the predictions within the same range of time and stress as used in calibration). Under this classification system, the regional groundwater model used for this assessment would be rated as Class 2 (medium confidence level) largely because the calibration is hindered by poorly defined historic mine development records prior to 1980, particularly for the mines to the west of Bowmans Creek. In the vicinity of the RERR mining area, however, there are good water level records and the mine history is well-documented. Surface water records are poor, however, restricting estimates of local baseflow. Hence the model would still be rated as Class 2. This class is deemed suitable for providing estimates of dewatering requirements for mines and excavations and the associated impacts and prediction of impacts of proposed developments in medium value aquifers (Barnett, et al., 2012).

Conceptualisation of the Groundwater System

Within the coal measures, the most permeable horizons are the coal seams themselves; non-coal interburden strata generally exhibit permeabilities that are one to two orders of magnitude less than the coal seams. Regionally, the coal seam aquifers are generally confined above and below by the interburden strata.

Groundwater in the coal measures moves down-dip from areas of recharge where individual seams subcrop and outcrop on the flank of the Muswellbrook Anticline. Rates of recharge through unweathered Permian bedrock are very low, with estimates varying from near zero to no more than 1% of annual rainfall (MER, 2011b). Recharge can be expected to be slightly higher where more permeable rocks (i.e. coal seams) subcrop and outcrop.

The alluvial aquifers are associated with the drainages of Bowmans, Glennies and Bayswater Creeks and the Hunter River. The alluvium is generally characterised by a succession of three units, grading from a basal coarse grained bed load comprising sand to cobble size deposits, to a middle unit comprising finer grained levee deposits, and finally an upper unit comprising floodplain deposits.

Previous investigations have shown that the Hunter River alluvium is deeper and generally more transmissive than the alluvium of the smaller tributaries such as Bowmans or Glennies Creeks. The basal coarse grained unit of the alluvial sequence forms the main aquifer of the alluvium and in places may be confined by the overlying fine grained terrace deposits.

Further details of the conceptualisation may be found in **Appendix A**.

Numerical Modelling Results

Drawdown

The model predicted drawdown at various times in the future and in all model layers. The key layers relevant to Ravensworth East are presented in **Figure 5-1** and .

In these cases, drawdown is defined as the difference in predicted head between the base case and mine expansion case at the specified time. The figures have been generated from the median values of all 20 model runs at all locations (*see Appendix A for details)*. In other words, the outcomes are not obtained from a single model run, rather they are estimated from a compilation of median heads estimated at every model cell. The results are presented for the Bayswater seam (Figure 5-1) and the immediately overlying “Overburden” layer (Figure 5-1) at times representing 2016 (the time of greatest predicted open cut inflow), 2019 (at the end of mining) and at 2120 (end of the modelling runs).

Negligible drawdowns are observed (i.e. ranging from 0 m to 2 m) in any alluvial materials (the model layer 1), except for isolated reaches at maximum drawdown (Figure 5-12). As modelled results are considered less than the Level 1 minmal impacts in accordance with the Aquifer Interference Policy, these impacts are considered acceptable to the NSW Office of Water and additional management actions are not required.

The consequence of the proposed operations will see drawdown centred on the open cut that will perpetuate in to the future due to the increased hydraulic conductivity of the infill material compared to the existing rocks. The low permeability of the country rock precludes significant impact away from the mine area and <1m drawdown will be propagated to the overburden and Bayswater seam beneath Glennies Creek, while no drawdown effects are anticipated beneath Bowmans Creek.

No impact is therefore anticipated on the alluvial aquifer from these operations.

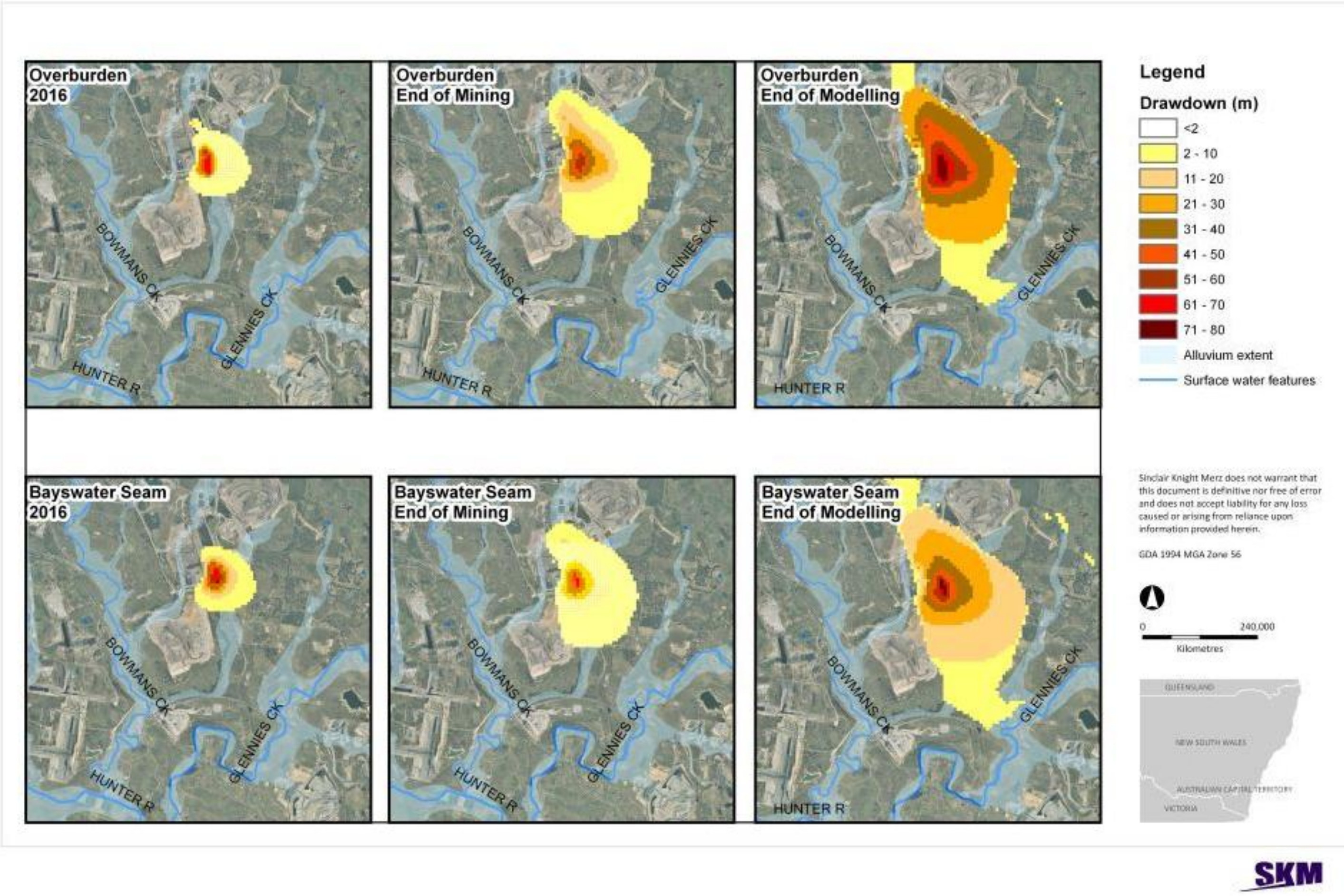


Figure 5-1. Predicted groundwater drawdown for the overburden layer at the year 2016

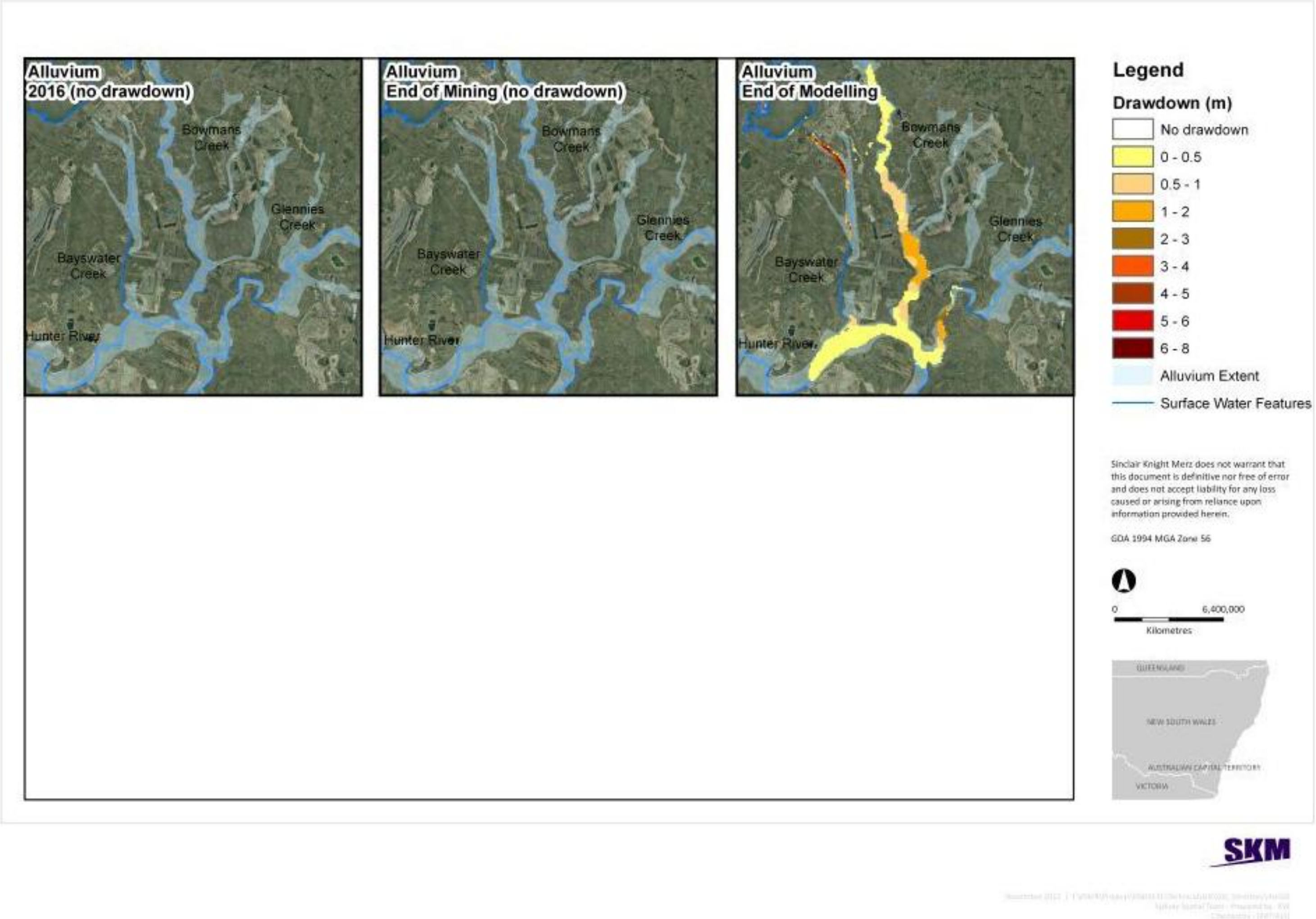
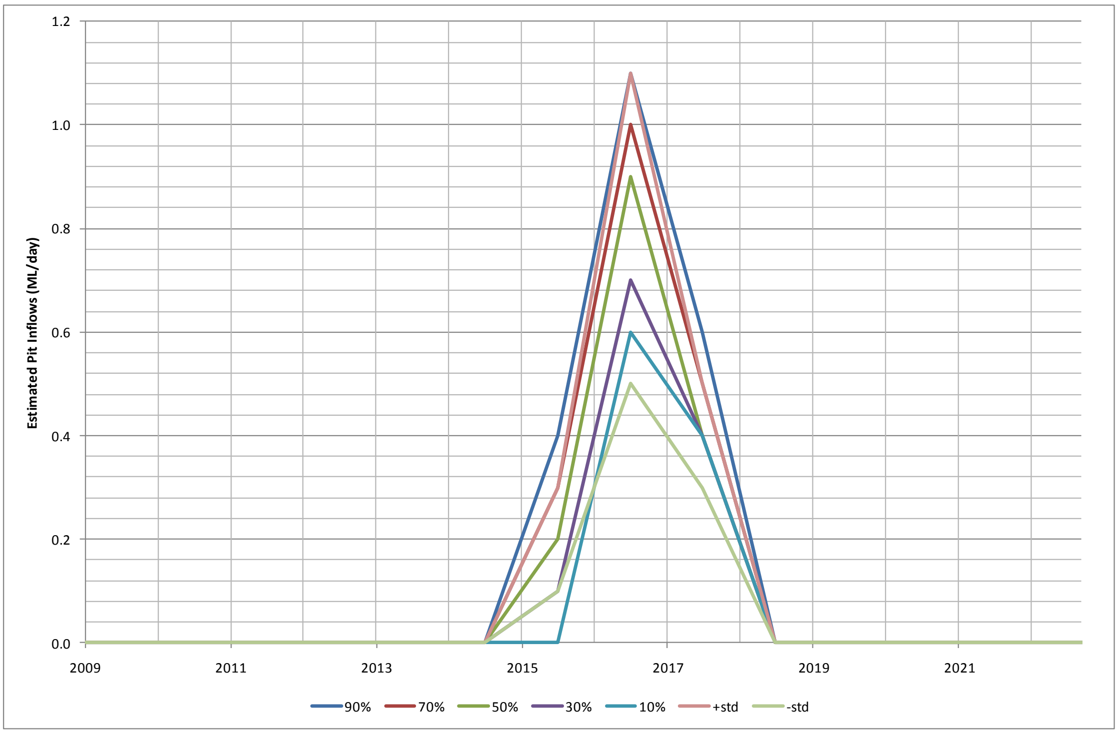


Figure 5-2. Predicted groundwater drawdown for the alluvium at maximum seam drawdown

Open cut inflow

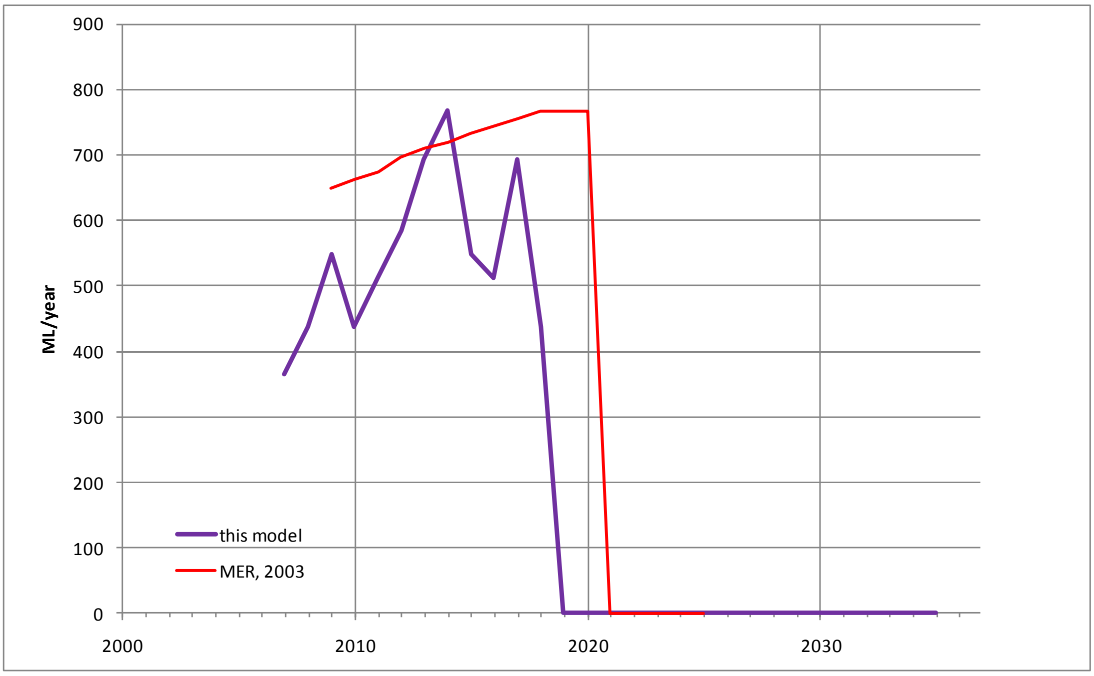
Figure 5-3 shows the estimated inflows to the RERR mining area of the Ravensworth East proposed modification for an average climate for the duration of the historical and predictive modelling period. Inflows range from zero to 0.9ML/day for the average modelled case. The model assumes that the existing landform is not impacted until 2014 and mining finishes at the end of the current consent. Predictied open cut inflows to the currently active West Pit are shown in **Figure 5-4**. These inflows range from 0 to 2.1 ML/day.

Combined (total for the RERR mining area plus West Pit) open cut inflows to the Ravensworth East Mine may be compared to previous estimates of groundwater ingress for this mine (**Figure 5-5**). Magnitudes of inflow are similar, though the mine progression has been modified so timings are different. The current model provides greater detail and increased certainty regarding the spatial distribution of inflows and potential temporal variability based on varying climate scenarios.



- **Figure 5-3. Predicted average daily inflows to the RERR area of the Ravensworth East Mine operations**

- **Figure 5-4. Predicted average daily inflows to the West Pit of the Ravensworth East Mine operations**



- **Figure 5-5. Comparison of open cut inflows determined using the SKM regional groundwater model and those predicted for a previous Glendell DA (MER, 2003)**

6. Environmental Impact Assessment

Pre-mining conditions

Prior to the establishment of mining operations in the region, monitoring of groundwater levels was very limited. As such, an assessment of the pre-mining condition is difficult. However, previous studies within the region have attempted to simulate the pre-mining groundwater system using numerical models (e.g. MER, 2011b) and these results can be used in a semi-quantitative assessment of pre-mining conditions.

Pre-mining groundwater levels are predicted to be a subdued reflection of topography, with overall drainage in the region to the south and southwest towards the Hunter River. Groundwater in the coal measures moves down-dip from areas of recharge where individual seams subcrop and outcrop. Rates of recharge through unweathered Permian bedrock are very low, with estimates varying from near zero to no more than 1% of annual rainfall (MER, 2011b). Recharge can be expected to be slightly higher where more permeable rocks (i.e. coal seams) subcrop and outcrop.

Due to an expected difference in hydraulic conductivity between Permian and Carboniferous aquifers (two orders of magnitude or greater), throughflow to the Permian rocks from the Carboniferous rocks from the north and east of the region is not likely to be significant compared to recharge of the Permian rocks via infiltration of rainfall.

Predicted pre-mining groundwater head elevations in the coal measures are generally higher than the elevation of the incised creek beds within the Hunter Valley; that is, artesian conditions within the coal measures can be expected to have existed along the larger surface water drainages. Therefore, upward leakage from the coal measures to the surface water features, especially the Hunter River, is likely to have formed a component of the pre-mining study area groundwater discharge.

Shallow groundwater (i.e. that forms the water table) is expected to have discharged as baseflow via the alluvium to the Hunter River perennially, and to Bowmans and Bayswater Creeks in times of low to average flows. In times of high creek flows, recharge of the shallow water table in the alluvium is expected to occur from the creeks, and this would extend through to this day. Numerical model-calculated perennial pre-mining baseflow to the Hunter River in the southwest of the Ravensworth East Mine is in the order of 0.35 to 0.40 ML/d, and model calculated intermittent baseflow to Bowmans and Bayswater Creek in the southwest of the Ravensworth East Mine to be in the order of 0.70 and 0.30 ML/d, respectively (MER, 2011b).

Impacts of mining operations

It has been previously demonstrated that the coal measures in the vicinity of Ravensworth East Mine are already partially depressurised as a result of mining activities across the region, in particular, through activities at the existing Ravensworth East, Mt Owen and Glendell operations and the underground working of Integra to the south.

These cumulative impacts must be understood as should the impacts on the shallow alluvial systems and consequent losses or gains to the stream flow in the local creeks. The key constraint to development in the region is the baseflow impact, which is regulated within the framework of the *Water Management Act* (2000) and the Hunter Unregulated Alluvial Aquifers Water Sharing Plan, applicable to Bowmans Creek and its tributaries.

Potential impacts on the groundwater environment arising from mining of coal resources at Ravensworth East open cut include:

- Loss of aquifer pressures and potential loss of yield at existing water bore locations.
- Leakage of shallow alluvial aquifer waters to deeper coal measures.
- Change in groundwater quality.

Loss of groundwater yield at bore locations

Mining of the coal measures will ultimately induce depressurisation of the groundwater system extending outward from the Ravensworth East mine. The loss of deep pressure may potentially impact existing bores constructed in the coal measures or in shallow alluvium connected to the coal measures. The area affected by loss of pressure is expected to expand to a distance of more than 2 to 3 kilometres from the RERR mining area open cut shell and any extraction bores situated within this zone of depressurisation (and within coal measures) could be affected by a loss of yield.

Figure 4-13 shows locations of registered private bores and wells in the vicinity of the RERR mining area. All locations are several kilometres from the existing open cut and are sited within shallow alluvium associated with Bowmans Creek (west) or Glennies Creek (south) and their tributaries. All private bores with unknown status are owned by Xstrata. Modelling suggests that negligible impact to any bores within four km would be expected from the proposed modification.

Seepage from local drainages

Reduction in aquifer pressures has the potential to induce leakage from local drainages. The nearest drainage is Swamp Creek and its associated colluvial and alluvial deposits. Much of this material has been removed as part of mining and the creek has been previously diverted eastward. Opportunity for downward leakage is generally minimal since the underlying coal measures comprise layered strata of differing permeability with vertical permeability potentially orders of magnitude lower than horizontal permeability. Presence of these very low permeability layers naturally impedes leakage of groundwater from the overlying shallow sediments. There is potential for discrete pockets of leakage to occur along occasional joint and fracture zones. However, these zones are typically orientated in a north-northwest direction parallel to local fold axes and as such, are unlikely to provide conduit pathways in a westerly direction towards the open cut.

Impacts to Yorks and Bettys Creeks are predicted to be negligible.

If monitoring indicates a lowering of water levels and hence the possibility of leakage, this would invoke the requirements of the existing XMO Surface Water and Groundwater Response Plan and further investigations would be undertaken.

Regional groundwater quality during mining

Water quality within the coal measures is saline and fails to meet quality guidelines for raw domestic waters (ANZECC, 2011) due to naturally-elevated primary salinity. The resource is considered to have limited beneficial use except possibly for stock water supply.

Depressurisation of the coal measures is predicted to have minimal impact on groundwater quality. Some localised vertical leakage may occur downwards from local drainages into the coal measures as pressures are reduced. However, such leakage will be confined to discrete joints and fractures and some improvement in groundwater quality can be expected in overlying sediments where upward leakage of saline groundwater currently prevails. Intergranular leakage through the bulk of the interburden will be negligible due to the very low hydraulic conductivity of sandstones, siltstones and shales, and the eastward dip (increasing depth) of sediments. Hence, groundwater quality is likely to remain broadly unchanged during mining associated with the proposed modification.

There has been no change to water quality as a result of existing operations to date and this strongly suggests that future impacts will also be negligible from the proposed Ravensworth East mine progression.

Void water quality

Mackie Environmental Research assessed the potential for salinisation of final void waters (MER, 1998). Final void water quality was estimated from laboratory core leach tests and direct sampling of existing void water and indicated a level of mobile salts lower than the prevailing undisturbed coal measures water quality. Existing void samples suggested a dissolved solids content of 4,700 mg/L which was higher than leach test calculations indicated, but is similar to or lower than coal measures groundwater which exhibit a local range of 1,800 mg/L up to 22,000 mg/L (Figure 4-9, Figure 4-10). Regional coal measures water quality has a similar range depending on seams sampled. Void or spoils leachate water quality is therefore predicted to be at least similar to or probably better than regional coal measures water quality.

Mixing of groundwaters as the void or emplaced spoils re-saturate is unlikely to impair the regional groundwater quality.

Following mine closure, the final voids act as evaporative sinks in the landscape and salinity is likely to increase, but will be diluted by inflows due to rainfall.

Groundwater impacts on ecology

The mapped distribution of groundwater pressures regionally highlights the presence of a depressurised zone around the existing mined area. Most of the area within this depressurised surface comprises coal measures. The quality of groundwater within the coal measures is considered to be poor and as such, no beneficial use can be identified. No obvious ecological system with a dependency on the presence of groundwater exists within the coal measures.

Water Management Strategy

Ravensworth East Mine currently operates under the Water Management Plan for the Mt Owen Complex (Xstrata, 2011b), which incorporates a Mt Owen Complex Groundwater Monitoring Program (Xstrata, 2011c) and Mt Owen Complex Surface Water and Groundwater Response Plan (Xstrata 2011d). In addition, the implementation of controls outlined in the Erosion and Sediment Control Plan (Xstrata, 2011e) are designed to facilitate the management and mitigation of the impacts of the existing operations on site water quality and surrounding waterways.

These plans are effective for the current development consent periods and for the Ravensworth East Mine. The Plans will be amended to reflect the new information regarding open cut groundwater inflows (**Table 6-1**) and consequent changes to the mine water balance.

- **Table 6-1. Future predicted groundwater inflows (ML/year)**

Year	Existing Open cut Inflow estimations	Revised open cut inflow estimations
2013	709	694
2014	720	767
2015	732	548
2016	744	511
2017	755	694
2018	767	438
2019	767	0
2020	767	0[1]
2021	0[1]	0[1]

[1] End of current and proposed modification consent for Ravensworth East Mine

The comprehensive site water monitoring plan for the Mt Owen Complex (which covers Ravensworth East) has been augmented with the addition of a series of vibrating wire piezometers (VWP) and a series of standpipes in the alluvium. This network was installed during 2012.

On-going monitoring will be applied to allow periodic update of the groundwater model to validate the predictive scenarios and modify future mine water balances. Monitoring will continue to include:

- water levels (including pressure heads via the VWPs), salinity, pH and periodic chemistry for the regional monitoring bore network;
- measurement of water levels and water quality in the mine surface water bodies (dams and voids); and

- annual reporting as part of the licensing conditions.

The monitoring program will continue to be reviewed by XMO.

7. Summary

The groundwater systems around the Ravensworth East Mine have been reviewed and a groundwater impact assessment undertaken to consider the impacts of proposed future mining activities on the groundwater resources and the groundwater flow regime. The assessment has been made with the aid of a regional numerical groundwater model, calibrated with data from the last 20 years of operation and groundwater monitoring.

As for previous assessments, two primary aquifer systems can be identified: hardrock coal measures and surficial alluvial deposits that support an ephemeral creek system. Within the hardrock system, the coal measures provide the greatest, but still limited, storage of groundwater and provide the primary flow pathways. Water quality of these aquifers is poor, with salinities approaching half that of seawater. The shallow, alluvial systems also have high salinities, with some samples returning readings up to one third that of seawater.

Numerical groundwater modelling indicates that the proposed modification will have negligible consequence to the existing groundwater regime and revised estimates of groundwater ingress to the RERR mining area is similar to previous estimates based on the existing mine sequence, reflecting the small footprint of the mine with little impact to regional groundwater flows beyond the RERR mining area.

The consequence of the proposed operations will see drawdown centred on the open cut that will perpetuate in to the future due to the increased hydraulic conductivity of the infill material compared to the existing rocks. The low permeability of the country rock precludes significant impact away from the mine area and <1m drawdown will be propagated in the overburden and Bayswater seam beneath Glennies Creek whilst no drawdown effects are anticipated beneath Bowmans Creek.

No impact is anticipated on the alluvial aquifer from these operations.

Inflows to the RERR mining area range from zero to 0.9ML/day for the average modelled case. The model assumes that the existing landform is not impacted until 2014 and mining finishes at the end of the current consent. Open cut inflows to the currently active West Pit range from 0 to 2.1 ML/day.

Combined (total for the RERR mining area plus West Pit) open cut inflows to the Ravensworth East Mine were compared to previous estimates of groundwater ingress for this mine. Magnitudes of inflow are similar, though the mine progression has been modified so timings are different. The current model provides greater detail and increased certainty regarding the spatial distribution of inflows and potential temporal variability based on varying climate scenarios.

Cumulative (historical) impacts from mines surrounding Ravensworth East Mine have contributed to an overall impact on the surrounding alluvial system baseflow, though negligible impact from Ravensworth East can be demonstrated, with no discernable drawdown modelled for the alluvial materials of Bowmans and Glennies Creek.

The on-going monitoring has shown little impact from mining with dominant influence on bore level trends being from climatic variability. The on-going monitoring program and groundwater response plan are designed to rapidly assess and mitigate any impacts in a timely manner and aids in the determination of the mine water balance and water management strategy.

There are no groundwater users identified outside the mine that will be impacted by these proposed operations.

8. References

Aquaterra, 2009. Creek Diversion: Groundwater Impact Assessment Report. Prepared for Ashton Coal Operations Pty Ltd by Aquaterra Consulting Pty Ltd.

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A. 2012. Australian Groundwater Modelling Guidelines. Waterlines report No. 82, National Water Commission, Canberra.

Beckett, 1987. The extent and Lithology of Bowmans Creek Alluvial Deposits and an Assessment of the Impact of Mining on the Flow Pattern and Water Balance in the Creek. NSW Department of Minerals Resources Coal Geology Branch file no. CGB 1987-008.

Corkery, et al., 2011Kellet, J.R., B.G. Williams, and J.K. Ward, 1989. Hydrogeochemistry of the Upper Hunter Valley, New South Wales. Bureau of Mineral Resources (Geology and Geophysics). Bulletin 221.

MER, 1998. Ravensworth East open Cut Mine Groundwater Management Studies

MER, 2011a. Mt Owen Optimisation Project – Assessment of Groundwater Constraints associated with Proposed Extensions of Open Cut Mining at Mt Owen and Glendell.

MER, 2011b. Ravensworth Underground Mine – Assessment of Groundwater Impacts associated with Modifications to Mining in the Liddell Seam. Draft report prepared for Ravensworth Underground Mine Pty Ltd by Mackie Environmental Research Pty Ltd.

NSW Office of Water, 2012. NSW Aquifer Interference Policy http://www.nsw.gov.au/sites/default/files/uploads/common/NSW-Aquifer-Interference-Policy_SD_v01.pdf *accessed 13th September, 2012*

Probert & Stevenson, 1970. Augmentation of Water Supplies for Liddell State Coal Mine Washery. Geological Survey of New South Wales Department of Mines Geological Survey Report GS 1970/006.

Umwelt, 2008a. Liddell Colliery Groundwater Monitoring Program. Prepared by Umwelt Environmental Consultants Pty Limited for Liddell Coal Operations Pty Limited.

Umwelt, 2008b. Mt Owen Complex Groundwater Monitoring Program. Prepared by Umwelt Environmental Consultants Pty Limited for Xstrata Mt Owen Pty Limited.

URS, 2009. Integra Open Cut Project Environmental Assessment – Chapter 7 Groundwater. Prepared by URS Australia Pty Ltd for Integra Coal Operations Pty Ltd.

Xstrata, 2011a. Glendell Mine Monthly Monitoring Report. Prepared by Xstrata Coal Glendell Mine.

Xstrata, 2011b. Mt Owen Complex Water Management Plan.

Xstrata, 2011c. Mt Owen Complex Groundwater Monitoring Program.

Xstrata, 2011d. Mt Owen Complex Surface Water and Groundwater Response Plan

Xstrata, 2011e. Mt Owen Complex Erosion and Sedimentation Control Plan

Appendix A Regional Numerical Groundwater Model Development

A.1 Modelling objectives

Xstrata Coal NSW (XCN) is committed to sustainable development. Business is conducted that integrates economic, social and environmental values and preserves the long term health, function and viability of the natural environments affected by XCN activities. As part of this commitment, XCN has commissioned Sinclair Knight Merz (SKM) to develop a regional numerical groundwater model that allows prediction of the impacts to groundwater caused by mining activities. This model builds on a previous model developed by Mackie Environmental Research for XCN operations around the Ravensworth Underground Mine. The new regional model incorporates all mining activities from the Hunter River north to Lake Liddell and east to Glennies Creek, embracing all coal mining activities within Bowmans Creek catchment, a tributary to the Hunter River (Figure A-1).

The regional numerical groundwater flow model has been developed in order to provide estimates of how groundwater conditions change in response to mining activities through time and to provide a basis for any groundwater impact assessments. In particular the model may provide estimates of the changes in groundwater head that will occur as a result of mine dewatering operations and the associated changes in baseflow in creeks and rivers of the region, including Bowmans Creek.

Ravensworth East Mine is situated in the centre of the model extents and accounts for only 1% of the total modelled region. It is therefore expected that the Ravensworth East contribution to cumulative mining impacts on the region will be small and critical measures will be the amount of open cut inflow generated by the proposed mine sequence.

A.2 Confidence Level Classification

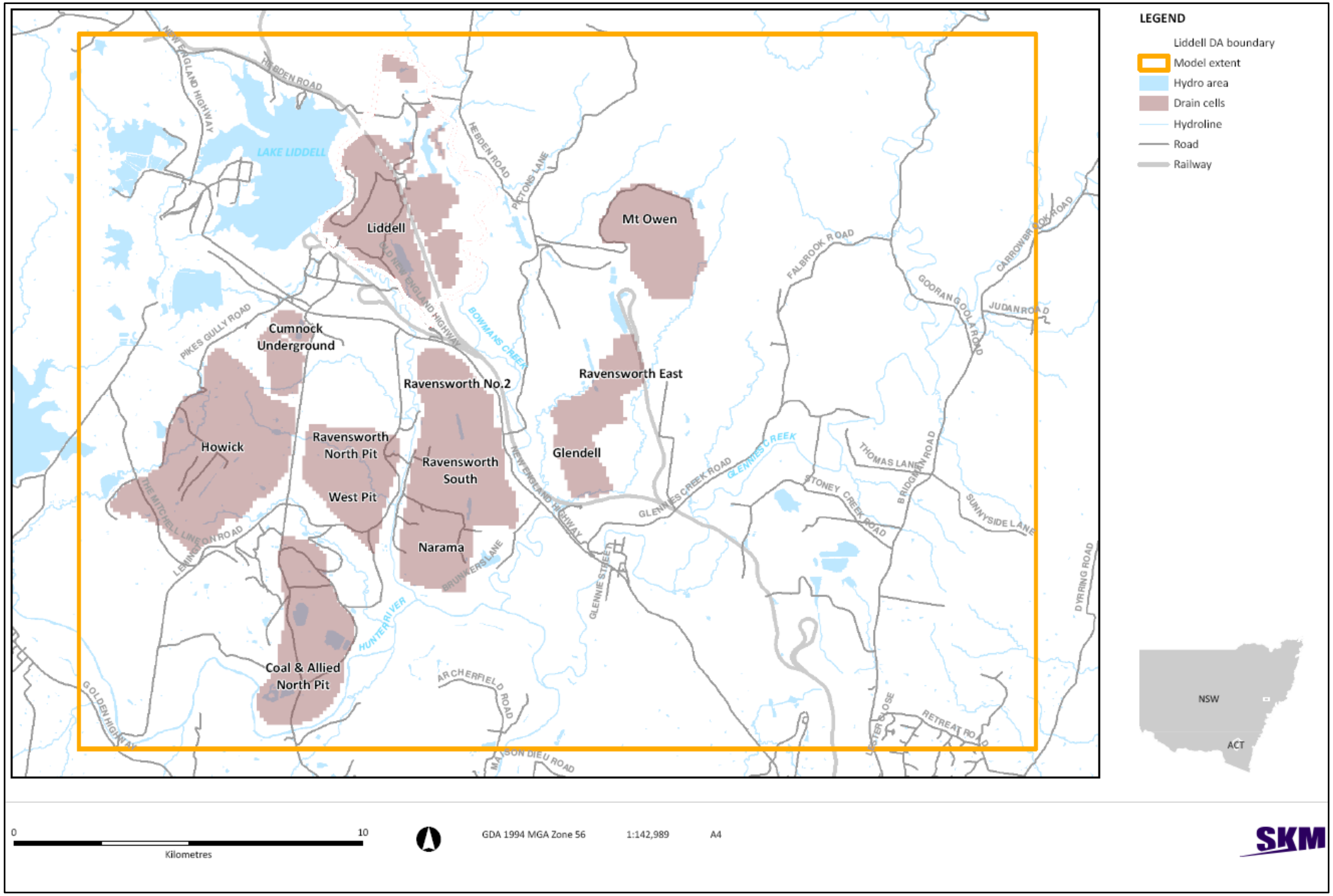
The Australian Groundwater Modelling Guidelines (Barnett et. al., 2012) defines model confidence level classification as a means of classifying models according to the confidence with which they can be used as a predictive tool. The classification depends on a number of factors including:

- The amount and quality of data on which the conceptualisation and model calibration are based,
- The manner in which the model is calibrated and the accuracy of the calibration,
- The objectives and requirements of the investigation, and
- The manner in which the predictions are formulated.

At the model planning stage it is important to decide on and document an appropriate target confidence level classification that reflects the expected modelling procedures and outcomes and takes account of the project requirements. In this case the salient aspects of the project that are likely to control the confidence level classification are:

- The level of expense associated with mine dewatering and water management infrastructure and the potential environmental consequences of adverse impacts would suggest that a high level of confidence in model predictions would be desirable.
- There is a reasonable level of regional hydrogeological data (including local scale geological information at the mine site) available for the study and hence the conceptualisation should be reasonably well founded.
- Calibration will be undertaken in steady state and transient mode to a limited data set. The available calibration data are limited to groundwater levels measured in bores in the vicinity of the mine site. There are no measured inflow rates to the mine during historic mining operations; in fact the exact history of mine development includes uncertainties. As a consequence calibration will provide limited constraints on the hydrogeological parameters that control the inflow to the mine and associated environmental impacts.

Given the issues discussed above and in consideration of the key indicators of model confidence level classification as described by Barnett et. al. (2012) it is proposed that the model be targeted as a Class 2 (medium confidence) model. Additional confidence in model predictions (and an increase in confidence level classification) can be expected should additional calibration or validation data be obtained in the future. It is expected that such improvements could be realised if future modelling was tested against detailed observations of groundwater levels and inflows to the mine and further river gauging and baseflow estimates to help quantify the groundwater contribution to the major rivers and streams included in the model.



▪ **Figure A 1 Open cut shells of mines modelled by the regional groundwater model**

A.3 Conceptualisation

The numerical groundwater model has been constructed in a manner aimed at reproducing the principal features of the geological setting described below within a numerical framework.

A.3.1 Geological Setting

The Project Area is located within the Hunter Coalfield of the Permian and Triassic-aged Sydney Basin.

The main Permian coal-bearing rocks in the Project Area are the coal seams of the Foybrook Formation of the Vane Subgroup of the Wittingham Coal Measures. These coal measures belong to the Singleton Super Group.

Structurally, the lower elevations of the Project Area sit within an area of gently folded Permian-aged rocks, with the folds generally on a north to south and north northwest to south southeast axis, and plunging gently to the south at an angle of 2 to 5º. Structural features include the Muswellbrook Anticline in the west, then moving further east the Bayswater Syncline, Camberwell Anticline, and Glennies Creek Syncline. The Muswellbrook Anticline is the most significant of these features, although its axis is located just outside of the Project Area to the west. The Liddell Coal Operations (LCO) is located on the eastern limb of the Bayswater Syncline. To the north and northeast along the flank of the Hunter Valley, a series of northwest to southeast trending faults and thrusts, including the minor Hebden Thrust and the major Hunter Thrust, that bring older Permian and then Carboniferous-aged rocks to the surface. The coal bearing Permian-aged rocks found elsewhere in the Project Area are not present. There are no major faults within the Permian rocks of the Project Area, although a north-south trending dyke has been emplaced within the Permian rocks in the immediate LCO area, and it is possible that further dykes exist in the Project Area. Some smaller scale faulting within the Permian rocks is known to be present in the Mt Owen area.

A weathered regolith is developed in the Permian rocks over much of the Project Area but is limited to less than 10 m depth.

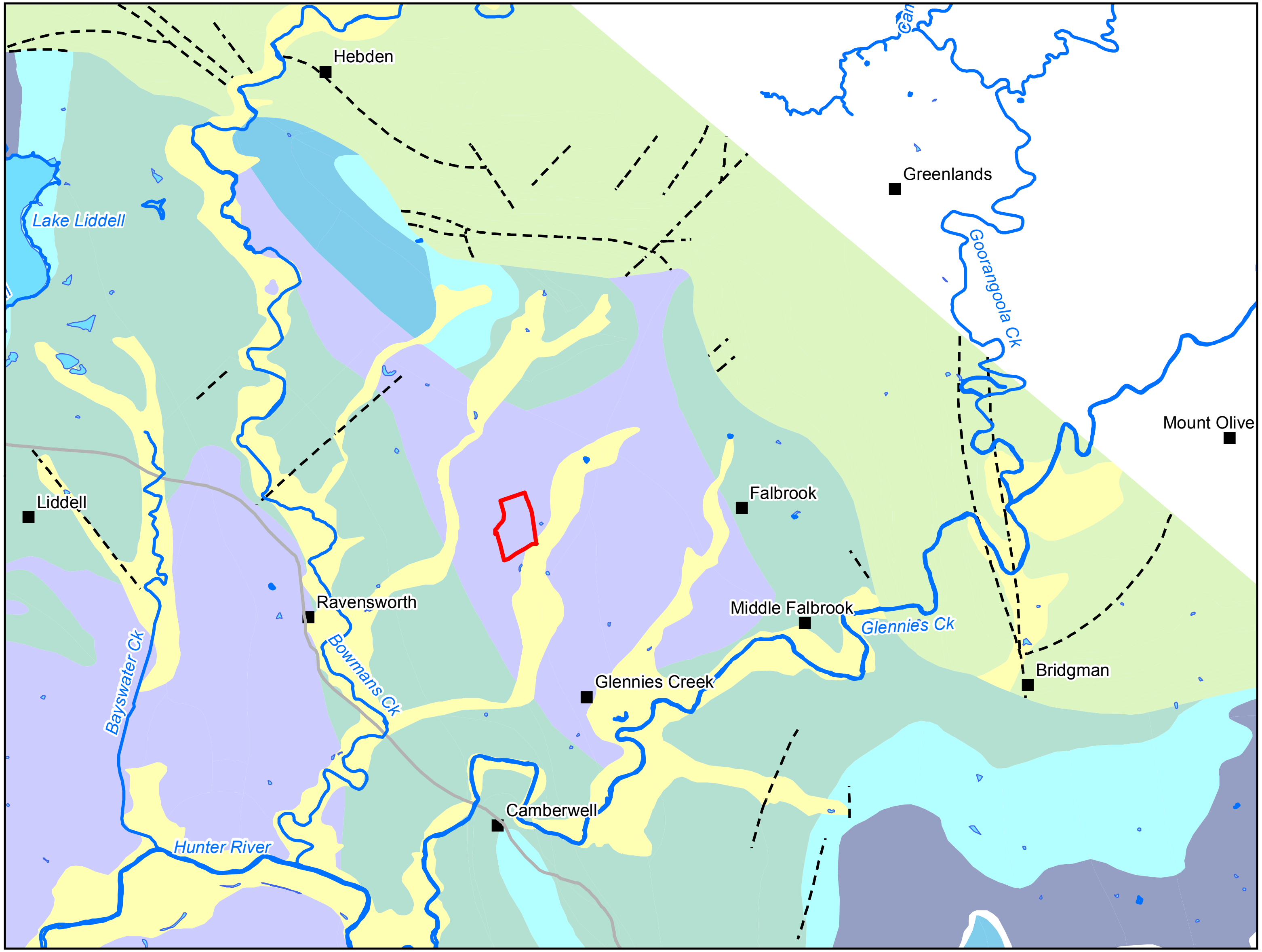
Figure A-2 presents the surficial geology and the locations of the major structural features of the Project Area.

A.3.2 Carboniferous

To the north and northeast of the Project Area a succession of older Carboniferous-aged rocks has been thrust upwards to the surface. These rocks consist of several hardrock formations and include sandstones, shales, conglomerates, mudstone, tillites and volcanics. These rocks are unlikely to play a major role in the groundwater system of the Project Area due to very limited permeability and storage properties compared to the coal seams of the Wittingham Coal Measures.

The Hunter Thrust zone is generally considered as a low permeability barrier to groundwater flow, but only limited data exist to the northeast to substantiate this claim, though numerous springs along the fault scarp attest to discharge to the north and east of the fault zone.

Ravensworth surface geology



Surface geology

- Alluvials
- Undifferentiated Carboniferous
- Branxton Formation, conglomerate
- Mulbring Siltstone, siltstone
- Saltwater Creek Formation, sandstone
- Denman Formation, coal
- Archerfield Sandstone, coal
- Surface water
- Stream
- Fault
- RERR Mining Area
- Main road
- Township

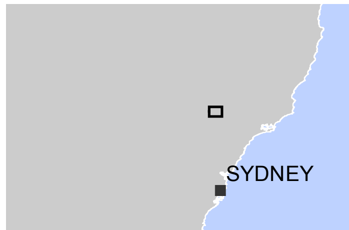
Sinclair Knight Merz does not warrant that this document is definitive nor freeof errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

[GDA 94]

A4 1:125,000

0 2

Kilometres



[FIGURE A-2]

D:\Documents and Settings\landers\My Documents\Projects\Xstrata\GIS\Figures\RERR_geology_v1.mxd

Prepared by : LA

A.3.3 Permian

The coal-bearing rocks of the Permian-aged Wittingham Coal Measures (WCM), mainly the Foybrook Formation unit, are the main subcropping and outcropping geological unit in the lower elevations of the Project Area (i.e. within the core of the Hunter Valley). The Foybrook Formation is the basal coal-bearing unit of the WCM, and is underlain by the Saltwater Creek Formation, which forms the basal rock unit of the WCM. Beneath the WCM lie the non-coal bearing Permian rocks of the Mulbring Siltstone, Muree Sandstone, and Branxton Formation.

The WCM contain up to seven main coal seams (each containing multiple plies) in the Project Area (refer to Table A-1), although some seams are not present in the vicinity of the axis of anticlines, and the WCM are not present in the Project Area west of Lake Liddell, due to the influence of the Muswellbrook Anticline. The coal seams are separated by interburden rock strata that consist of sandstone, siltstone, conglomerate, mudstone and shale. The deeper seams of the WCM subcrop and outcrop on the eastern flank of the Muswellbrook Anticline in the vicinity of Lake Liddell, whilst the shallow seams outcrop in areas of incised topography on the valley floor.

A list of the coal seams occurring in the project area and their related interburden, along with their thicknesses is presented in Table A-2. Individual coal seams may split into multiple seams down-dip and along strike; for example the Liddell seam starts as a single seam in the northeast of the region, but splits into three seams to the south and southeast.

The lowermost coal unit of the Foybrook Formation, the Hebden Seam, is underlain by the Saltwater Creek Formation, which consists of a marine regressional sequence of sandstone, siltstone and laminite. The Saltwater Creek Formation forms the basal unit of the Wittingham Coal Measures. It lies at depth within the Hunter Valley over most of the Project Area, but subcrops north of Mt Owen where it is upthrown between the Hebden Thrust and Hunter Thrust. In this area of overthrusted older rocks, the Permian-aged Branxton Formation (consisting of sandstone, siltstone and conglomeritic rocks and which is in turn lower in the stratigraphic sequence than the Saltwater Creek Formation) also subcrops.

The Ravensworth East Mine proposes only to mine down to the Bayswater Seam, though this can dip down in excess of 200m in the vicinity of the mining lease.

■ **Table A-1 Stratigraphy of the Wittingham Coal Measures**

<table>
<tr><td rowspan="29">Singleton Super Group</td><td rowspan="29">Wittingham Coal Measures</td><td colspan="3">Denman Formation</td></tr>
<tr><td rowspan="19">Jerrys Plains Subgroup</td><td>Mount Leonard Formation</td><td>Whybrow Seam</td></tr>
<tr><td colspan="2">Allthorp Formation</td></tr>
<tr><td rowspan="7">Malabar Formation</td><td>Redbank Creek Seam</td></tr>
<tr><td>Wambo Seam</td></tr>
<tr><td>Whynot Seam</td></tr>
<tr><td>Blakefield Seam</td></tr>
<tr><td>Saxonvale Seam</td></tr>
<tr><td>Glen Munro Seam</td></tr>
<tr><td>Woodlands Hill Seam</td></tr>
<tr><td colspan="2">Milbrodale Formation</td></tr>
<tr><td rowspan="3">Mount Thurney Formation</td><td>Arrowfield Seam</td></tr>
<tr><td>Bowfield Seam</td></tr>
<tr><td>Warkworth Seam</td></tr>
<tr><td colspan="2">Fairford Formation</td></tr>
<tr><td rowspan="5">Burnamwood Formation</td><td>Mt Arthur Seam</td></tr>
<tr><td>Piercefield Seam</td></tr>
<tr><td>Vaux Seam</td></tr>
<tr><td>Broonie Seam</td></tr>
<tr><td>Bayswater Seam</td></tr>
<tr><td colspan="3">Archerfield Sandstone</td></tr>
<tr><td rowspan="7">Vane SubGroup</td><td colspan="2">Bulga Formation</td></tr>
<tr><td rowspan="6">Foybrook Formation</td><td>Lemmington Seam</td></tr>
<tr><td>Pikes Gully Seam</td></tr>
<tr><td>Arties Seam</td></tr>
<tr><td>Liddell- Ramrod Creek Seam</td></tr>
<tr><td>Barrett Seam</td></tr>
<tr><td>Hebden Seam</td></tr>
<tr><td colspan="3">Saltwater Creek Formation</td></tr>
</table>

- **Table A-2 Summary of thickness of relevant coal and interburden strata in the Project Area (m)**

Unit	Average	Minimum	Maximum
Broonie Seam	0.3	0	0.7
Broonie-Bayswater interburden	3.7	0	122
Bayswater Seam	9.2	0	25
Bayswater-Lemington interburden	14	0	92
Lemington Seam	53	0	128
Lemington-Pikes Gully interburden	7.5	0	43
Pikes Gully Seam	6.0	0	34
Pikes Gully-Arties interburden	8.3	0	52
Arties Seam	14	0	42
Arties- Liddell interburden	8.2	0	36
Liddell Seam	33	0	81
Liddell-Barrett interburden	17	0	54
Barrett Seam	3.5	0	14
Barrett-Hebden interburden	19	0	50
Hebden Seam	2.1	0	3.0

Source: Xstrata LCO coal exploration drillhole database
Values represent stratigraphic unit thickness, not coal seam thickness
Average values are skewed by 'zero' thickness in database where strata are absent

A.3.4 Recent Alluvial Deposits

Alluvium is developed along the Hunter River and the courses of the major creeks in the Project Area. The lateral extent of the alluvial deposits is shown on **Error! Reference source not found.** as "undifferentiated sand". As shown, the alluvial plains vary in width from approximately 1 km to less than 10 m where creeks cross outcrops of bedrock. The average width of alluvial deposits is around 700 m.

The alluvium is generally characterised by a succession of three units, grading from a basal coarse grained bed load comprising sand to cobble size deposits, to a middle unit comprising finer grained levee deposits, and finally an upper unit comprising floodplain deposits (Beckett, 1987). The alluvium is generally thickest adjacent the Hunter River compared with any of its tributaries. The basal unit generally varies in thickness across the Project Area from 0 to 12 m, whilst the middle and upper units vary in thickness from 1 to 3 m and 1 to 2 m, respectively. The sediments within the upper tributaries of Bowmans and Glennies Creeks are expected to have similar lithologies to that described above, perhaps with a thinner intersection of the basal coarse grained unit. In the tributaries to the Hunter River, the thickest recorded intersections of basal gravels occur immediately downstream of where the Creeks cross bedrock outcrops.

Groundwater occurs in coal seams that are relatively thin and exhibit relatively low permeability. The seams are separated by interburden sediments that are generally thicker than the coal seams but are of much lower permeability. Recharge of the coal seams occurs from rainfall on areas where the seams outcrop and subcrop. Pre-mining groundwater discharge is not well defined. However it is likely that discharge occurred through lateral seepage away from the mining area and as vertical seepage upwards through the interburden and into streams that drain the area. Despite the relatively low permeability of the interburden, groundwater responses are transmitted vertically and as a result groundwater heads in localised alluvial sediments overlying the coal seams are influenced by mining and dewatering operations.

A.4 Hydraulic properties

Table A-3 and Table A-4 present a summary of estimated hydraulic parameters for the Permian coal measures obtained from previous investigations within the region. Note that laboratory core testing results (as presented for the interburden strata in MER, 2011) will give permeabilities at the lower end of the expected realistic range, as the reported data represent matrix permeabilities and do not take into account the effect of secondary porosity such as fracturing on bulk formation permeability. Hydraulic conductivities derived from airlift testing have not been reported here as they represent the bulk conductivity for the entire open borehole during testing (i.e. multiple seams and interburden strata).

Table A-3 - Summary of hydraulic conductivity values for the coal measures (m/day)

<table>
<tr><th rowspan="2">Unit</th><th colspan="3">Previous Studies within Project Area</th></tr>
<tr><th>MER, 2011a, 1998 (mean of test values)</th><th>MER, 2011b (modelled values)</th><th>Aquaterra, 2009</th></tr>
<tr><td>Bayswater Seams</td><td>5.0×10^{-3}</td><td></td><td></td></tr>
<tr><td>Lemington Seams</td><td>8.7×10^{-3}</td><td>-</td><td>2.0×10^{-3} to 3.0×10^{-2}</td></tr>
<tr><td>Pikes Gully Seams</td><td>2.3×10^{-2}</td><td>Kh - 2.0×10^{-3}
Kv - 2.0×10^{-4}</td><td>4.0×10^{-2}
(median)</td></tr>
<tr><td>Arties Seams</td><td>1.1×10^{-2}</td><td>-</td><td rowspan="4">2.0×10^{-3} to 3.0×10^{-2}</td></tr>
<tr><td>Liddell Seams</td><td>1.4×10^{-2}</td><td>Kh – 7.0×10^{-4}
Kv – 1.0×10^{-4}</td></tr>
<tr><td>Barretts Seams</td><td>8.4×10^{-3}</td><td>Kh - 4.0×10^{-4}
Kv - 1.0×10^{-4}</td></tr>
<tr><td>Hebden Seams</td><td>-</td><td>-</td></tr>
<tr><td>Interburden (core data)</td><td>Kh – 4.6×10^{-6}
Kv – 2.5×10^{-6}</td><td rowspan="2">Kh – 4.0×10^{-6} to 3.3×10^{-4}
Kv – 2.0×10^{-7} to 3.4×10^{-5}</td><td rowspan="2">3.0×10^{-4}
(median)</td></tr>
<tr><td>Interburden (packer tests)</td><td>2.0×10^{-3}</td></tr>
</table>

Notes: Kh = horizontal hydraulic conductivity and Kv = vertical hydraulic conductivity

Table A-4 - Summary of storage values for the Permian coal measures

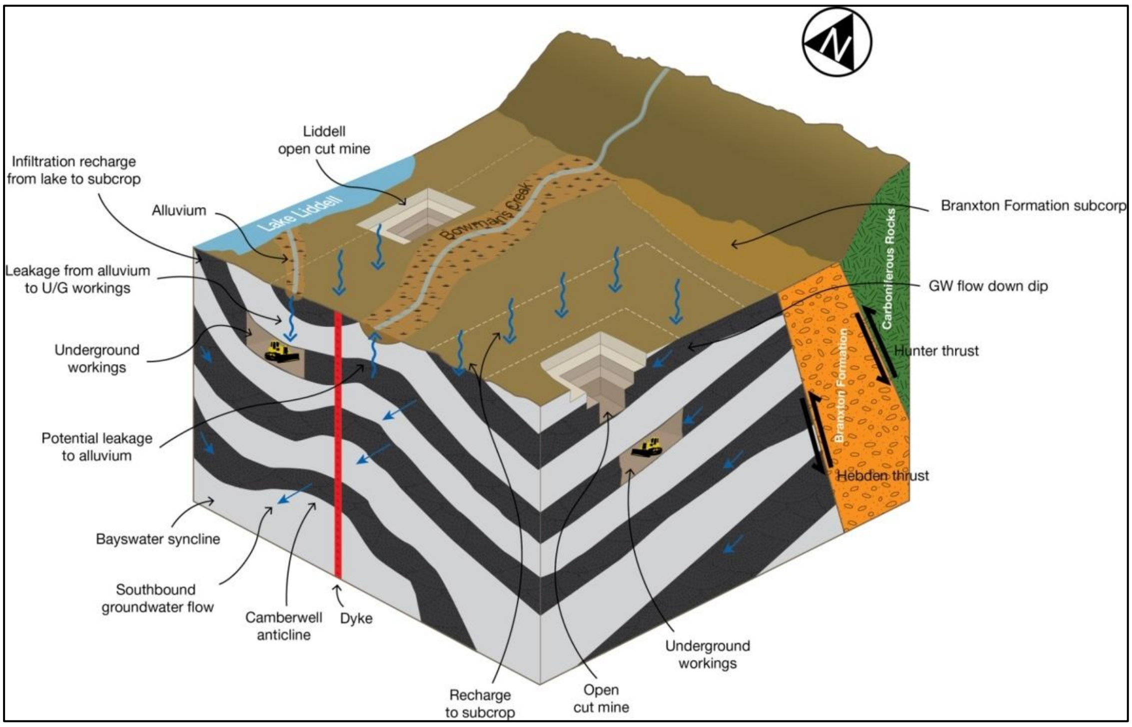
Unit	Previous Studies within Project Area		
	MER, 2011a (mean)	MER, 1998	Aquaterra, 2009
Bayswater Seams	-	-	-
Lemington Seams	Sy = 1.0 x 10^{-3} to 3.0 x 10^{-2}	-	S – 1.0 x 10^{-4} Sy – 5.0 x 10^{-3}
Pikes Gully Seams		-	S – 1.0 x 10^{-4} Sy – 5.0 x 10^{-3}
Arties Seams		-	S – 1.0 x 10^{-4} Sy – 5.0 x 10^{-3}
Liddell Seams		-	
Barretts Seams		-	
Hebden Seams		-	
Interburden	Sy = 1.0 x 10^{-4} to 5.0 x 10^{-2}	-	S – 1.0 x 10^{-5} Sy – 5.0 x 10^{-3}

Notes: S = confined storativity and Sy = unconfined specific yield

Structural Controls on Groundwater Flow

The groundwater model incorporates the dykes and faults within the region. Whilst more prominent and critical in coal measures to the west of Bowmans Creek, these features are reported to result in significantly less groundwater inflows to mine workings on one side compared to the other. These features act to limit groundwater depressurisation in the coal measures on the downstream side of them and can effectively separate groundwater systems into separate compartments.

A generalised block diagram summarising the conceptual regional hydrogeological model is shown in Figure A-3. This schematic conceptually represents hydrological processes and is not to scale.



- **Figure A-3 Conceptual hydrogeological block diagram of the project area and surrounds (not to scale)**

A.5 Model history

The numerical model built for the purpose of the RERR GIA is based on the Ravensworth Underground Mine (RUM) model (MER, 2011b). The RUM model utilised the finite difference code MODFLOW-SURFACT. Its grid has 240 rows and 260 columns varying in size from approximately 50 to 100 m and is composed of 16 layers representing the hydrostratigraphy from the surface down to the Saltwater Creek Formation. The RUM model has a total of 962,256 active cells. It includes the Ravensworth underground and open cut mine and the Coal & Allied and Ashton underground operations and covers an area of 240 km^2 (15 x 16 km).

The RUM model was extended by 5.5 km to the north to include Liddell open cut and underground operations and 11.4 km to the east to include Mt Owen and Glendell mines to form the model extent.

A.6 Model code and strategy

The model was built and run in the MODFLOW-SURFACT code version 4 (Hydrogeologic, 2011) using the graphical user interface Groundwater Vistas version 6.18 (Environmental Simulations, 2011). MODLFOW-SURFACT was chosen for its ability to model variably saturated conditions, its advanced solver, PCG5, and the TMP1 module which allows the hydraulic properties to vary in time and is able to replicate the changes in hydrogeological parameters that occur as mining progresses.

The TMP1 module is particularly useful for underground mines in which collapse of old workings and disturbance to overlying units leads to substantial changes in the local hydrogeological setting as a result of mining. It can also provide a means of accounting for the removal of geological material from open cut mines and the subsequent infilling of mine voids.

A.7 Model description

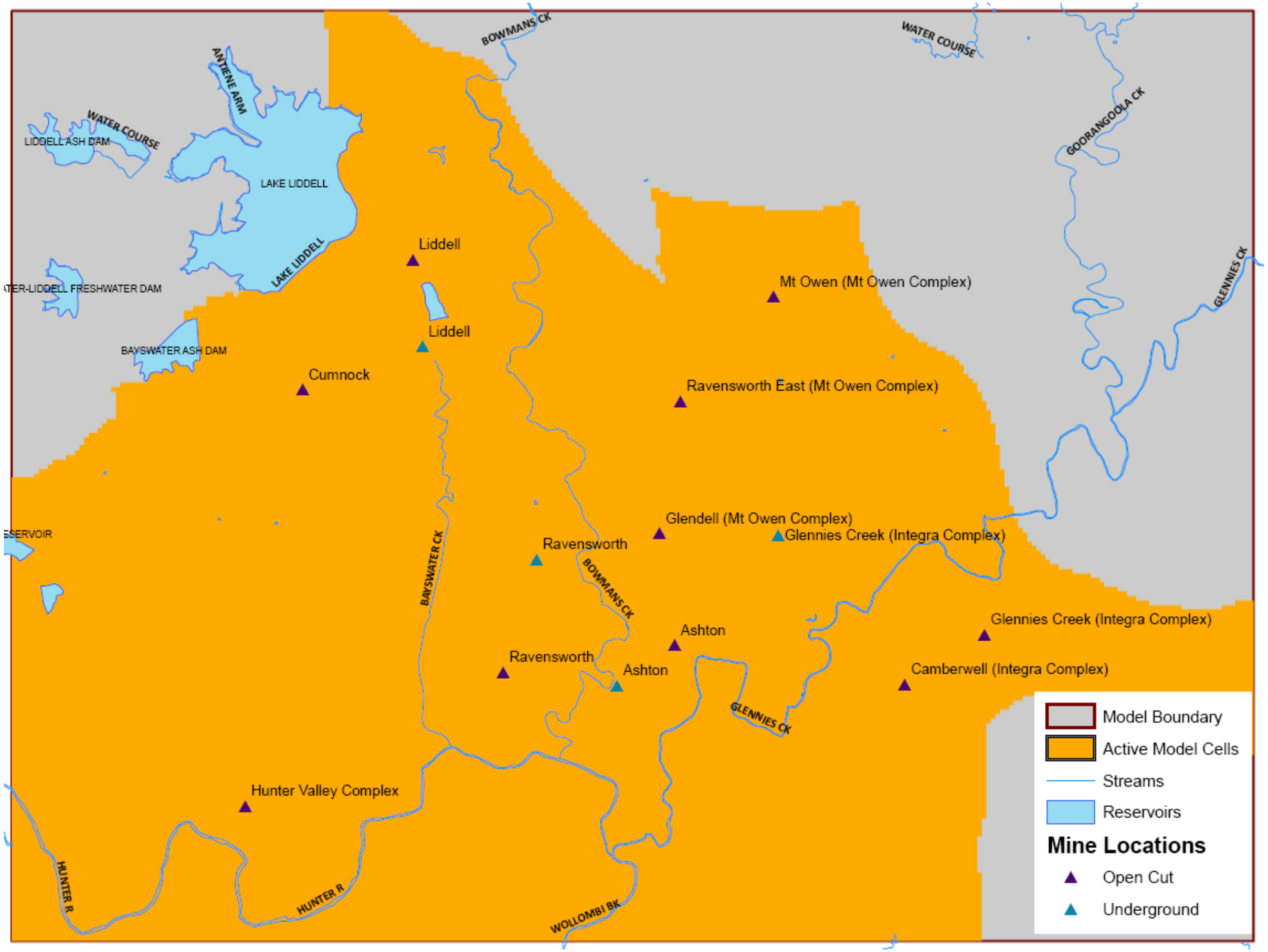
A.7.1 Grid

The model is 20.5 km in the north-south direction and 27.4 km in the east-west direction. The coordinates of the model origin (south-west corner) are 305,000E 6,400,000N (GDA94 MGA Zone 56). Grid cells are 100 x 100 m in size resulting in 205 rows and 274 columns.

Inactive cells were assigned in the areas where the Vane Subgroup seams are not present, in the northwest and southeast corners, and beyond the Hunter Thrust. The model has a total of 676,533 active cells. Figure A shows the model grid and the locations of significant features.

A.7.2 Surfaces

The model is composed of 19 layers representative of the geology from the ground surface down to the Saltwater Creek Formation which underlies the seams of the Foybrook Formation. Table A-5 describes each layer.



- **Figure A 4 Plan view of the model grid showing inactive cells in grey locations of all mines considered in the model and water courses used in the modelling process**

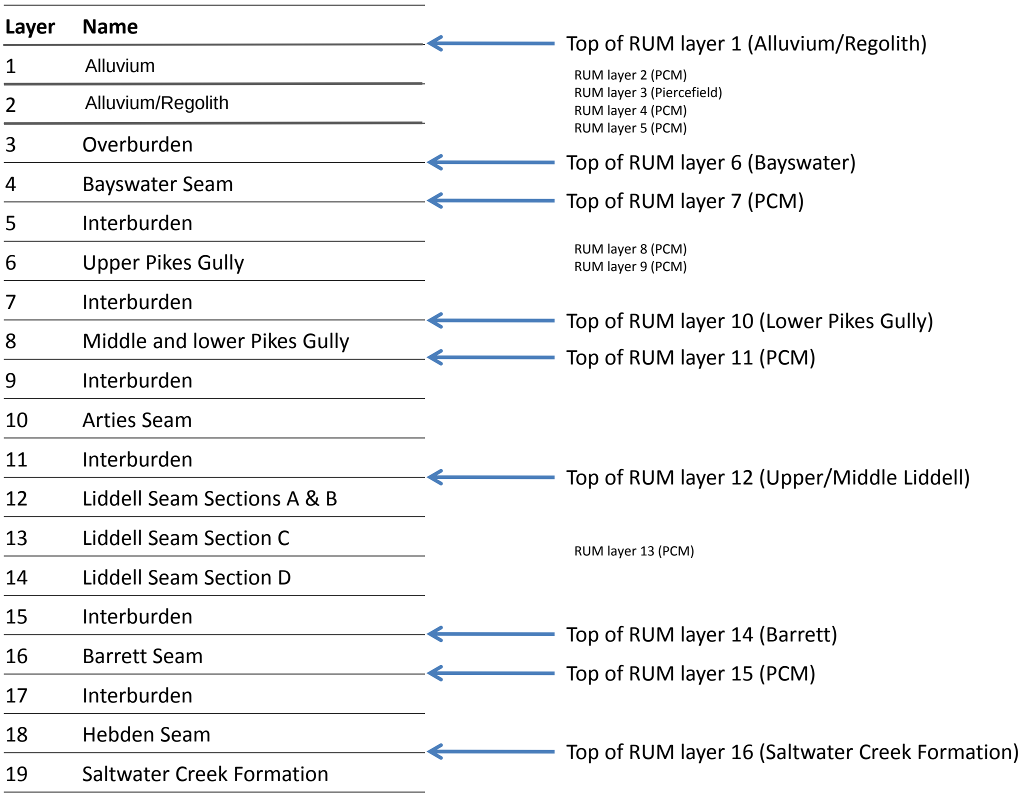
Table A-5 Model layers

Layer	Name	Description
1	Alluvium	Alluvial deposits surrounding the major rivers.
2	Alluvium/Regolith	Basal Alluvial sediments surrounding the rivers and Regolith (weathered rock) elsewhere.
3	Overburden	Everything between the base of weathering and the top of the Bayswater Seam, can include seams, but mostly sandstone, claystone and/or siltstone.
4	Bayswater Seam	All the Bayswater Seams. Includes the upper Bayswater 1, upper Bayswater 2 and Lower Bayswater at Liddell. Also includes interburden between these seams.
5	Interburden	Everything between the base of the Bayswater Seam and the top of the Upper Pikes Gully Seam, includes Lemington Seam.
6	Upper Pikes Gully Seam	Upper Pikes Gully Seam.
7	Interburden	Everything between the base of the upper Pikes Gully Seam and the top of the middle Pikes Gully Seam.
8	Middle and lower Pikes Gully Seam	Everything between the top of the middle Pikes Gully Seam and the base of the lower Pikes Gully Seam, includes interburden between the two seams.
9	Interburden	Everything between the base of the lower Pikes Gully Seam and the top of the Arties Seam.
10	Arties Seam	All the Arties Seams. Includes the Arties A, Arties B, Arties L1 and Arties L2 at Liddell.
11	Interburden	Everything between the base of the lower Pikes Gully Seam and the top of the Arties Seam.
12	Liddell Seam Sections A & B	All the Liddell Seams in Sections A and B. Includes the Liddell A1, Liddell Parting, Liddell B1, upper Liddell B2 and lower Liddell B2 at Liddell. Also includes interburden between these seams.
13	Liddell Seam Section C	All the Liddell Seams in Section C. Includes the upper Liddell C1, lower Liddell C1 at Liddell. Also includes interburden between the two seams.
14	Liddell Seam Section D	All the Liddell Seams in Section D. Includes the upper Liddell D1, lower Liddell D1 at Liddell. Also includes interburden between the two seams.
15	Interburden	Everything between the base of the Liddell Seam Section D and the top of the Barrett Seam.
16	Barrett Seam	All the Barrett Seams. Includes the Barrett A, upper Barrett B, middle Barrett B, lower Barrett B, Barrett C1, Barrett C2 and Barrett D at Liddell. Also includes interburden between these seams.
17	Interburden	Everything between the base of the Barrett Seam and the top of the Hebden Seam.
18	Hebden Seam	All the Hebden Seams. Includes upper Hebden and lower Hebden at Liddell. Also includes interburden between the two seams.
19	Saltwater Creek Formation	This layer represents the basement below the Hebden Seam, its upper part is composed of the Saltwater Creek Formation.

A number of assumptions were made to create the model layer top surfaces:

- The top of layer 1 which represents the ground surface is based on a 25 m DEM (Digital Elevation Model) obtained from NSW Land and Property Information.
- Alluvial deposits are included in the uppermost layer of the model. In areas where alluvial sediments are present the thickness of the top model layer varies linearly from 10 m (in the upper reaches of Bowmans, Bayswater and Glennies Creeks) to 30 m (along the Hunter River). These values are based on Probert & Stevenson (1970) and Beckett (1987) and represent the maximum thicknesses of alluvial sediments beneath the alignment of the rivers and creeks. The alluvium thickness was set to 1 m along the boundaries of the alluvium extent. This extent is based on the analysis of the latest available LIDAR data (Personal communication with Col Mackie). Outside the areas where alluvium is present the top model layer is uniformly 1 m thick.
- Layer 2 of the model represents alluvial sediments within the river valleys and regolith elsewhere.
- The top and bottom of the model layers that represent the coal seams were based on the surfaces from the Liddell Open Cut Mine Minescape Geological Model (MBGS, 2012) in the Liddell mine area and from the Mt Owen geological model in the region of the Mt Owen mine. Beyond the Liddell and Mt Owen mine extents, the RUM model layers were used where a correspondence exists (the RUM model layer structure is not identical to that of the current regional model). The correspondence between the RUM model layers and the regional model layers is shown in Figure A 5.
- The subcrop locations for the individual seams were not known with accuracy outside the Liddell and Mt Owen geological models. The Bayswater Seam was assumed to subcrop where the Jerrys Plain Subgroup does, while the Pikes Gully, Arties, Liddell, Barrett and Hebden Seams were assumed to subcrop where the Vane Subgroup subcrops. The subcrop of the Jerrys Plain Subgroup and the Vane Subgroup were located according to the Hunter Coalfield Regional Geology map (NSW Department of Mineral Resources, 1993).
- The top of RUM model layer 10 (Lower Pikes Gully Seam) was assumed to be the top of the Middle Pikes Gully Seam in the regional model. This assumption is reasonable to the south of Liddell where the difference is less than 4 m although greater discrepancies may occur further to the south.
- The division of the Liddell Seam between Sections A/B, C and D was based on their elevations at Liddell. However the seams separate towards the south further away from Liddell. In the southern part of the model, the three model layers representing the Liddell Seam may therefore incorporate a significant thickness of interburden. In order to account for this anomaly lower hydraulic conductivity values are assigned to the model layers that represent the Liddell Seam in the south of the model where the seams are believed to separate.
- The bottom layer (basement) was assigned a constant thickness of 20 m.

- **Figure A 5 Correspondence between Ravensworth Underground and the regional model layers**



A.7.3 Variably saturated flow

The model simulates variably saturated flow and is able to replicate the partial and complete desaturation and re-saturation of cells. All layers are defined as unconfined with constant storage and transmissivity allowed to vary.

A.7.4 Mining operations

The mining operations are represented in the model in two ways:

1) Increased hydraulic conductivity (both horizontal and vertical) to represent the removal of material from underground operations and associated collapse of overlying. The conductivity of the disturbed materials is assumed to be five times higher than the conductivity of the in-situ materials within the underground mining footprint.
2) Drain cell boundary conditions are used to represent both underground and open cut mine operations. The drain stage is set 0.1 m above the base of the seam that is being mined with a uniform conductance of 100 m^2/d. This value has been chosen as being sufficiently high to ensure that water levels drop to the base of excavations as required but low enough to prevent numerical instability.

A.8 Calibration

A.8.1 Approach

Calibration is the process used to help refine the various uncertain hydrogeological parameters used in the model to simulate the movement and storage of water within the model domain. It involves running the model over an historic time frame so that model results can be compared against observed or measured groundwater behaviour. In the case of the regional model the calibration approach involves the following tasks:

1) Run the model in steady state mode and match to pre-mining heads measured and interpreted throughout the model domain. To account for the fact that there are few observations of groundwater head prior to the start of mining, it was necessary to use a number of interpreted heads that not only fit with the groundwater heads measured during and after mining but also take account of preceding mining conditions.
2) Run the model from 1980 to present and compare model predicted changes in groundwater head to those measured in monitoring wells over the same time frame. Most observations bores show groundwater responses during mining (i.e. drawdown due to dewatering) and following mine closure (i.e. recovery of heads).

In all cases the possible range of hydraulic conductivity adopted during calibration has been restricted or constrained by the measurements of hydraulic conductivity obtained from tests performed on a number of the coal seams as described below. The specific yield and the rainfall recharge were also allowed to vary within a representative range.

Other parameters were fixed and did not vary from one run to another. These are:

- The specific storage was considered in first approximation to be almost entirely related to the compressibility of water (as opposed to compressibility of the matrix material). A uniform specific storage value of $5x10^{-6}$ m-1 was used;
- The wall boundary hydraulic conductivity was set sufficiently low to be an obstacle to flow;
- The maximum evapotranspiration rate and extinction depth; and
- The drain conductance of the cells representing non-perennial streams and the mining operations were set sufficiently high to ensure that calculated groundwater heads do not exceed the specified drain levels.

Among all the observations bores within the model domain, 104 were selected for use as calibration targets. Bores were chosen based on the following criteria:

- observed heads available as elevations in m AHD;
- at least three years of data; and
- at least ten records.

Historical mining operations have been included in the transient calibration model through the use of drain boundary conditions to represent the dewatering of both open cut and underground mines to the base of seam. The modelled representation of historical mining operations was obtained in part directly from the inputs to the RUM model and these are believed to represent an approximation of actual mining operations undertaken in the calibration period (from 1980 to present). The mining operations at Liddell, Ravensworth East and Mt Owen, which were not included in the RUM model (they are outside the RUM model domain), were added based on available historical records at these mines.

Calibration has been hampered by both a lack of measured pre-mining groundwater level data that define steady state conditions prior to the commencement of mining and inadequate records of historic mining activities throughout the transient calibration period. Only a crude representation of historic mining in the transient calibration has been possible. In light of these problems a calibration approach has been adopted to provide a hierarchy of calibration data that recognises the accuracy of the various data sets used:

1) Maximum weight is applied to the measured hydraulic characteristics of the coal seams. Hydraulic conductivities for all model layers are assigned values that are consistent with the testing that has been undertaken at the site,
2) Steady state calibration has been given secondary priority,
3) Transient calibration has been given the lowest priority.

Initial calibration attempts using the PEST code (Watermark Numerical Computing, 2012) with the singular value decomposition procedure illustrated that most of the transient calibration data sets included significant responses to historic mining activity, the details of which are not included in the model. Accordingly the calibration models were unable to replicate many of the responses included in the observed hydrographs.

An alternative approach to calibration was adopted, in which the model was run multiple times using randomly generated data sets from within pre-defined parameter limits. The parameter limits were obtained from measured or calculated values of hydraulic conductivity of the coal seams and from the results of the previous calibration attempts.

A.8.2 Stochastic modelling approach

Difficulties in obtaining suitable data for a transient calibration have led to a model that is non-unique and is not highly constrained. There are many different combinations of parameters that can provide an equally valid level of calibration. As a result the model can be classified, under Australian Groundwater Modelling Guidelines, as being of medium confidence level. In such circumstances it is worth while carrying out a formal uncertainty analysis and to this end a stochastic modelling approach has been adopted to investigate the variability in parameter values that might lead to adequate model calibration. The analysis includes an assessment of how such variability in key parameters may influence the predictive modelling outcomes generated by the model. The stochastic approach has been undertaken in two stages:

1) Running a set of 1000 realisations of the calibration to determine the parameter sets that provide a reasonable level of calibration.
2) Running a set of 20 realisations derived from the best calibration models (those with the lowest phi values suggesting the best match to the objective function) to determine the range of outputs that these models generate when run in predictive mode.

The approach is aimed at generating a population of models and model outcomes that are consistent with both the measured hydraulic conductivity values in the coal seams and with the calibration data. The population of predictive model outcomes therefore represents an indication of the potential range in likely outcomes that may occur during future mining.

A.8.3 Stress periods

The transient calibration model simulated the period from 1 January 1980 to 31 December 2011 in 16 stress periods, the first of which was steady state. The steady-state stress period was aimed at providing stable initial heads for the subsequent transient calibration run. No drain cell boundary conditions representing mining operations are included in the steady-state model. However this model does include artefacts of the historical mining operations as enhanced conductivity zones representing the impacts of previous underground mining. Table A-2 lists the stress periods and their durations.

- **Table A-6 Calibration model stress periods**

Stress period	Start date	End date	Number of days
1		Steady-state	
2	01/01/1980	01/01/1985	1827
3	01/01/1985	01/01/1990	1826
4	01/01/1990	01/01/1995	1826
5	01/01/1995	01/01/2000	1826
6	01/01/2000	01/01/2002	731
7	01/01/2002	01/01/2003	365
8	01/01/2003	01/01/2004	365
9	01/01/2004	01/01/2005	366
10	01/01/2005	01/01/2005	365
11	01/01/2006	01/01/2007	365
12	01/01/2007	01/01/2008	365
13	01/01/2008	01/01/2009	366
14	01/01/2009	01/01/2010	365
15	01/01/2010	01/01/2011	365
16	01/01/2011	01/01/2012	365

A.8.4 Outcome

The model parameter ranges and median values are shown in Table A-7 as the limiting values assumed by the stochastic modelling and the ranges of parameters included in the 20 calibrated models.

- **Table A-7 Summary of parameter values obtained from calibration**

Kh refers to horizontal hydraulic conductivity
Kv refers to vertical hydraulic conductivity
Sy refers to specific yield
MAR refers to Mean Annual Rainfall

Parameter	Zone	Min	Max	Median of calibrated realisations	Unit
Kh	Alluvium	0.1	100	6.25E+01	m/d
Kh	Alluvium/Regolith	0.1	50	2.39E+00	m/d
Kh	Interburden	0.00001	0.03	4.87E-03	m/d
Kh	Pikes Gully Seam	0.001	0.2	6.30E-03	m/d
Kh	Liddell Seam	0.001	0.4	6.02E-03	m/d
Kh	Barrett Seam	0.001	0.05	5.45E-03	m/d
Kh	All other seams	0.0009	0.4	8.74E-03	m/d
Kh	Pikes Gully Seam – old underground workings	0.005	1	3.15E-02	m/d
Kh	Liddell Seam – old underground workings	0.005	2	3.01E-02	m/d
Kv	Alluvium	0.01	10	6.25E+00	m/d
Kv	Alluvium/Regolith	0.01	5	2.39E-01	m/d
Kv	Interburden	0.000001	0.003	4.87E-04	m/d
Kv	Pikes Gully Seam	0.0001	0.02	6.30E-04	m/d
Kv	Liddell Seam	0.0001	0.04	6.02E-04	m/d
Kv	Barrett Seam	0.0001	0.005	5.45E-04	m/d
Kv	All other seams	0.00009	0.04	8.74E-04	m/d
Kv	Pikes Gully Seam – old underground workings	0.0005	0.1	3.15E-03	m/d
Kv	Liddell Seam – old underground workings	0.0005	0.2	3.01E-03	m/d
Sy	Alluvium	0.05	0.2	6.44E-02	-
Sy	Regolith	0.01	0.1	5.62E-02	-
Sy	Interburden	0.005	0.05	6.11E-03	-
Sy	Pikes Gully Seam	0.005	0.05	5.52E-03	-
Sy	Liddell Seam	0.005	0.05	5.59E-03	-
Sy	Barrett Seam	0.005	0.05	5.68E-03	-
Sy	All other seams	0.005	0.05	3.71E-03	-
Sy	Pikes Gully Seam – old underground workings	-	-	7.35E-08	-
Sy	Liddell Seam – old underground workings	-	-	7.90E-07	-
Recharge	Alluvium	1	15	9.90	% of MAR
Recharge	Jerrys Plain Subgroup subcrop	0.001	2	4.93E-02	% of MAR
Recharge	Vane Subgroup subcrop	0.001	2	5.19E-02	% of MAR

Parameter	Zone	Min	Max	Median of calibrated realisations	Unit
Recharge	Saltwater Creek Formation subcrop	0.001	2	4,47E-02	% of MAR
Recharge	Western subcrop	1E-05	0.1	4.16E-03	% of MAR

A.9 Predictive models

A.9.1 Approach

The predictive model has been designed to start from the end of the calibration model and includes the proposed modification and a recovery period after mining ceases. The model was run for the 20 best calibration realisations with rainfall recharge reflecting an average, dry and wet weather. The average, dry and wet weather were defined as the 50th, 10th and 90th percentiles of the annual rainfall records at Jerrys Plains Post Office.

The 20 models were run with two different future mining assumptions:

- The base case model assumes future mining operations that would be expected under current approvals.
- The expanded mine case assumes future mining that would occur under the proposed modification.

The expanded mine scenario runs provide predictions of the cumulative impacts of mining operations at Liddell and elsewhere. Results from the two different scenario cases can be subtracted to generate the incremental impacts associated with the proposed mine modification.

A.9.2 Mining operations

Estimated groundwater extractions arising from future mining operations in the modelled area were simulated by the MODFLOW drain package. Drain cells were placed in the model at locations of future mine modification with the drain reference level dictated by the basal elevation of model layer representing the particular seams being mined. Open cut operations were represented by drain cells in all layers from the ground surface down to the base of the deepest mined seam. In the case of future underground mine operations, drain cells were only assigned in model layers corresponding to the mined seams.

Timing of drain cell operation was defined based on the proposed or expected future mining sequences. Drain cells for open cut mines were deactivated following a period of active dewatering to represent the lateral progression of the active mine open cuts. Drain cells for underground mines were deactivated following the completion of each underground operation.

A.9.3 Ravensworth East Open Cut

For the Ravensworth East open cut mine, the following processes were specifically accounted for in the model:

- changes in hydraulic conductivity and specific yield as a result of the transition from country rock to void then to spoil or final void;

- changes in groundwater recharge as a result of the transition from country rock to spoil or final void;
- ground surface as used to define the reference level for evapotranspiration (the evapotranspiration surface) is simulated to dynamically follow the base of mine in the open cut during excavation and backfilling up to final landform;
- altered evapotranspiration extinction depths as a result of vegetation (rehabilitation) removal from the mining areas.

In each model cell corresponding to part of the open cut operations, the hydraulic conductivity and specific yield parameters were changed during the simulation to represent either backfill or void one year following commencement of drainage in each cell. Both the hydraulic conductivity and specific yield of backfill are expected to be considerably greater than typical parent rocks. The implication from a mine dewatering perspective is that backfill materials will have a greater storage capacity and will more easily transmit water than the in-situ interburden and coal, and will have a greater potential for recharge from rainfall. Table A-8 shows hydraulic parameters used for backfill and air.

- **Table A-8 Hydraulic parameters assigned to backfill and void.**

Material	K_{xy} (m/d)	K_z (m/d)	Sy
Backfill	1	1	0.1
Void (air)	1000	1000	1

Changes to the distribution of groundwater recharge were also applied during the predictive model runs to account for increased infiltration in fill compared to parent rock. Recharge changes were linked to material parameter changes. A recharge rate equating to 10% of mean annual precipitation (MAP) was assigned for areas of backfill, while recharge of 100% of MAP was applied to the final void lakes.

A time-variable evapotranspiration (ET) surface was applied to the predictive model to allow representation of ET losses from near-surface processes where the surface changes with time. A time-series of land surface elevation was generated for each model cell which details its transition from original land surface down to total mined depth and back to final landform.

A.9.4 Stress periods

The predictive model simulated the period from 1 January 2012 to 1 January 2120 in 21 stress periods. The regional model simulates mine progressions with yearly time steps from 2012 until completion of the latest current mine extension in 2021. After 2021, the stress periods gradually increase to allow for long term groundwater recovery after mining has ceased.

Table A-9 lists the stress periods and their durations.

- **Table A-9 Calibration model stress periods**

Stress period	Start date	End date	Number of days
1	1/01/2012	1/01/2013	366
2	1/01/2013	1/01/2014	365
3	1/01/2014	1/01/2015	365
4	1/01/2015	1/01/2016	365
5	1/01/2016	1/01/2017	366
6	1/01/2017	1/01/2018	365
7	1/01/2018	1/01/2019	365
8	1/01/2019	1/01/2020	365
9	1/01/2020	1/01/2021	366
10	1/01/2021	1/01/2025	1461
11	1/01/2025	1/01/2030	1826
12	1/01/2030	1/01/2035	1826
13	1/01/2035	1/01/2040	1826
14	1/01/2040	1/01/2050	3653
15	1/01/2050	1/01/2060	3652
16	1/01/2060	1/01/2070	3653
17	1/01/2070	1/01/2080	3652
18	1/01/2080	1/01/2090	3653
19	1/01/2090	1/01/2100	3652
20	1/01/2100	1/01/2110	3652
21	1/01/2110	1/01/2120	3653

APPENDIX 6

Water Balance

HYDROLOGY AND WATER MANAGEMENT CONSULTANTS

Gilbert & Associates Pty Ltd

REPORT

MT OWEN COAL COMPLEX

RAVENSWORTH EAST RESOURCE RECOVERY PROJECT

Water Balance

Prepared for: **Umwelt Australia Pty Ltd**

Dec-12
J1005-8 rm1e.docx

PO Box 2143
Toowong, Qld. 4066

Tel: (07) 3367 2388
Fax: (07) 3367 2833

A.C.N 085 419 852
A B N 62 085 419 852

TABLE OF CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

The Mt Owen Complex comprises three open cut mining operations (refer Figure 1) Mt Owen (North Pit), Ravensworth East (West Pit) and Glendell (Barrett Pit). All coal is transported to the Mt Owen coal handling and preparation plant (CHPP) for washing, with product export by rail. Mining in the West Pit is scheduled to be completed in the third quarter of 2013. Mining in the North Pit is currently planned to occur until the end of 2018, while mining at Glendell is planned until 2021.

The Ravensworth East Resource Recovery (RERR) Project (proposed modification) would see additional open cut mining in a former open cut area known as Tailings Pit 2 (TP2) (refer Figure 1) located south-east of the West Pit. Mining is planned from the second quarter of 2013 to mid-2018. The proposed modification would involve the excavation of overburden from within the RERR mining area, with this overburden being placed in the Ravensworth East void. Some overburden would be placed over the adjacent TP1 tailings emplacement as capping material.

Approval for the proposed modification is being sought as a modification under Section 75W of the *NSW Environmental Planning and Assessment Act 1979*. An environmental assessment is being prepared by Umwelt Australia Pty Ltd (Umwelt). Gilbert & Associates Pty Ltd (G&A) have been engaged to undertake water balance modelling of the proposed modification with this report prepared as part of the assessment. The aim of the modelling is to identify any changes that would occur to the water balance of the Mt Owen Complex as a result of the proposed modification.

G&A have previously developed a water balance model of the Mt Owen Complex. This model has been expanded to simulate the future predicted water balance for the proposed modification. This report outlines model assumptions and describes results.

The remainder of this report is structured as follows:

Section 2 Describes the model structure and methodology and details assumptions.

Section 3 Provides a summary of model results.

An understanding of the existing Mt Owen Complex water management system and site layout has been developed based on discussions with Xstrata Mt Owen (XMO) personnel, together with site inspections. The conceptual layout of the future water management system is given in the RERR Surface Water Assessment by Umwelt. A series of future mine stage plans were provided by XMO. Figure 2 shows a plan layout of the proposed RERR mining area and the surrounding area towards the end of the open cut operation in 2017.

Figure 1 Site Plan

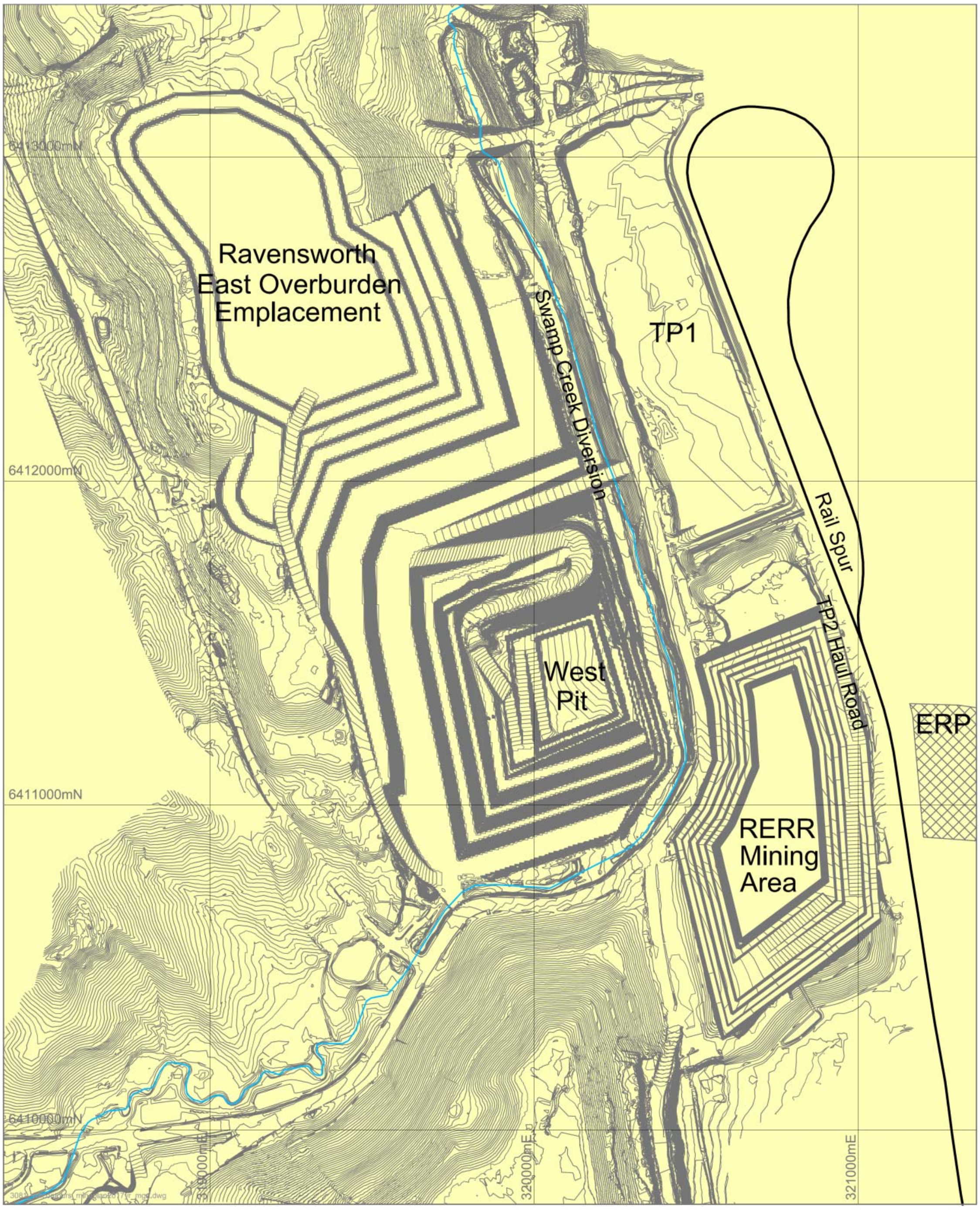


Figure 2 RERR Open Cut Pit Plan (2017)

2.0 WATER BALANCE MODEL

2.1 Model Description

The water balance model has been developed to simulate the storages and linkages shown in schematic form in Figure 3. Figure 3 was developed for the existing mine water management system (developed in consultation with XMO personnel), with additions made for the proposed modification (as advised by Umwelt).

The model simulates the behaviour of water held in and pumped between all simulated water storages shown in Figure 3. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes rainfall runoff, groundwater inflow (for mine open cut pits), tailings bleed[1] (for tailings storages), water sourced from the Hunter River and all pumped inflows from other storages.

Outflow includes evaporation, spill, seepage, licensed discharge to the Hunter River via the Hunter River Salinity Trading Scheme (HRSTS) and all pumped outflows to other storages or to a demand sink (for example, the CHPP).

The model operates on a daily time step and simulates the 6½-year period (mid-2012 to end of 2018 inclusive) to the end of the RERR Project, using the full period of available climatic data for the region from 1892 to 2011[2]. 115 possible 6½-year climatic "realizations" are simulated using the available climatic record.

2.2 Model Assumptions and Data

2.2.1 Rainfall Runoff Modelling

Rainfall runoff in the model is simulated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a nationally-recognised catchment-scale water balance model that estimates streamflow from rainfall and evaporation.

AWBM simulation of flow from six different sub-catchment types was undertaken, namely: undisturbed (natural) areas, hardstand (for example, roads and pre-strip), open cuts, spoil, rehabilitated spoil and tailings. Each storage catchment area was subdivided into these sub-catchment areas which were estimated from available aerial photography, current mine contour plans and future mine stage plans provided by XMO and water management system information provided by Umwelt. For the undisturbed sub-catchment type, model parameters were derived from regionally calibrated values[3]. For other sub-catchment types, model parameters were estimated based on experience at other coal mines.

---

[1] Tailings bleed water is water liberated from tailings slurry as it settles within a tailings storage. This water reports to the tailings surface, ponds and is available for reclaim pumping.

[2] Data was sourced from 'Data Drill' generated climatic data for the mine location. The Data Drill is a system which provides synthetic data sets for a specified point by interpolation between surrounding point records held by the Bureau of Meteorology (based on Jeffrey, *et al* 2001). Both rainfall and pan evaporation data were obtained from this source.

[3] For NOW gauging station GS210042 – Foy Brook. As documented in Boughton and Chiew (2003).

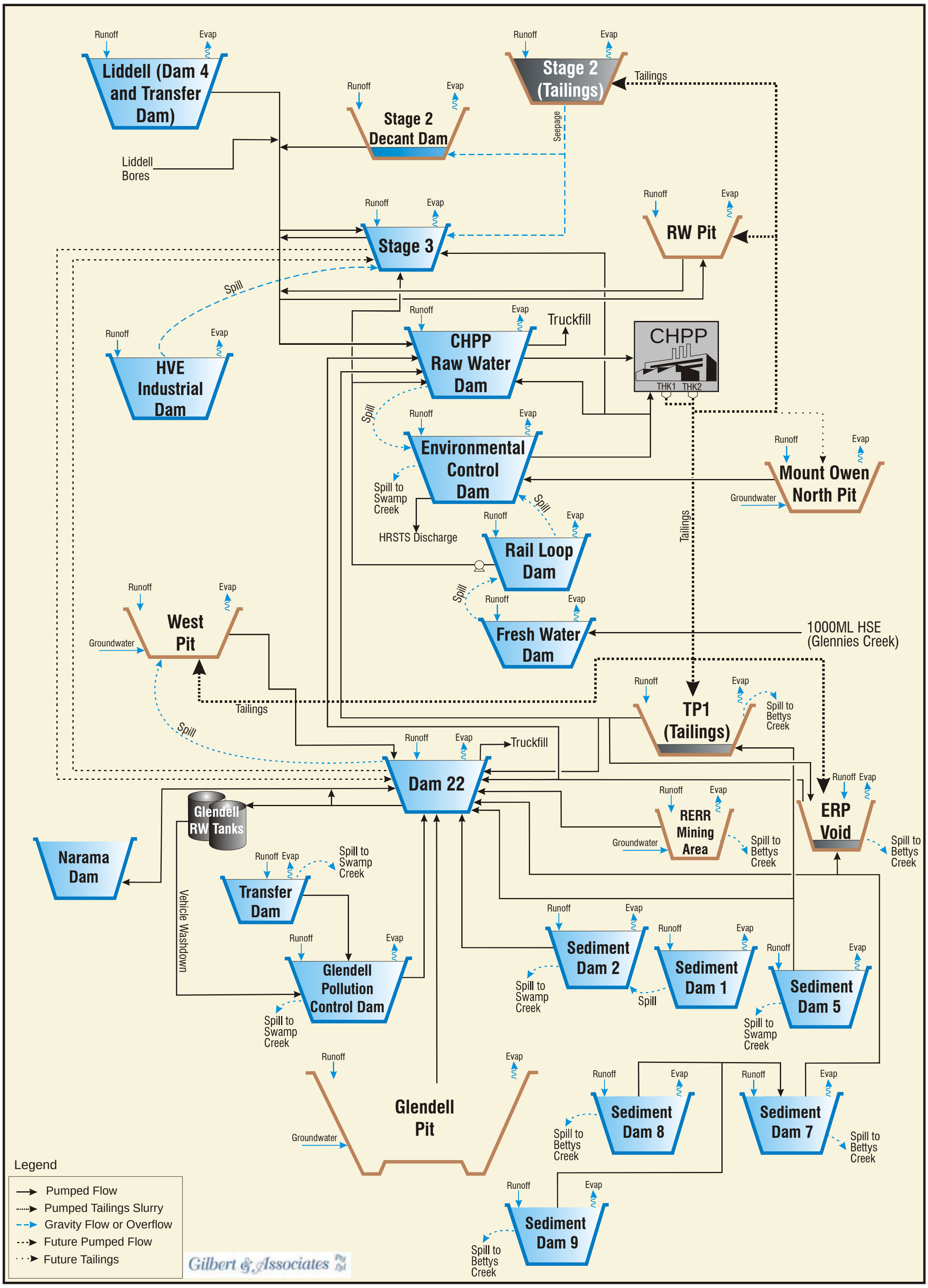


Figure 3 Mt Owen Complex Water Management System Schematic

2.2.2 Tailings Disposal

A tailings management strategy has been developed for the Mt Owen Complex (including the Proposed Modification) by XMO[4]. This involves future emplacement of CHPP tailings to mined-out voids (ERP and RW Pit) until the third quarter of 2013, followed by emplacement to the mined-out West Pit thereafter.

Reclaim of supernatant tailings water (bleed) and rainfall runoff from each of the above emplacements was included in the water balance model. Relevant coal and tailings properties which affect CHPP water demand and tailings water calculations are summarised below (sourced from XMO):

- ROM Coal Moisture: 6%
- Product Coal Moisture: 9.8%
- Coarse Reject Moisture: 14%
- Product Coal as percent of ROM: 60%
- Tailings as percent of ROM: 19%
- Pumped Tailings solids content: 32%
- Tailings water bleed rate as percent of water pumped with tailings: 53%.

2.2.3 CHPP Coal Washing Rate

Planned ROM coal tonnages (CHPP feed) for the Mt Owen Complex, including ROM coal tonnages from proposed modification are summarised in Figure 4.

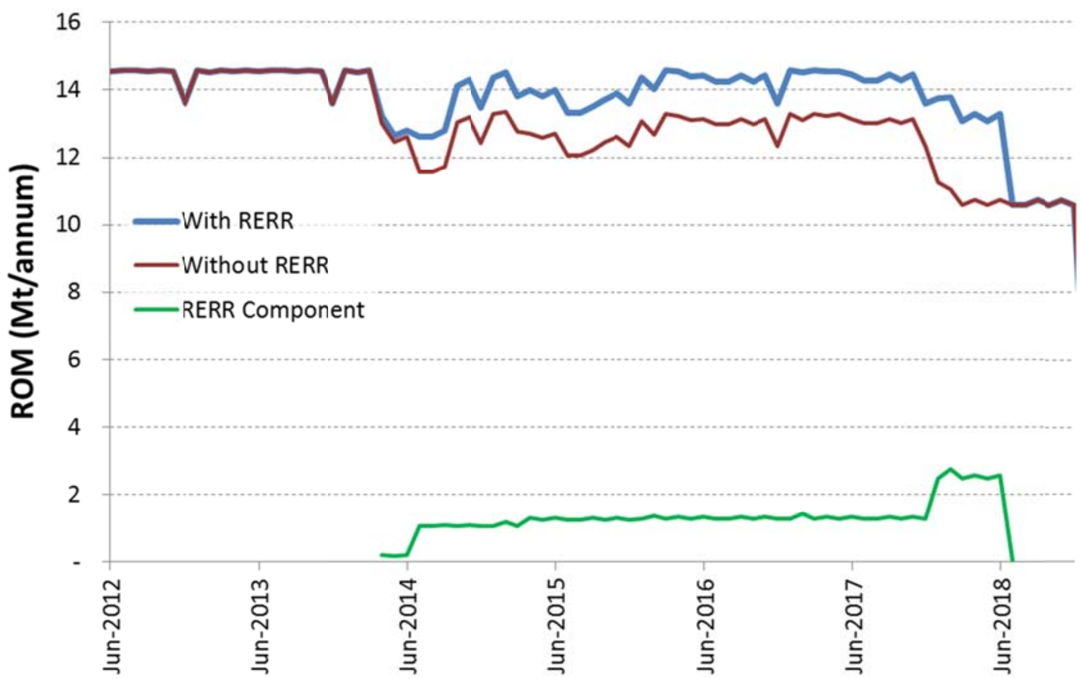


Figure 4 Planned CHPP Feed ROM Tonnage

[4] S.Holmes, XMO, via email 6th July 2012.

The peak planned Mt Owen Complex CHPP feed rate is approximately 14.6 Mt/annum. The planned peak ROM production rate from the RERR mining area is approximately 2.5 Mt/annum.

The planned ROM tonnages shown in Figure 4 and the assumed coal and tailings properties listed in Section 2.2.2 were used in the model to calculate CHPP water demand for the Mt Owen Complex. This is summarised in Figure 5.

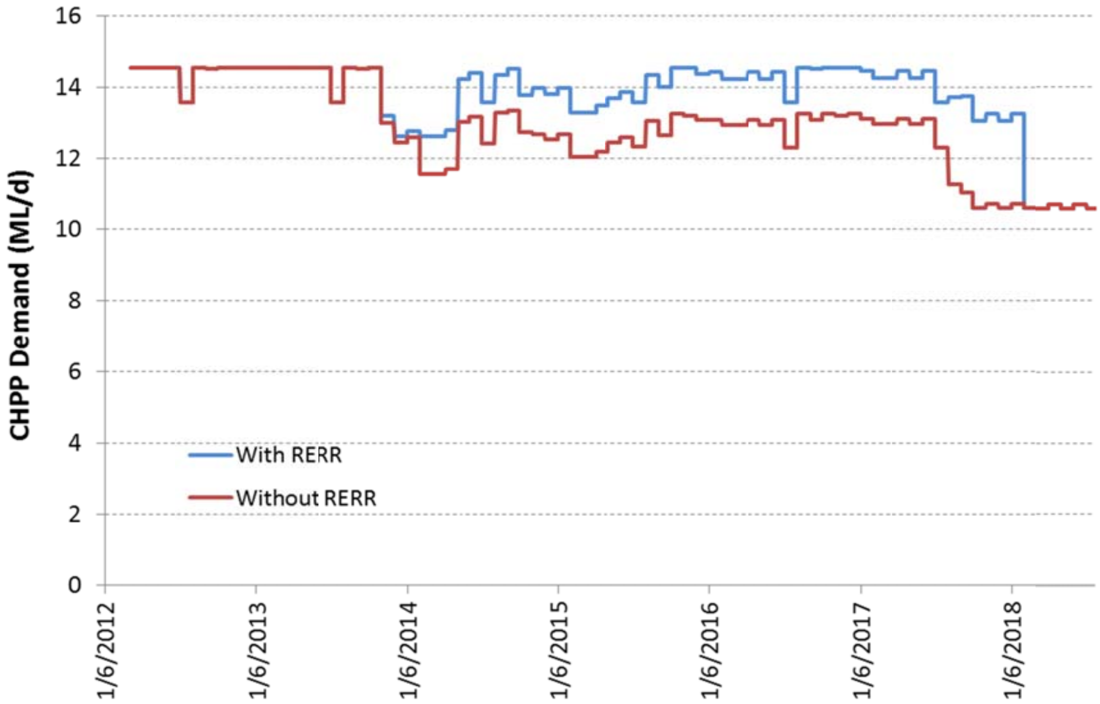


Figure 5 Calculated CHPP Water Demand

2.2.4 Groundwater

Predictions of groundwater inflow rates versus time for the West Pit and the RERR mining area were obtained from groundwater modelling undertaken for the proposed modification by SKM (2012), while inflow rates for the Mt Owen North Pit and Glendell Pit were taken from estimates documented in the Mt Owen EIS (Umwelt, 2003) and Glendell EA (Umwelt, 2007) reports respectively. Groundwater inflow rates are summarised in Figure 6.

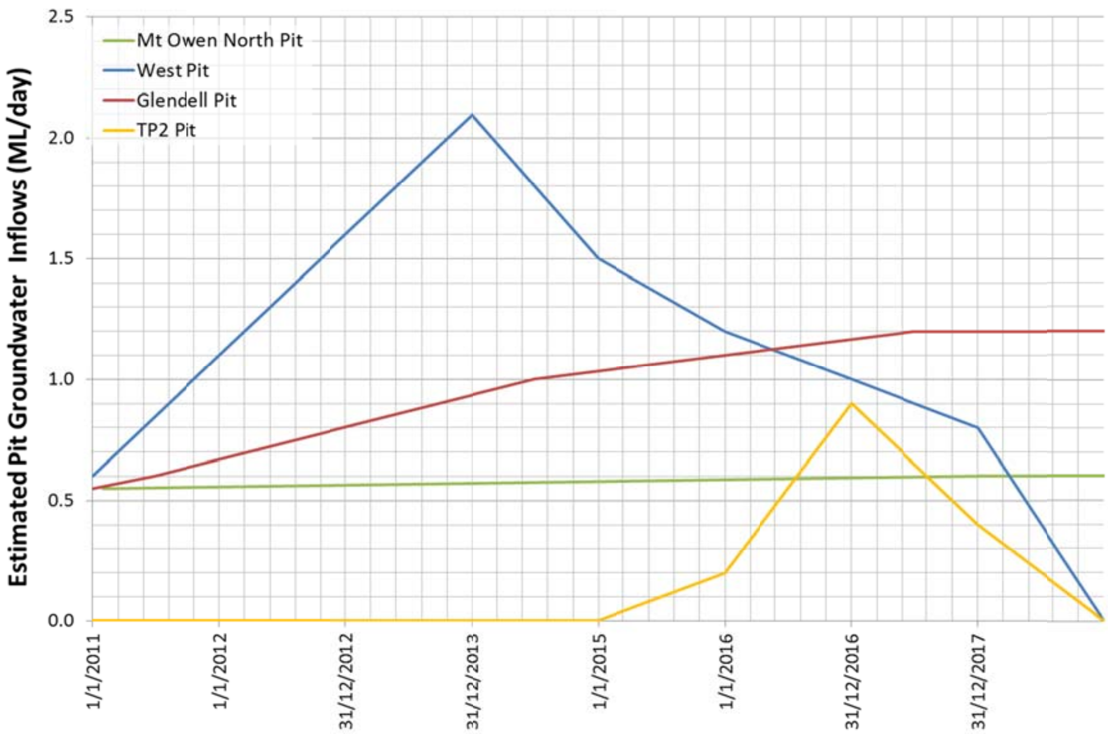


Figure 6 Predicted Open Cut Groundwater Inflow Rates (SKM, 2012)

2.2.5 Glennies Creek Supply

The model includes the ability to include water sourced from Glennies Creek water allocation licences (WALs). The NSW Office of Water's (NOW) Hunter River Integrated Quantity and Quality Model (IQQM) has been run to simulate announced allocation levels for the proposed modification life and the IQQM output used as input to the water balance model. Currently Mt Owen holds 1,056 ML/year of High Security Entitlement (HSE) and 861 ML/year of General Security Entitlement (GSE). Water was assumed able to be sourced from Glennies Creek to the Fresh Water Dam whenever the total volume of water held in all modelled storages dropped below 3,000 ML (depending on announced allocation levels and the volume of water sourced up to that point in time in a given year).

2.2.6 Hunter River Licensed Release

The model includes the ability to simulate controlled discharge (licensed release) under the HRSTS. IQQM simulated or recorded actual flows for the Hunter River at Singleton were used, along with relationships between flow and salinity (Electrical Conductivity - EC) developed from historical recorded data, to simulate EC in the river and to model allowable release using the 12 credits held by XMO. It is recognised that as at mid-2012 no release infrastructure exists, however it was assumed that this would be installed by the beginning of 2013. Water was assumed able to be discharged from the Environmental Control Dam (ECD) via the HRSTS whenever the total volume of water held in all storages rises above 4,500 ML (depending on simulated flow in the Hunter River at that point in time).

2.2.7 Transfer to/from Other Mines

The model simulates transfers to/from other mines as follows (refer Figure 3):

- Liddell to Mt Owen – from Mt Owen bores, Transfer Dam, Dam 17, and Dam 4; to CHPP Dam and Stage 3 void.
- Mt Owen to Ravensworth Operations – from Dam 22 to Narama Dam.
- Ravensworth Operations to Mt Owen – from Narama Dam to Dam 22.

In the model, the decision to transfer water is made using a set of rules. Mt Owen can source up to a maximum[5] 1,577 ML/year water from Liddell and transfer occurs on any day that:

1. The CHPP Dam (main supply storage for CHPP) is below a nominated “high” operating volume (85% of its capacity); or
2. The Stage 3 void (main on site water storage with an estimated capacity of 11,500 ML) is below a nominated “high” operating volume (90% of its capacity).

It is assumed that the volume of 1,577ML/year (4.3ML/d) is available at all times (no account is taken of any supply shortfalls from Liddell).

Dam 22 is the main transfer dam at Glendell for pumping water sourced from the Glendell operations to either the Stage 3 void (for subsequent use at Mt Owen) or to Ravensworth Operations’ Narama Dam. In the model transfer to Ravensworth Operations occurs from Dam 22 at a maximum rate of 10 ML/d occurs if:

1. The Dam 22 pump has supplied all other demands;
2. Dam 22 is above a nominated “low” storage volume (35% of capacity); and
3. Water is not being sourced from Ravensworth Operations.

In the model it is assumed that water is sourced from Ravensworth Operations to Dam 22 if Dam 22 is below its nominated “low” operating volume (35%). It is assumed that Ravensworth Operations’ Narama Dam is available to supply water to and receive water from Dam 22 as required.

2.2.8 Other Assumptions and Limitations

The following summarises additional assumptions used in the model:

- Storage level-area-volume relationships were developed from available topographic contour and other survey information. This data was used in the model to calculate daily evaporation losses. Pan evaporation was multiplied by a pan factor of 0.9 in the calculation of storage evaporation losses for water storages, while a pan factor of 1.1 was used in the estimation of evaporation from wet tailings surfaces.

[5] Estimate provided by Liddell Coal Operations personnel (2009).

- Storage capacities were also developed from available topographic contours and other available survey information. The initial volumes of water stored in each of the modelled storages were set based on data provided by XMO for July 2012.

  Table 1 summarises storage capacity and initial stored water volume for each of the storages in the water balance model.

Table 1 Assumed Storage Capacities and Initial Volumes

Storage	Storage Capacity (ML)	Initial Stored Water Volume (ML)
Dam 22	48	34
Environmental Control Dam (ECD)	114	114
Eastern Rail Pit (ERP)	3615	15
Fresh Water Dam (FWD)	8.1	3.5
Glendell Pollution Control Dam (PCD)	0.9	0.3
Glendell Pit	-	20
Sediment Dam 1	10.1	0
Sediment Dam 2	12.8	1.3
Sediment Dam 5	14.2	1.9
Sediment Dam 7	37.7	11.8
Sediment Dam 8	38.6	2.0
Industrial Dam	10.0	4.4
Mt Owen North Pit	-	0
Rail Loop Dam (RLD)	100	70
RW Pit	1475	10
CHPP Raw Water Dam (RWD)	96	88
Glendell Transfer Dam	1.4	0.2
Stage 2 Tailings Storage	1628	20
Stage 2 Decant Dam	32.0	2.3
Stage 3 Void	11523	4179
Tailings Pond 1 (TP1)	1237	1170
West Pit	44568	31

- Haul road water demands for both Mt Owen and Glendell (sourced from the CHPP Raw Water Dam and Dam 22 respectively) were assumed based on recorded data and were varied on a monthly basis. Mt Owen rates varied from 0.8 to 1.7 ML/d, while Glendell rates varied from 0.4 to 1.4 ML/d. In addition, Glendell has an estimated truckfill usage rate from its Raw Water Tank of 0.2 ML/d and a washdown usage rate of 0.05 ML/d.
- Assumed pump rates for pumping from various modelled storages are summarised in Table 2 below.

Table 2 Assumed Pump Rates

Source Storage	Pump Rate (L/s)
Mt Owen North Pit	100
West Pit	100
Glendell Barrett Pit	100
RW Pit	282
Stage 3 Void	160*
Environmental Control Dam (ECD)	235
Rail Loop Dam	100
Glennies Creek	65
Tailings Pit 1 (TP1)	180
RERR Open Cut	100
Eastern Railway Pit (ERP)	100
Dam 22	70 & 100**
Stage 2 Decant Dam	110
Glendell Pollution Control Dam	50
Glendell Service Compound Sediment Dam	30
Glendell Sediment Dams	100

* A 110L/s rate was advised by XMO personnel as the current pump rate. This was increased to 160L/s to prevent predicted supply shortfalls occurring (to CHPP and Mt Owen haul road supply) while a volume of water was still simulated in the Stage 3 void

**Two pumps with the larger capacity pump transferring water to the Stage 3 void

- Three storages (CHPP Raw Water Dam, Dam 22 and the ECD) had operating levels (high and low) defined in the model. These levels affect when pumping to and from these dams occurs. These were arbitrarily set and changing of these was found to not significantly affect model predictions.
- The model simulates the water balance of the Mt Owen Complex from August 2012 until December 2018 and does not include the post closure water balance.

3.0 MODEL RESULTS

3.1 Water Balance

Figure 7 shows average system inflows and outflows plotted as average ML/year rates and as percentages. It may be seen from these plots that runoff and tailings water (liberated from settling tailings) contributes to the majority of the inflows to the system both with and without the RERR. Approximately 57 to 58 % of modelled system outflow is accounted for in CHPP make-up. Although modelled inflows from Liddell and Narama approximately balance outflow to Narama, it should not be interpreted that the system could do without these components – in dry periods both Liddell and Narama provide an important supply source, while in wet periods, Narama provides an option to transfer water from the system as an alternative to HRSTS discharge (which is only a small outflow component on average).

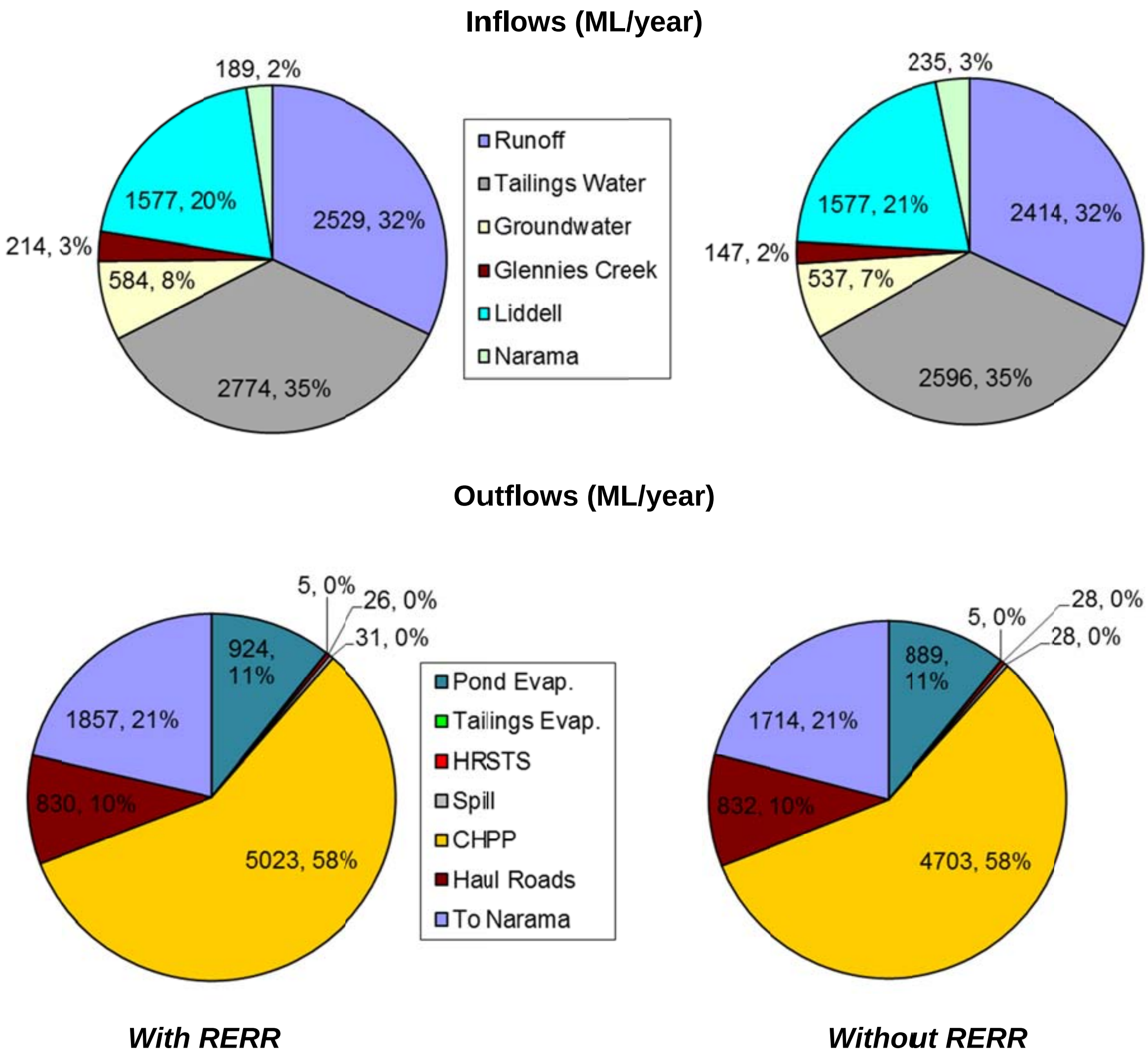


Figure 7 Modelled Average System Inflows and Outflows

Comparison of the two sets of graphs in Figure 7 indicates that the model predicts on average (as a result of the RERR):

- an increase in groundwater inflow and runoff as a result of the development of the RERR open cut (higher runoff rates are expected from the open cut area);
- an increase in water liberated from settling tailings due to the higher rate of tailings production;
- a higher rate of licensed extraction from Glennies Creek as a result of comparatively higher planned CHPP ROM coal feed rates (refer Figure 4);
- a slight reduction in water imported from Narama – this water is supplied to Dam 22, which will be less “available” due to a higher input from the RERR open cut area runoff and groundwater;
- an increase in evaporation due to evaporation from the RERR open cut;
- higher CHPP water usage; and
- an increase in water exported to Narama as a result of water transferred to Dam 22 from the RERR open cut.

Even though simulated outflows exceed inflows on average, a high average water supply reliability is predicted (refer Section 3.2). Water would continue to be sourced from Liddell and Narama as part of the Greater Ravensworth Water Sharing Scheme (GRWSS) and XMO could increase the rate of water sourced from these (Xstrata Coal owned) operations if required.

Table 3 below summarises simulated total system inflows and outflows over the 9 year simulation period as 10-percentile (low), median and 90-percentile (high) statistics for each component derived over all 6½ years and 115 realizations. Note that the difference between total inflows and outflows in Table 3 represents the simulated change in volume of water stored.

Table 3 Summary Water Balance

	10 Percentile Volume (ML)		**Median Volume (ML)**		**90 Percentile Volume (ML)**	
Inflows	*Without RERR*	*With RERR*	*Without RERR*	*With RERR*	*Without RERR*	*With RERR*
Runoff	10203	10709	15585	16147	20339	21380
Tailings Water Bleed	16662	17804	16662	17804	16662	17804
Groundwater	3447	3749	3447	3749	3447	3749
Glennies Creek	0	0	738	1212	2293	2816
Liddell	10120	10120	10120	10120	10120	10120
Narama	1165	850	1382	1081	1708	1676
TOTAL	41597	43233	47934	50113	54569	57545
Outflows	*Without RERR*	*With RERR*	*Without RERR*	*With RERR*	*Without RERR*	*With RERR*
Evaporation	5316	5471	5731	5954	6202	6469
HRSTS Discharge	0	0	96	82	476	468
Storage Spill	5	14	109	128	426	466
CHPP Supply	30180	32248	30180	32248	30180	32248
Haul Road Supply	5311	5307	5340	5337	5378	5374
Narama	10514	11245	11150	12220	11653	12636
TOTAL	51325	54286	52606	55969	54315	57662

The simulated total volume of water contained in all storages versus time is shown in Figure 8.

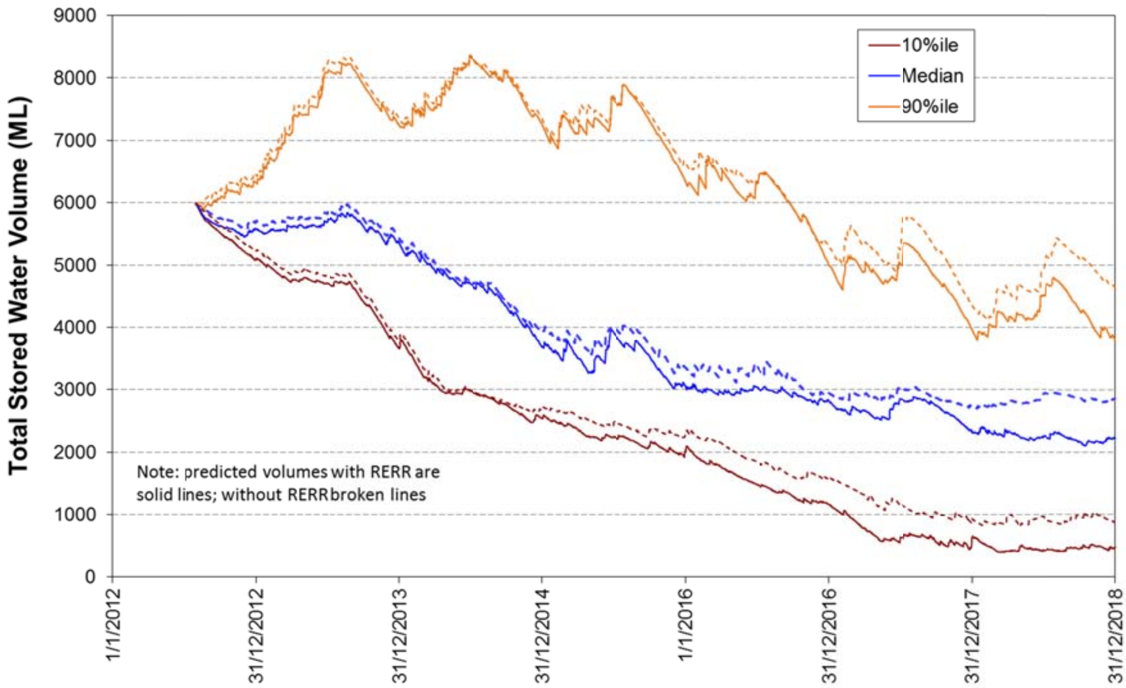


Figure 8 Simulated Total Volume of Water in all Storages

Figure 8 indicates that the median total stored water volume is predicted to fall during the mine life, both with and without the RERR Project. The 10 and 90 percentile plots in Figure 8 indicate predicted total water volume ranges within which the predicted total volume could vary, within these risk or confidence limits/levels (derived from an analysis of results from all realizations modelled).

3.2 Supply Reliability

A summary of average water supply reliability for CHPP and haul road requirements is shown in Tables 4 and 5 respectively. Predicted reliability is expressed as total water able to be supplied divided by total demand (that is, volumetric reliability) averaged over all years. The "average" reliability is averaged over all realizations, while the "90-percentile" represents the reliability which is exceeded in 90% of realizations. These numbers provide a "single measure" of water supply reliability for the mine life.

Table 4 Summary of Modelled CHPP Supply Reliability

	Current Planned Operation (without proposed modification)	With proposed modification
Average	99.9%*	99.9%
90-percentile	99.9%*	99.9%*

* Although no shortfalls were simulated, the inherent uncertainty in the representativeness of low rainfall periods in the historical climate data set used in the model precludes the use of the term "100%".

Table 5 Summary of Modelled Haul Road Supply Reliability

		Current Planned Operation (without proposed modification)	**With proposed modification**
Mt Owen Haul Roads	Average	99.9%	99.3%
	90-percentile	99.9%*	99.9%*
Glendell Haul Roads	Average	99.9%*	99.9%*
	90-percentile	99.9%*	99.9%*

* Although no shortfalls were simulated, the inherent uncertainty in the representativeness of low rainfall periods in the historical climate data set used in the model precludes the use of the term "100%".

Tables 4 and 5 indicate quite high water supply reliability and very little difference between the simulations undertaken with and without the proposed modification. Glendell haul road water supply has a high reliability because this supply is drawn from Dam 22 which is provided water from the West Pit tailings reclaim (from late 2013 onwards) which is a reliable source of water.

It should be noted that both CHPP and haul road supply reliability results given in Tables 4 and 5 are averaged over the mine life and include extremes of low and high periods of rainfall through the mine life.

3.3 Storage Spills

Model predicted total spill volumes from storages which spill off site are shown in Figures 9 and 10. Again these are expressed at different probability or risk levels.

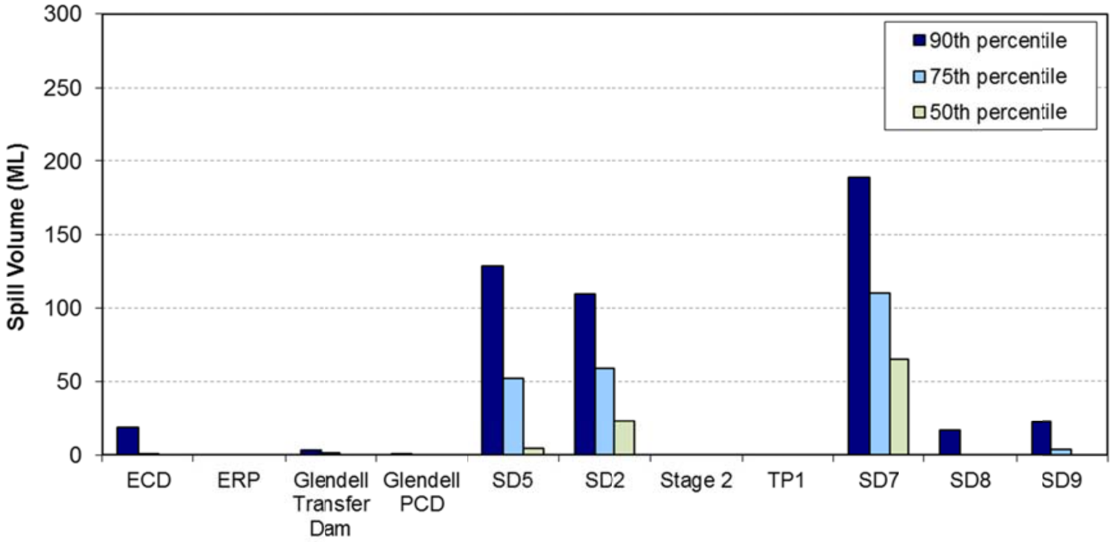


Figure 9 Modelled Total Spill Volumes (without proposed modification)

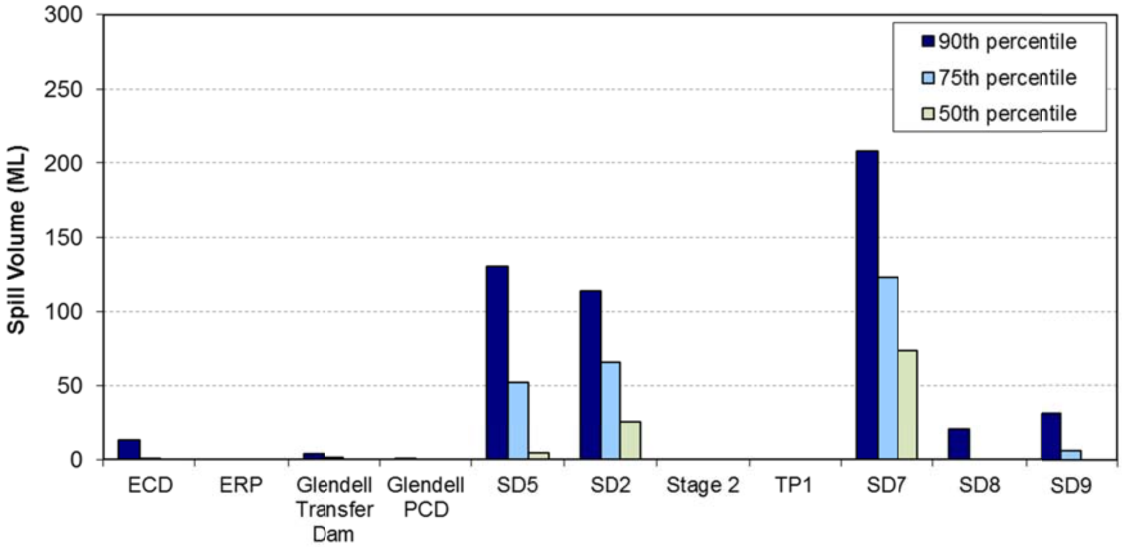


Figure 10 Modelled Total Spill Volumes (with proposed modification)

Storages which are predicted to spill in 10% or more of realizations are the ECD, Glendell Transfer Dam, Glendell Pollution Control Dam, SD2, SD5, SD7, SD8 and SD9. The likelihood of spill from the ECD, Glendell Pollution Control Dam, Glendell Transfer Dam, SD2, SD7, SD8 and SD9 is increased by between 4% and 17% by the proposed modification. No spill is predicted with the proposed modification from dams which did not spill without the modification. It is understood that sediment dams (SD) have been designed in accordance with Landcom (2004) guidelines and are expected to spill on occasions following significant rainfall.

3.4 Open Cut Water Volume

Figures 11 shows a plot of predicted water volume in the RERR Open cut at different probability levels.

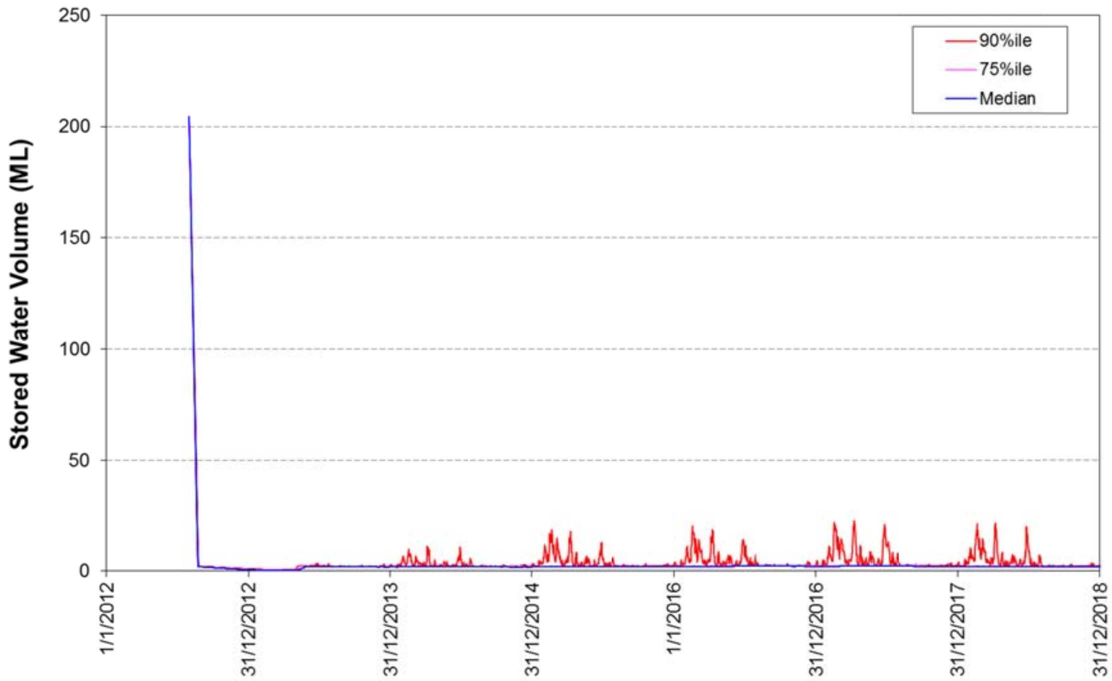


Figure 11 Predicted Water Volume in RERR Open Cut

The above figure indicates a low risk of large volumes of water being held in the RERR open cut for extended periods of time.

3.5 Summary

In summary the model predicted effects of the RERR on the overall water balance are as follows:

- Relatively small increases to average groundwater, runoff and tailings water inflows and licensed extraction from Glennies Creek and small increases in average evaporation, CHPP water use and water exported to Narama.
- A high level of supply reliability with the flexibility to import additional water from nearby (Xstrata Coal owned) operations if required.
- A reduction in the total water volume stored on site into the future.
- No spill with the proposed modification from dams which did not spill without the modification. A small increase in the risk of spill from the ECD, Glendell Pollution Control Dam, Glendell Transfer Dam, SD2, SD7, SD8 and SD9.

4.0 REFERENCES

Boughton & Chiew, 2003. *Calibrations of the AWBM for use on ungauged catchments*, Cooperative Research Centre for Catchment Hydrology.

Jeffrey, S.J., Carter, J.O., Moodie, K.M and Beswick, A.R.. *Using spatial interpolation to construct a comprehensive archive of Australian climate data*, *Environmental Modelling and Software*, Vol 16/4, pp 309-330, 2001.

Landcom, 2004. *Managing Urban Stormwater: Soils & Construction Volume 1*, 4th Edition, March.

Umwelt (Australia) Pty Limited, 2003. *Environmental Impact Statement Mt Owen Operations*.

Umwelt (Australia) Pty Limited, 2007. *Environmental Assessment for Modification of Glendell Mine*, prepared for Xstrata Mt Owen Pty Limited.

SKM, 2012. *Ravensworth East Resource Recovery (RERR) Project Groundwater Impact Assessment.* Draft report prepared by Sinclair Knight Merz for Umwelt (Australia) Pty Limited, on behalf of Xstrata Mt Owen (XMO) Pty Limited, St Leonards, October.

APPENDIX 7

Ecological Appendices

Threatened Species Assessment

Threatened species, endangered populations, and threatened ecological communities (TECs) identified through searches of the Office of Environment and Heritage (OEH) Atlas of New South Wales (NSW) Wildlife and Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) Protected Matters Database for a 10 kilometre radius of the Ravensworth East Mine are listed in **Tables 1** and **2** below.

Tables 1 and **2** contain the relevant ecological details of each listing (including their habitat requirements, known range and reservation with conservation reserves), as well as an assessment as to whether there may be an impact on any recorded or potentially occurring threatened species or TECs as a result of the proposed modification. This assessment is based on the information contained in **Section 6.7** of the main text of this report as well as the specific habitat requirements of each threatened species or TEC. For the purposes of these tables, the 'region' is broadly defined as the Sydney Basin Bioregion.

An assessment of significance was prepared in accordance with the requirements of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for each threatened species, population or TEC for which there is the potential for impact as a result of the proposed modification. The assessment of significance is provided below. An assessment of significance for those species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) which have potential to be impacted by the proposed modification is also provided.

Table 1 - Threatened Flora Assessment

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Bothriochloa biloba *** V (EPBC)**	Grows in woodlands and grasslands on poorer soils.	Regionally recorded across much of the central and upper Hunter Valley with fewer records in the lower Hunter but as far east as Maitland.	Wollemi NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No
Euphrasia arguata *** CE (TSC)** **CE (EPBC)**	Specific habitat information for this species is scarce. The species was re-discovered in 2008 in the NSW North Western Slopes and tablelands in eucalypt forest with a mixed grass and shrub understorey.	This species was presumed to be extinct until it was rediscovered in 2008. When present, it was recorded from as far south as Bathurst and as far north as Walcha. It was believed to occur in the botanical subdivisions of the North Coast, Northern Tablelands, Central Tablelands, North Western Slopes and Central Western Slopes.	This species is not known to occur in reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No
Leek-orchid *Prasophyllum* sp. Wybong *** CE (EPBC)**	This species generally occurs in grassy and scrubby habitats in open eucalypt woodland and grasslands.	This species is endemic to NSW, from which there are only seven known populations from near NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield. It is not known to occur outside the Sydney Basin, New England Tablelands, Brigalow Belt South and NSW South Western Slopes bioregions. It's area of occupancy is estimated at 1.5 km^2.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Illawarra greenhood *Pterostylis gibbosa* *** E (TSC)** **E (EPBC)**	All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage.	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra).	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No
Commersonia rosea *** E (TSC)**	Occurs on skeletal sandy soils in scrub or heath vegetation with occasional emergents of *Eucalyptus crebra, Callitris endlicheri* or *Eucalyptus caleyi* subsp*. caleyi.*	Only known from four localities in the Sandy Hollow district of the upper Hunter Valley, New South Wales, all within an 8 km radius of Sandy Hollow.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Scant pomaderris *Pomaderris queenslandica* *** E (TSC)**	This species is found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	This species is widely scattered but not common in north-east NSW and in Queensland. It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW North Coast.	Manobalai NR	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Denman pomaderris *Pomaderris reperta* *** E (TSC)** **PD E (EPBC)** **2V (ROTAP)**	This species occupies woodland in association with *Eucalyptus crebra, E. blakelyi, Notelaea microcarpa*, and *Allocasuarina littoralis*. This species grows on a sandy loam on sandstone or conglomerate.	This species has been recorded from a small number of sites near Denman in the upper Hunter Valley (Muswellbrook local government area (LGA)). This species is also known from the Wybong area.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Lasiopetalum longistamineum *** V (TSC)** **V (EPBC)** **2VC- (ROTAP)**	The species typically grows in rich alluvial deposits and flowers in spring. Little is known about this species' ecology or biology.	This species occurs in the Mt Dangar – Gungal area within Merriwa and Muswellbrook LGAs. Three sites are recorded within Goulburn River NP.	Goulburn River NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Finger panic grass *Digitaria porrecta* *** E (TSC)** **E (EPBC)**	Native grassland, woodlands or open forest with a grassy understorey, on richer soils. Often found along roadsides and travelling stock routes where there is light grazing and occasional fire.	Found in NSW and Queensland. In NSW, occurs on north-west slopes and plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran.	This species is not known from any conservation reserves in the region.	The project ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Ozothamnus tesselatus *** V (TSC)** **V (EPBC)** **2VC- (ROTAP)**	Dry sclerophyll forest and woodlands.	Restricted to a few locations north of Rylstone. Unconfirmed recording exists near Mt Owen.	Goulburn River NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Painted diuris *Diuris tricolor* *** V (TSC)** *** V (EPBC)**	Sclerophyll forest among grass, often with *Callitris*. Sandy soils, either on flats or small rises.	Muswellbrook LGA is the eastern limit of the known range and the only recorded occurrence in the Sydney Basin Bioregion.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Austral toadflax *Thesium australe* *** V (TSC),** **V (EPBC)**	This species occurs in grassland or grassy woodland and is often found in damp sites in association with kangaroo grass (*Themeda australis*). This species is a root parasite that takes water and some nutrient from other plants, especially kangaroo grass.	This species is found in very small populations scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania, Queensland and in eastern Asia. Occurs also at Anvil Hill, NSW.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Slaty red gum *Eucalyptus glaucina* *** V (EPBC)** **V (TSC)**	Typically grows in grassy woodland on deep, moderately fertile and well-watered soil and can be locally frequent but very sporadic.	Occurs near Casino and from Taree to Broke in the North Coast botanical subdivision.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Acacia pendula (a tree) in the Hunter Catchment ***EP (TSC)**	Grows on major river floodplains on heavy clay soils, sometimes as the dominant species and forming low open woodlands. Within the Hunter catchment it typically occurs on heavy soils, sometimes at the margins of small floodplains, but also in more undulating locations remote from floodplains, such as at Jerrys Plains.	There are 17 confirmed and four unconfirmed naturally occurring remnants of the *A. pendula* population in the Hunter catchment. These range as far east as Warkworth, and as far west as Kerrabee, west of Sandy Hollow. *Acacia pendula* is not known to occur naturally further north than the Muswellbrook-Wybong area. Eight planted *A. pendula* populations (not naturally occurring) have been recorded in the Hunter, and it is likely that numerous more planted populations occur.	This population is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this population and it has not been recorded at the site. There is no potential for a significant impact on this endangered population.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Tiger orchid *Cymbidium canaliculatum* ***EP (TSC)**	This species occurs within dry sclerophyll forests and woodlands of tablelands and western slopes, growing in hollows of trees. It is usually found occurring singularly or as a single clump, typically between two and six metres above the ground.	The population of *Cymbidium canaliculatum* in the Hunter Catchment is at the south-eastern limit of the geographic range for this species.	This population is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this population and it has not been recorded at the site. There is no potential for a significant impact on this endangered population.	No.
River red gum *Eucalyptus camaldulensis* in the Hunter Catchment ***EP (TSC)**	River red gums are located on the banks and floodplains of watercourses on alluvial soils. This endangered population may occur with *Eucalyptus tereticornis, Eucalyptus melliodora, Casuarina cunninghamiana subsp. cunninghamiana* and *Angophora floribunda.*	The Hunter population occurs as far east as Hinton, east of Maitland, west to Bylong, and north to near Scone. Currently only 28 populations are known in the Hunter Valley, covering an area of only 83 hectares and constituting about 1840 trees, and occurring over a range of at least 2000 km^2.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this population and it has not been recorded at the site. There is no potential for a significant impact on this endangered population.	No.
Leionema lamprophyllum subsp. *obovatum* in the Hunter Catchment ***EP (TSC)**	Found on a rocky cliff line in a dry eucalypt forest.	The Hunter Catchment population of *L. lamprophyllum* subsp. *obovatum* is currently known to occur in Pokolbin State Forest. The total number of mature individuals is estimated to be very low with only four individuals currently known.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this population and it has not been recorded at the site. There is no potential for a significant impact on this endangered population.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Lowland Rainforest of Subtropical Australia ***CEEC (EPBC)**	This community occurs on basalt soils, alluvial soils, floodplain alluvia and occasionally on enriched rhyolitic soils and basaltically enriched metasediments. It is mostly found in areas below 300 metres (m) above sea level with annual rainfall >1300 millilitres (mm). Canopy vegetation is usually dominated by bangalow palm (*Archontophoenix cunninghamiana*), cabbage palm (*Livistona australis*), *Syzygium floribundum* and weeping lilly pilly (*Waterhousea floribunda*). Remnants are generally less than 10 hectares (ha) in size.	This critically endangered ecological community (CEEC) primarily occurs from Maryborough in Queensland to the Clarence River (near Grafton) in NSW. It also occurs in isolated stands between the Clarence River and Hunter River, including the Bellinger Valley. It is known to occur in the Hunter-Central Rivers and Northern Rivers Catchment Management Areas.	This CEEC is not known to occur in conservation reserves in the Region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.
River-flat Eucalypt Forest ***EEC (TSC)**	Associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains.	This Environment and Community Coordinator (EEC) occurs in the NSW North Coast, Sydney Basin and south-east corner bioregions. The Ravensworth East Mine is within the known distribution of this species.	There are no known occurrences of this EEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Weeping Myall – Coobah – Scrub Wilga Shrubland ***CEEC (EPBC)**	This EEC consists of a woodland of weeping myall (*Acacia pendula*) with coobah (*Acacia salicina*) and scrub wilga (*Geijera salicifolia*). yarran (*Acacia omalophylla*) and stiff canthium (*Canthium buxifolium*) are also present in the small tree/shrub layer. The ground stratum is dense and primarily grassy. Grasses include kangaroo grass (*Themeda triandra/australis*), wallaby grass (*Austrodanthonia* sp.), snow grass (*Poa sieberiana*) and barbed wire grass (*Cymbopogon refractus*).	The EEC occurs in a small stand on heavy, brown clay soil at Jerry's Plains in the Hunter Valley, in the South Hunter Province of the Sydney Basin Bioregion.	There are no known occurrences of this EEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.
Central Hunter Grey Box-Ironbark Woodland in the NSW North Coast and Sydney Basin Bioregions ***EEC (TSC)**	The EEC occurs on Permian sediments in the Hunter Valley and typically forms a woodland to open forest on slopes and undulating hills. Dominated by narrow-leaved ironbark (*Eucalyptus crebra*) and grey box (*E. moluccana*) with a moderately dense to dense ground layer dominated by grasses and forbs.	Located in the NSW North Coast and Sydney Basin Bioregions.	There are no known occurrences of this EEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Central Hunter Ironbark-Spotted Gum-Grey Box Forest in the NSW North Coast and Sydney Basin Bioregions *** EEC (TSC)**	The EEC occurs on Permian sediments in the Hunter Valley and typically forms an open forest to woodland on slopes and undulating hills. Dominated by narrow-leaved ironbark (*Eucalyptus crebra*), spotted gum (*Corymbia maculata*) and grey box (*E. moluccana*) with a sparse to moderately dense ground layer dominated by numerous forbs and a few grasses.	Located in the NSW North Coast and Sydney Basin Bioregions.	Belford NP	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.
Hunter Valley Footslopes Slaty Gum Woodland in the Sydney Basin Bioregion ***VEC (TSC)**	This ecological community generally occurs at the interface of Narrabeen Sandstone and Permian sediments in the Hunter Valley and typically forms a low to mid-high woodland. The community is characterised by an overstorey of slaty gum (*Eucalyptus dawsonii*) and/or grey box (*E. moluccana*) with a moderately dense to dense shrub stratum. The ground layer is generally sparse to very sparse and generally species poor.	Located in the Sydney Basin Bioregion.	Minor occurrences in Wollemi NP and Goulburn River NP.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Hunter Floodplain Red Gum Woodland in the NSW North Coast and Sydney Basin Bioregions ***EEC (TSC)**	Occurs on floodplains and associated floodplain rises along the Hunter River and its associated tributaries. This community typically occurs in tall woodland form and is dominated by river red gum (*Eucalyptus camaldulensis*).	Located in the NSW North Coast and Sydney Basin Bioregions along the Hunter River.	There are no known occurrences of this EEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.
Hunter Lowland Red Gum Forest *** EEC (TSC)**	Occurs on gentle slopes arising from depressions and drainage flats on permian sediments of the Hunter Valley floor.	Recorded from Maitland, Cessnock and Port Stephens LGAs (in the Sydney Basin Bioregion) and Muswellbrook and Singleton LGAs (in the NSW North Coast Bioregion) but may occur elsewhere in these bioregions. The Ravensworth East Mine is within the known distribution of this EEC.	Werakata NP Werakata SCA	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Hunter Valley Weeping Myall Woodland ***EEC (TSC)**	Associated with heavy clay soils on depositional landforms in the south-western part of the Hunter River valley floor. This EEC typically comprises a relatively dense or open tree canopy up to about 15 m tall, sometimes with an open understorey of semi-sclerophyllous shrubs, and a variable groundcover dominated by grasses or herbs.	Currently known from parts of the Muswellbrook and Singleton LGAs, but may occur elsewhere, including the Upper Hunter LGA.	There are no known occurrences of this EEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.
Lower Hunter Valley Dry Rainforest in the Sydney Basin and NSW North Coast Bioregions *** VEC (TSC)**	Lower Hunter Valley Dry Rainforest typically occurs on Carboniferous sediments of the Barrington footslopes along the northern rim of the Hunter Valley Floor, where it occupies gullies and steep hillslopes with south facing aspects. It is generally found at elevations less than 300 m ASL with a mean annual rainfall less than 900 mm.	Lower Hunter Valley Dry Rainforest has been recorded from the LGAs of Cessnock, Maitland and Port Stephens, and is also likely to occur or have occurred in Muswellbrook, Singleton, Upper Hunter and Dungog.	This EEC is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
White Box – Yellow Box – Blakely's Red Gum Woodland *** EEC (TSC)**	This EEC is characterised by the presence or prior occurrence of white box, yellow box and/or Blakelys red gum. The trees may occur as pure stands, mixtures of the three species or in mixtures with other trees, including wattles. Commonly co-occurring eucalypts include apple box (*E. bridgesiana*), red box (*E. polyanthemos*), candlebark (*E. rubida*), snow gum (*E. pauciflora*), Argyle apple (*E. cinerea*), brittle gum (*E. mannifera*), red stringybark (*E. macrorhyncha*), grey box (*E. microcarpa*), cabbage gum (*E. amplifolia*) and others. The understorey in intact sites is characterised by native grasses and a high diversity of herbs; the most commonly encountered include kangaroo grass (*Themeda australis*) poa tussock (*Poa sieberiana*), wallaby grasses (*Austrodanthonia* sp.) and spear-grasses (*Austrostipa* sp.). Shrubs are generally sparse or absent, though they may be locally common.	This EEC is found from the Queensland border in the north, to the Victorian border in the south. It occurs in the tablelands and western slopes of NSW.	Goulburn River NP Manobalai NR Towarri NP Wingen Maid NR Wollemi NP	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

Table 1 - Threatened Flora Assessment (cont.)

Species	Specific Habitat	Distribution in Relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland *** CECC (EPBC)**	This ecological community occurs in areas where rainfall is between 400 and 1200 mm per annum, on moderate to highly fertile soils at altitudes of 170 m to 1200 m.	This EEC occurs in an arc along the western slopes and tablelands of the Great Dividing Range from Southern Queensland through NSW to central Victoria. It occurs in the Brigalow Belt South, Nandewar, New England Tableland, South Eastern Queensland, Sydney Basin, NSW North Coast, South Eastern Highlands, South East Corner, NSW South Western Slopes, Victorian Midlands and Riverina Bioregions.	There are no known occurrences of this CEEC within the conservation reserves of the region.	The ecological study area does not provide suitable habitat for this community and it has not been recorded at the site. There is no potential for a significant impact on this community.	No.

* Legal Status:

E:	endangered	NR:	Nature Reserve
C:	recorded in a conservation reserve (ROTAP)	NP:	National Park
CEEC:	critically endangered ecological community	R:	rare (ROTAP)
EEC:	endangered ecological community	ROTAP:	Rare or Threatened Australian Plants
EPBC:	*Environment Protection and Biodiversity Conservation Act 1999*	SCA:	State Conservation Area
i:	inadequately reserved (ROTAP)	TSC:	*Threatened Species Conservation Act 1995*
K:	poorly known	V:	vulnerable
FR:	Flora Reserve	VEC:	vulnerable ecological community
LGA:	Local Government Area	2:	species found over <100km (ROTAP)

REFERENCES:

Botanic Gardens Trust 2012
PlantNET – The Plant Information Network System of Botanic Gardens Trust, Sydney, Australia (version 2.0). http://plantnet.rbgsyd.nsw.gov.au (accessed 16 February 2009)

Briggs J.D & Leigh J.H, 1996, *Rare or Threatened Australian Plants: 1995 Revised edition*. CSIRO: Australia.

Table 2 - Threatened Fauna Assessment

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Amphibians					
Green and golden bell frog *Litoria aurea* ***E (TSC)** **V (EPBC)**	Occurs among vegetation in permanent water bodies (Cogger 2000), particularly where bullrush (*Typha* spp.) and spikerush (*Eleocharis* spp.) occur. Known to occur in degraded water bodies such as brick-pits and industrial sites.	Occurs in eastern and south-eastern NSW to far eastern Victoria, largely at low altitudes (Cogger 2000). Once widespread, it is now restricted to isolated coastal populations. The Ravensworth East Mine is at the western limit of the species distribution.	Hunter Wetlands NP	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	Yes.
Booroolong Frog *Litoria booroolongensis* ***E (TSC)** **E (EPBC)**	Live along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses. Adults occur on or near cobble banks and other rock structures within stream margins. Shelter under rocks or amongst vegetation near the ground on the stream edge.	The Booroolong frog is restricted to NSW and north-eastern Victoria, predominantly along the western-flowing streams of the Great Dividing Range. It has disappeared from the Northern Tablelands and is now rare throughout most of the remainder of its range. Most recent records are from the south-west slopes of NSW.	Mt Royal NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Reptiles					
Pale-headed snake *Hoplocephalus bitorquatus* *** V (TSC)**	Found mainly in dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest. Favours streamside areas, particularly in drier habitats.	A patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah. The Ravensworth East Mine is within the known distribution of this species.	The species is not known from conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Stephens banded snake *Hoplocephalus stephensii* *** V (TSC)**	Rainforest and eucalypt forests and rocky areas up to 950 m in altitude.	Coast and ranges from Southern Queensland to Gosford in NSW. The Ravensworth East Mine is within the known distribution of this species.	Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Birds					
Black-necked Stork *Ephippiorhynchus asiaticus* *** E (TSC)**	Inhabits permanent freshwater wetlands including margins of billabongs, swamps, shallow floodwaters, and adjacent grasslands and savannah woodlands; can also be found occasionally on inter-tidal shorelines, mangrove margins and estuaries.	This species is widespread across coastal northern and eastern Australia, becoming uncommon further south into NSW, and rarely found south of Sydney.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Australian painted snipe *Rostratula benghalensis australis* *** E (TSC)** **V (EPBC)** **MAR (EPBC)** **MIG (EPBC)** **CAMBA**	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	In NSW, this species has been recorded at the Paroo wetlands, Lake Cowel, Macquarie Marshes and Hexham Swamp. Most common in the Murray-Darling Basin.	Hunter Wetlands NP Pambalong NR	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Australasian bittern *Botaurus poiciloptilus* *** E (TSC)** **E (EPBC)**	Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleoacharis* spp.).	This species may be found over most of the state except for the far north-west.	Hunter Wetlands NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Blue-billed duck *Oxyura australis* *** V (TSC)**	This species prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation. The species is completely aquatic, swimming low in the water along the edge of dense cover.	Widespread in NSW, but most common in the southern Murray-Darling Basin area. The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Freckled duck *Stictonetta naevosa* *** V (TSC)**	This species prefers permanent freshwater swamps and creeks with heavy growth of cumbungi, lignum or tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. This species generally rests in dense cover during the day, usually in deep water. Nesting usually occurs between October and December but can take place at other times when conditions are favourable. The nests are usually located in dense vegetation at or near water level.	The freckled duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. This species may also occur as far as coastal NSW and Victoria during such times. The Ravensworth East Mine is within the known distribution of this species.	The species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Little eagle *Hieraaetus morphnoides* *** V (TSC)**	This species is typically identified in open eucalypt forests, woodlands and open woodlands, and other areas where prey are plentiful. The nest in tall living trees within remnant patches. This species occurs as a single population within Australia.	The little eagle is distributed throughout mainland Australia except for the most densely forested parts of the Great Dividing Range escarpment.	Mt Royal NP	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Spotted harrier *Circus assimilis* *** V (TSC)**	Their habitat of choice is open grassy woodland, grassland, inland riparian woodland and shrub steppe. Although mostly associated with native grasslands it has also been identified in agricultural farmland. Their nest is made in a tree and composed of sticks. Individuals of this species are sparsely distributed throughout Australia and occur as a single population.	The spotted harrier can be found throughout mainland Australia except for areas of dense forest on the coast, escarpments and ranges and rarely ever in Tasmania.	Wollemi NP	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	No.
Swift parrot *Lathamus discolor* *** E (TSC)** **E (EPBC)**	Often visits box-ironbark forests, feeding on nectar and lerp (Garnett and Crowley 2000). In NSW, typical feed species include mugga ironbark, grey box, swamp mahogany, spotted gum, red bloodwood, narrow-leaved red ironbark, forest red gum and yellow box (Swift Parrot Recovery Team 2001).	Breeds in Tasmania, migrating to the mainland in May to August, mainly foraging in Victoria and NSW (Swift Parrot Recovery Team 2001). In NSW, it has been recorded from the western slopes region along the inland slopes of the Great Dividing Range, as well as forests along the coastal plains from southern to northern NSW (Swift Parrot Recovery Team 2001). The Ravensworth East Mine is within the known distribution of this species.	Tomaree NP Lake Macquarie SCA	The ecological study area does not provide suitable habitat for this species and it has not been recorded in the ecological study area. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	**Specific Habitat**	**Distribution in relation to Ravensworth East Mine**	**Reservation in the Region**	**Potential to Occur/Potential for Impact**	**Further Assessment Required?**
Regent honeyeater *Anthochaera phrygia* *** CE (TSC) E (EPBC)**	Semi-nomadic, generally occurs in temperate eucalypt woodlands and open forests, commonly recorded from box-ironbark eucalypt associations, wet lowland coastal forests dominated by swamp mahogany, spotted gum and riverine *Casuarina* woodlands.	Patchily distributed across the eastern states of Australia, from Adelaide, to Dalby, Queensland, and from the coast to the western foothills of the Great Dividing Range (Garnett and Crowley 2000). The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded in the ecological study area. There is no potential for a significant impact on this species.	No.
Glossy black-cockatoo *Calyptorhynchus lathami* *** V (TSC)**	Habitat for this species includes forests on low-nutrient soils, specifically those containing key *Allocasuarina* feed species. They will also eat seeds from eucalypts, angophoras, acacias, cypress pine and hakeas, as well as eating insect larvae. Breeding occurs in autumn and winter, with large hollows required.	The glossy black-cockatoo has a sparse distribution along the east coast and adjacent inland areas from western Victoria to Rockhampton in Queensland. In NSW, it has been recorded as far inland as Cobar and Griffith. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Mount Royal NP Manobalai NR Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Gang-gang cockatoo *Callocephalon fimbriatum* *** V (TSC)**	In summer this species occurs in tall mountain forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. In winter this species moves to drier more open eucalypt forests and woodlands. It favours old growth trees for nesting and roosting.	In NSW this species occurs from the south east coast to the Hunter region and inland to the Central Tablelands and south-west Slopes. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Little lorikeet *Glossopsitta pusilla* *** V (TSC)**	This species can be found in dry-open eucalypt forests and woodlands, and have been identified in remnant vegetation, old growth vegetation, logged forests, and roadside vegetation. The little lorikeet usually forages in small flocks, not always with birds of their own species. They nest in hollows, mostly in living smooth-barked apples.	This species is distributed from just north of Cairns, around the east coast of Australia down to Adelaide. In NSW this species is found from the coast to the western slopes of the Great Dividing Range, extending as far west as Albury, Dubbo, Parkes and Narrabri.	Manobalai NR Wollemi NP Yengo NP Mount Royal NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Powerful owl *Ninox strenua* *** V (TSC)**	The powerful owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. It generally requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation.	The powerful owl occurs in eastern Australia, mostly on the coastal side of the Great Dividing Range, from south western Victoria to Bowen in Queensland. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Mt Royal NP Belford NP Manobalai NR Barrington Tops NP	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	No.
Masked owl *Tyto novaehollandiae* *** V (TSC)**	Generally recorded from open forest habitat with sparse mid-storey but patches of dense, low ground cover. It is also recorded from ecotones between wet and dry eucalypt forest, along minor drainage lines and near boundaries between forest and cleared land (Kavanagh 2004).	Occurs sparsely throughout the continent and nearby islands, including Tasmania and New Guinea (Kavanagh 2002). The Ravensworth East Mine is within the known distribution of this species.	Karuah NR Tomaree NP Watagans NP Medowie SCA Jilliby SCA	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Malleefowl *Leipoa ocellata* *** E (TSC)** **V (EPBC)** **MIG (EPBC)**	The mallefowl is typically found in semi-arid and arid areas of temperate Australia, in shrubland and low woodlands dominated by dense but discontinuous mallee vegetation. They are usually on loamy or sandy soils with an annual average rainfall between 200 and 450 mm. The mallefowl has been known to forage in open grassland and farmland areas; and breeds in areas with plentiful leaf litter.	The mallefowl is distributed across southern Australia. Typically found west of the Great Dividing Range, from the Pilliga south-west through to the Griffith and Wentworth districts. A small number of records have been identified from east of the Great Dividing Range in the Goulburn River NP. This species is predicted to occur in the region based upon a search of the Liverpool Plains (Part B) CMA Sub-region (DECC 2009).	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Brown treecreeper (eastern subsp.) *Climacteris picumnus victoriae* *** V (TSC)**	Typical habitat for this species includes drier forests, woodlands, scrubs, with fallen branches; river red gums on watercourses and around lake-shores; paddocks with standing dead timber; and margins of denser wooded areas (Pizzey and Knight 1997). This species prefers areas without dense understorey.	This species occurs over central NSW, west of the Great Dividing Range and sparsely scattered to the east of the Divide in drier areas such as the Cumberland Plain of Western Sydney, and in parts of the Hunter, Clarence, Richmond and Snowy River valleys. The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Black-chinned honeyeater (eastern subsp.) *Melithreptus gularis gularis* *** V (TSC)**	In NSW, it is mainly found in woodlands with annual rainfall of 400 to 700 mm containing box-ironbark associations and river red gum (Garnett and Crowley 2000). It is also known from drier coastal woodlands of the Cumberland Plain, Western Sydney and in the Hunter, Richmond and Clarence valleys.	Found mainly west of the Great Dividing Range through NSW into southern Queensland, and south into Victoria and South Australia. The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Speckled warbler *Chthonicola saggitata* *** V (TSC)**	In NSW, occupies eucalypt and cypress woodlands, generally on the western slopes of the Great Dividing Range. Inhabits woodlands with a grassy understorey, leaf litter and shrub cover, often on ridges or gullies (Garnett and Crowley 2000).	The speckled warbler has a distribution from south-eastern Queensland, through central and eastern NSW to Victoria. The Ravensworth East Mine is within the known distribution of this species.	Belford NP (T Peake pers. obs.)	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Grey-crowned babbler (eastern subsp.) *Pomatostomus temporalis temporalis* *** V (TSC)**	Habitat for this species includes open forest and woodland, acacia scrubland and adjoining open areas (Garnett and Crowley 2000).	Occurs on the western slopes and plains of NSW. Isolated populations are known from coastal woodlands on the North Coast, in the Hunter Valley and from the South Coast near Nowra. The Ravensworth East Mine is within the known distribution of this species.	Munmorah SCA Belford NP (T Peake pers. obs.)	The species has not been recorded in the ecological study area; however, it could occur there. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Varied sittella *Daphoenositta chrysoptera* *** PV (TSC)**	The varied sittella can typically be found in eucalypt forests and woodlands, especially of rough-barked species and mature smooth-barked gums with dead branches, it can also be identified in mallee and acacia woodlands. This species builds a cup shaped nest made of plant fibres and spiders webs which is placed at the canopy level in the fork of a living tree.	The varied sittella is a sedentary species that inhabits the majority of mainland Australia with the exception of the treeless deserts and open grasslands. Its NSW distribution is basically continuous from the coast to the far west.	Manobalai NR Wollemi NP Yengo NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Hooded robin (south-eastern form) *Melanodryas cucullata cucullata* *** V (TSC)**	Hooded robins are found in lightly timbered woodland, mainly dominated by acacia and/or eucalypts.	Hooded robins are found extensively over much of mainland Australia, but are more commonly found in south-eastern Australia from Adelaide to Brisbane. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Scarlet robin *Petroica boodang* *** V (TSC)**	This robin can be found in woodlands and open forests from the coast through to inland slopes. The birds can sometimes be found on the eastern fringe of the inland plains in the colder months of the year. Woody debris and logs are both important structural elements of its habitat. It forages from low perches on invertebrates either on the ground or in woody debris or tree trunks.	The scarlet robin can be found in south-eastern Australia, from Tasmania to the southern end of Queensland, to western Victoria and South Australia.	Wollemi NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Flame robin *Petroica phoenicea* *** V (TSC)**	This species is known to breed in moist eucalypt forests and woodlands. It can usually be seen on ridges and slopes in areas where there is an open understorey layer. This species migrates during the winter to more lowland areas such as grasslands where there are scattered trees, as well as open woodland of the inland slopes and plains.	This robin is located in south-eastern Australia from the Queensland border to Tasmania and into Victoria as well as south-east South Australia.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Diamond firetail *Stagonopleura guttata* *** V (TSC)**	Habitat includes a range of eucalypt-dominated communities with a grassy understorey, including woodland, forest and mallee (Garnett and Crowley 2000). Populations appear unable to persist where remnants are less than 200 ha in area.	In NSW, it mainly occurs west of the Great Dividing Range, although populations are known from drier coastal areas such as the Cumberland Plain and the Hunter, Clarence, Richmond and Snowy River valleys. The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Painted honeyeater *Grantiella picta* *** V (TSC)**	Inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests.	The greatest concentrations of this species bird and almost all breeding occur on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Mammals					
Spotted-tailed quoll *Dasyurus maculatus* *** V (TSC)** **E (EPBC)**	Habitat for this species is highly varied, ranging from sclerophyll forest, woodlands, coastal heathlands and rainforests. Records exist from open country, grazing lands and rocky outcrops. Suitable den sites including hollow logs, tree hollows rocky outcrops or caves.	In NSW the spotted-tailed quoll occurs on both sides of the Great Dividing Range, with the highest densities occurring in the north east of the state. It occurs from the coast to the snowline and inland to the Murray River. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Mt Royal NP Belford NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded in the ecological study area. There is no potential for a significant impact on this species.	No.
Koala *Phascolarctos cinereus* *** V (TSC)** **V (EPBC)**	This species inhabits eucalypt forest and woodland, with suitability influenced by tree species and age, soil fertility, climate, rainfall and fragmentation patterns. The species is known to feed on a large number of eucalypt and non-eucalypt species; however it tends to specialise on a small number in different areas. *Eucalyptus tereticornis, E. punctata, E. cypellocarpa, E. viminalis, E. microcorys, E. robusta, E. albens, E. camaldulensis* and *E populnea* are some preferred species.	The koala has a fragmented distribution throughout eastern Australia, with the majority of records from NSW occurring on the central and north coasts, as well as some areas further west. It is known to occur along inland rivers on the western side of the Great Dividing Range. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Mt Royal NP Manobalai NR Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Eastern pygmy possum *Cercartetus nanus* *** V (TSC)**	Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.	This species is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extents from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Squirrel glider *Petaurus norfolcensis* *** V (TSC)**	Inhabits a variety of mature or old growth habitats, including box, box-ironbark woodlands, river red gum forest, and blackbutt-bloodwood forest with heath understorey. It prefers mixed species stands with a shrub or acacia mid-storey, and requires abundant tree hollows for refuge and nest sites.	The species is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Mt Royal NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Brush-tailed phascogale *Phascogale tapoatafa* *** V (TSC)**	Prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter. It also inhabits heath, swamps, rainforest and wet sclerophyll forest.	This species has a patchy distribution around the coast of Australia. In NSW it is more frequently found in forest on the Great Dividing Range in the north-east and south-east of the State. There are also a few records from central NSW.	Mt Royal NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Grey-headed flying-fox *Pteropus poliocephalus* *** V (TSC)** **V (EPBC)**	This species feeds on a variety of flowering and fruiting plants, including native figs and palms, blossoms from eucalypts, angophoras, tea-trees and banksias (Tidemann 2002). Camps sites are usually formed in gullies, usually in vegetation with a dense canopy and not far from water (Tidemann 2002).	Recorded along the eastern coastal plain from Bundaberg in Queensland, through NSW and south to eastern Victoria. The Ravensworth East Mine is within the known distribution of this species.	Wallaroo NR Karuah NR Lake Macquarie SCA Glenrock SCA Munmorah SCA	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Eastern freetail-bat *Mormopterus norfolkensis* *** V (TSC)**	Occurs mostly in dry eucalypt forest and woodland. Also recorded over a rocky river in rainforest and wet sclerophyll forest (Churchill 1998). Generally roosts in tree hollows, but may use man-made structures (Churchill 1998).	Has a distribution along the east coast of NSW from south of Sydney north into south east Queensland, near Brisbane (Churchill 1998). The Ravensworth East Mine is within the known distribution of this species.	Tomaree NP	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.
Eastern bentwing-bat *Miniopterus schreibersii oceanensis* *** V (TSC)**	Habitat varies widely, from rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grasslands (Churchill 1998). Requires caves for roosting and maternity sites.	This species has an eastern distribution from Cape York along the coastal side of the Great Dividing Range, and into the southern tip of South Australia (Churchill 1998). There are records of this species north of the Assessment Area. The Ravensworth East Mine is within the known distribution of this species.	Wallaroo NR Kooragang NR Lake Macquarie SCA Munmorah SCA	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Eastern long-eared bat (SE form) *Nyctophilus corbeni* *** V (TSC)** **V (EPBC)**	Inhabits a variety of vegetation types, including mallee, bulloak (*Allocasuarina luehmanni*) and box/eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices, and under loose bark.	Overall, the distribution of the south eastern form coincides approximately with the Murray Darling Basin with the Pilliga Scrub region being the distinct stronghold for this species. The Ravensworth East Mine is within the known distribution of this species.	Manobolai NR Wollemi NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Little bentwing-bat *Miniopterus australis* *** V (TSC)**	Habitat includes wet and dry sclerophyll forest, rainforest, dense coastal banksia scrub, and *Melaleuca* swamps. Cave-dwelling, often sharing roosts with the eastern bentwing-bat (*Miniopterus scheribersii oceanensis*). Sometimes roost in tree hollows. Forages for small insects beneath the canopy of densely vegetated habitats. May depend on a large colony for the high temperatures required to rear the young. May hibernate over winter in southern parts of their range.	Occurs in coastal areas from Cape York to northern NSW. The Ravensworth East Mine is within the known distribution of this species.	Werakata NP	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Yellow-bellied sheathtail bat *Saccolaimus flaviventris* *** V (TSC)**	This species forages for insects, flies high and fast over the forest canopy, but lower in more open country. It forages in most habitats across its very wide range, with and without trees; and appears to defend an aerial territory. It roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to use mammal burrows.	The yellow-bellied sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Manobalai NR	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.
Eastern false pipistrelle *Falsistrellus tasmaniensis* *** V (TSC)**	Habitat for this species includes sclerophyll forest. It prefers wet habitats, with trees over 20 m high, and generally roosts in tree hollows or trunks.	This species has a range from south eastern Queensland, through NSW, Victoria and into Tasmania, and occurs from the Great Dividing Range to the coast. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Greater broad-nosed bat *Scoteanax rueppellii* *** V (TSC)**	The greater broad-nosed bat appears to prefer moist environments such as moist gullies in coastal forests, or rainforest. They have also been found in gullies associated with wet and dry sclerophyll forests and open woodland. It roosts in hollows in tree trunks and branches and has also been found to roost in the roofs of old buildings.	The greater broad-nosed bat is found mainly in the gullies and river systems that drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however it does not occur at altitudes above 500 m. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Yengo NP Barrington Tops NP	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.
Eastern cave bat *Vespadelus troughtoni* *** V (TSC)**	This species is a cave-roosting bat that is usually found in dry open forest and woodland, near cliffs or rocky overhangs. It has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals, and is occasionally found along cliff-lines in wet eucalypt forest and rainforest.	The eastern cave bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. The Ravensworth East Mine is within the known distribution of this species.	Wollemi NP Manobalai NR Yengo NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
Large-eared pied bat *Chalinolobus dwyeri* *** V (TSC) V (EPBC)**	Generally found in a variety of drier habitats, including the dry sclerophyll forests and woodlands, however probably tolerates a wide range of habitats (Hoye and Dwyer 2002). Tends to roost in the twilight zones of mines and caves (Churchill 1998).	Has a distribution from south western Queensland to Bungonia in southern NSW, from the coast to the western slopes of the Great Dividing Range (Churchill 1998, Strahan 2002). The Ravensworth East Mine is within the known distribution of this species.	Watagans NP	The species has not been recorded in the ecological study area; however, it could occur there as it is known to (tentatively) occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.
Large-footed myotis *Myotis adversis* *** V (TSC)**	Occurs in most habitat types providing they are near to water (Richards 2002). Commonly cave-dwelling, however it is also recorded from tree hollows, dense vegetation, bridges, mines and drains (Churchill 1998).	This is a coastal species, ranging from the Kimberley to South Australia (Churchill 1998). The Ravensworth East Mine is within the known distribution of this species.	This species is not known from any conservation reserves in the region.	The species has not been recorded in the ecological study area; however, it could occur there as it is known to occur in suitable habitat at Mt Owen. There is no potential for a significant impact on this species.	Yes.
Brush-tailed rock-wallaby *Petrogale penicillata* *** E (TSC) V (EPBC)**	This species occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north. It browses on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees. This species shelters or basks during the day in rock crevices, caves and overhangs and is most active at night.	The brush-tailed rock-wallaby was once abundant and ubiquitous throughout the mountainous country of south-eastern Australia. Its distribution roughly followed the Great Dividing Range for 2500 km from the Grampians in West Victoria to Nanango in south-east Queensland, with outlying populations in coastal valleys and ranges to the east of the divide, and the slopes and plains as far west as Cobar in NSW and Injune (500 km north-west of Brisbane) in Queensland.	This species is not known to occur in any reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

Table 2 - Threatened Fauna Assessment (cont.)

Species	Specific Habitat	Distribution in relation to Ravensworth East Mine	Reservation in the Region	Potential to Occur/Potential for Impact	Further Assessment Required?
New Holland mouse *Pseudomys novaehollandiae* *** V (EPBC)**	The New Holland Mouse has a fragmented distribution across Tasmania, Victoria, NSW and Queensland. Across the species' range the New Holland Mouse is known to inhabit open heathlands, open woodlands with a heathland understorey and vegetated sand dunes The species peaks in abundance during early to mid stages of vegetation succession typically induced by fire.	The New Holland Mouse has a fragmented distribution across Tasmania, Victoria, NSW and Queensland. In 2006 there were known to be 6 - 8 meta-populations of the species (NSW Atlas of Wildlife, VIC Atlas of Wildlife, TAS Natural Values Atlas). Across the species' range, the total population size of mature individuals is estimated to be less than 10,000 individuals.	This species is not known to occur in conservation reserves in the region.	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.
Hastings River mouse *Pseudomys oralis* *** E (TSC)** **E (EPBC)**	Known to inhabit a variety of dry open forest types with dense, low ground cover and a diverse mixture of ferns, grass, sedges and herbs. Access to seepage zones, creeks and gullies is important, as is permanent shelter such as rocky outcrops. Nests may be in either gully areas or ridges and slopes.	This species has a patchy distribution along the east side of the Northern Tablelands and great escarpment of north-east NSW, usually but not always at elevations between 500 m and 1100 m. Also recorded in south-east Queensland.	Mt Royal NP Barrington Tops NP	The ecological study area does not provide suitable habitat for this species and it has not been recorded at the site. There is no potential for a significant impact on this species.	No.

* Legal Status: :

E:	endangered
EPBC:	*Environment Protection and Biodiversity Conservation Act 1999*
LGA:	Local Government Area
NR:	Nature Reserve
NP:	National Park
SCA:	State Conservation Area
TSC:	*Threatened Species Conservation Act 1995*
V:	vulnerable

Assessment of Significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires the completion of an Assessment of Significance relating to the potential impacts of a Project on listed Matters of National Environmental Significance (MNES).

Under the Commonwealth EPBC Act, the approval of the Commonwealth Minister responsible for the Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) is required for any action that may have a significant impact on MNES. These matters are:

- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- The Commonwealth marine environment;
- World Heritage properties;
- National Heritage places;
- Great Barrier Reef Marine Park; and
- nuclear actions.

The matters relevant to the proposed modification are consideration of impacts on listed threatened species and ecological communities.

A search of the DSEWPC Protected Matters Search Tool (May 2012) and collated information from literature reviews (see **Section 6.7** of the main text) identified two threatened ecological communities (TECs), 20 threatened species and 15 migratory species that could occur in suitable habitat, on the basis of habitat modeling, within the ecological study area. Each of these has been included within the Threatened Species Assessment Tables, which determine whether the ecological study area contains known or potential habitat for the species and whether the species warrants further assessment by way of an Assessment of Significance.

No EPBC Act threatened flora species or threatened ecological communities were recorded in the ecological study area and none are expected to occur.

No EPBC Act threatened fauna species have been recorded in the ecological study area however very low quality potential habitat was identified for the vulnerable green and golden bell frog (*Litoria aurea*) and large-eared pied bat (*Chalinolobus dwyeri*). Each of these threatened species is assessed below.

There were no migratory species recorded during the site inspection and potential habitat for migratory species listed under international conventions was limited. An assessment of the impact of the proposed modification on migratory species is provided below.

Vulnerable Species – Green and golden bell frog (*Litoria aurea*) and large-eared pied bat (*Chalinolobus dwyeri*)

The green and golden bell frog was not recorded in the ecological study area; however very low quality potential habitat was identified. This species was recorded at Mt Owen in 1996, 1997 and 1999, associated with Bettys Creek to the east of the ecological study area. A tentative record was also made in 2005 within the Mt Owen Complex in habitats associated with Main Creek, also to the east of the ecological study area.

The large-eared pied bat has been tentatively recorded within the Mt Owen Complex in 1999, 2001, 2006 and 2008. The ecological study area provides potential foraging habitat for the species, however the very low quality habitat is expected to be marginal due to the general lack of structural and floristic complexity required to support suitable insect communities.

In this case, an *important population* is a population that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal; or
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

The ecological study area forms part of the Upper Hunter Green and Golden Bell Frog Key Population consisting of one main diffuse population at, or in the vicinity of, the Ravensworth and Liddell area and bordering areas of the Singleton and Muswellbrook local government areas (DECC 2007). The very low quality potential habitat for the species in the ecological study area is located within the boundary of the Upper Hunter Key Population. The ecological study area is considered unlikely to contain a key source population for breeding and dispersal within the Upper Hunter Key Population and therefore is not likely to be important for the maintenance of genetic diversity within the Population. Therefore the low quality potential habitat identified in the ecological study area is not considered to contain an *important population* as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006).

The large-eared pied bat has not been recorded in the ecological study area, however it has been tentatively recorded within the Mt Owen Complex in 1999, 2001, 2006 and 2008. Potential roosting habitat is limited within the ecological study area, with natural caves and crevices or anthropogenic structures such as buildings or culverts suitable for bat occupation not identified during fauna habitat assessments. As such, the ecological study area is not expected to support an *important population* of the large-eared pied bat.

An action has, will have, or is likely to have a significant impact on threatened species if it does, will, or is likely to:

- **lead to a long-term decrease in the size of an important population of a species;**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied-bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to result in a long-term decrease in the size of an important population.

- **reduce the area of occupancy of an important population, or;**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to reduce the area of occupancy of an important population.

- **fragment an existing important population into two or more populations, or**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to fragment an existing important population into two or more populations.

- **adversely affect habitat critical to the survival of a species, or**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to adversely affect habitat critical to the survival of these species.

- **disrupt the breeding cycle of an important population, or**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to disrupt the breeding cycle of an important population.

- **modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or**

  The ecological study area is not considered likely to contain an important population of the green and golden bell frog or large-eared pied bat, as defined by the EPBC Act impact assessment guidelines (EPBC Act Policy Statement 2006) and therefore the action is not likely to modify, destroy, remove or isolate or decrease the availability of habitat to the extent that these species are likely to decline.

- **result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or**

  The proposed modification is not expected to result in the establishment of invasive species that are harmful to the green and golden bell frog or large-eared pied bat becoming established in potential habitat for the species, including the mosquito fish (*Gambusia holbrookii*) which has been implicated in the decline of the green and golden bell frog.

- **interfere substantially with the recovery of the species.**

  The ecological study area provides only very low quality potential habitat for the green and golden bell frog and large-eared pied bat and high quality potential habitat for both species occurs within the Mt Owen complex, including compensatory habitat areas. Therefore, the action is not expected to interfere with the recovery of the species.

Conclusion

The loss of two sediment and erosion control dams from that provide very low quality potential habitat for the green and golden bell frog is not expected to result in a significant impact on the species.

Similarly, the loss of 7.3 hectares of Rehabilitation (Forest Complex) will not result in a significant impact on the large-eared pied bat.

Migratory Species

The Protected Matters Search has identified 15 migratory species for which the ecological study area may provide potential terrestrial and aquatic habitat. These species include:

- Fork-tailed swift (*Apus pacificus*);
- Great egret (*Ardea alba*)*;
- Cattle egret (*Ardea ibis*)*;
- White-bellied sea-eagle (*Haliaeetus leucogaster*);
- White-throated needletail (*Hirundapus caudacutus*);
- Malleefowl (*Leipoa ocellata*);
- Rainbow bee-eater (*Merops ornatus*);
- Black-faced monarch (*Monarcha melanopsis*);
- Satin flycatcher (*Myiagra cyanoleuca*);
- Rufous fantail (*Rhipidura rufifrons*);
- Regent honeyeater (*Anthochaera phrygia*);
- Latham's snipe (*Gallinago hardwickii*); and
- Painted snipe (*Rostratula benghalensis*).

*The great egret and cattle egret are listed as both migratory marine birds and migratory wetlands species.

An area of *important habitat* is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species; or
- habitat that is of critical importance to the species at particular life-cycle stages; or
- habitat utilised by a migratory species which is at the limit of the species range; or
- habitat within an area where the species is declining.

The ecological study area provides two sediment and erosion control dams that provide potential aquatic habitat for migratory species. Terrestrial habitats within the project area are not considered to provide potential habitat for migratory species. Records from the local area do not suggest the presence of an ecologically significant proportion of the population of these species in the ecological study area. The ecological study area is not at the limit of the known distribution for any of the species, nor is there any evidence to suggest these species are declining in the local area. It is unlikely that the ecological study area forms an area of important habitat. Therefore it is considered that the action will not have a significant impact on any migratory species.

Conclusion

The proposed modification is not expected to result in a significant impact on migratory species listed under the EPBC Act.

EP&A Act Assessment of Significance

Threatened species identified in **Tables 1** and **2** above that are considered to have reasonable potential to occur within the ecological study area (based on known distribution and habitat requirements) are addressed in more detail in the following 'Assessment of Significance'. This assessment of significance is conducted in accordance with Section 5A of the *Environmental Planning and Assessment Act 1979* (EP&A Act), taking the form of 'seven part tests of significance'.

All species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requiring further assessment are considered in a separate assessment provided below.

Threatened fauna species assessed include the following threatened micro-bats and the green and golden bell frog (*Litoria aurea*), which have previously been recorded during fauna surveys in suitable habitat at the Mt Owen Complex:

- eastern bentwing-bat (*Miniopterus schriebersii oceanensis*);
- eastern freetail-bat (*Mormopterus norfolkensis*);
- little bentwing-bat (*Miniopterus australis*);
- yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*);
- large-eared pied-bat (*Chalinolobus dwyeri*);
- greater broad-nosed bat (*Scoteanax rueppellii*); and
- large-footed myotis (*Myotis macropus*).

Green and Golden Bell Frog

The green and golden bell frog was not recorded in the ecological study area; however very low quality potential habitat was identified. This species was recorded at Mt Owen in 1996, 1997 and 1999, associated with Bettys Creek to the east of the ecological study area. A tentative record was also made in 2005 within the Mt Owen Complex in habitats associated with Main Creek, also to the east of the ecological study area.

(A) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Two sediment and erosion control dams that provide very low quality potential habitat for the green and golden bell frog were identified within the ecological study area. Extensive monitoring for the green and golden bell frog is undertaken at the Mt Owen Complex (Forest Fauna Surveys and Clulow 2011) and the species has not been recorded positively since 1999 (with one tentative record from 2005).

The removal of the two dams that provide low quality potential habitat is not considered to substantially reduce the area of habitat for the species such that a potentially occurring local viable population of the species is placed at risk of extinction.

(B) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

N/A

(C) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

N/A

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

N/A

(D) In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed modification would result in the removal of two dams that provide potential habitat for the green and golden bell frog.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed modification would not result in the fragmentation or isolation of habitat for the green and golden bell frog.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The potential habitat recorded in the ecological study area is not considered to be important to the species' long-term survival in the locality due to the highly degraded nature of the habitat and the presence of more suitable foraging habitat in the local area and region.

(E) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

There is no critical habitat declared for the ecological study area.

(F) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

The ecological study area does not contain a known population of the species, the proposed modification is not considered to contradict the objectives of the Draft Recovery Plan. The proposed modification is not consistent with the objectives of the Draft Recovery Plan (DEC 2005) for the green and golden bell frog, however the Plan specifically relates to the protection and management of known populations of the species rather than areas of potential habitat. The ecological study area occurs within the bounds of the Upper Hunter Green and Golden Bell Frog Key Population consisting of one main diffuse population at, or in the vicinity of, the Ravensworth and Liddell area and bordering areas of the Singleton and Muswellbrook local government areas (DECC 2007). The marginal, low quality potential habitat for the species in the ecological study area is located within the boundary of the Upper Hunter Key Population. The ecological study area is considered unlikely to contain a key source population for breeding and dispersal within the Upper Hunter Key Population as the species has not been positively recorded since 1999 despite extensive seasonal survey.

(G) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action is not a defined Key Threatening Process or likely to exacerbate the impact of any Key Threatening Process in the ecological study area.

Threatened Micro-bats

The micro-bats listed above have the potential to forage within the ecological study area. Roosting habitat by way of tree hollows or caves and similar structures were not recorded in the ecological study area and therefore the project area provides potential foraging habitat only.

(C) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Potential foraging habitat was identified within the ecological study area for all of the threatened micro-bats listed above.

None of the threatened micro-bat species known to occur at Mt Owen Complex have been identified in the ecological study area. Fauna monitoring is undertaken at two rehabilitation sites in the northern rehabilitation area of Mt Owen Mine (Mahony and Clulow 2011). The monitoring results have been examined to determine the range of threatened micro-bat species that have been previously identified occurring in mine rehabilitation at the Mt Owen Complex. The greater broad-nosed bat (*Scoteanax rueppellii*) has been recorded at a rehabilitation monitoring site that is located adjacent to intact native vegetation in Ravensworth State Forest. The eastern bent-wing bat (*Miniopterus schriebersii oceanensis*) and eastern freetail-bat (*Mormopterus norfolkensis*), both of which are recorded frequently across a range of habitats within Mt Owen Complex; and the yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*) which has been tentatively recorded, are known to occur within rehabilitation vegetation to the north west of Mt Owen Mine.

Based on these monitoring results, it is considered that threatened micro-bats have the potential to forage within the ecological study area, however the habitat is considered to be marginal and of poor quality. Also, the habitats are isolated in relation to the more natural habitats associated with native woodland and forest communities that occur within the Mt Owen Complex. Roosting habitats in the form of tree hollows, caves or man-made roosting structures such as buildings or bridges were not identified in the project area.

The removal of a maximum of 7.3 hectares of Rehabilitation (Forest Complex); 53.1 hectares of Rehabilitation (Grassland Complex) and two dams as a result of the proposed modification is not considered to substantially reduce the foraging habitat of the threatened micro-bats that could potentially occur within the ecological study area such that the a local viable population of these species' are placed at risk of extinction.

(B) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

N/A

(C) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

N/A

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

N/A

(D) In relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The proposed modification will result in the removal of 7.3 hectares of Rehabilitation (Forest Complex); 53.1 hectares of Rehabilitation (Grassland Complex) and three dams which may comprise foraging habitat for the threatened micro-bat species.

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed modification will not result in the fragmentation or isolation of habitat for the highly mobile threatened micro-bat species.

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The potential habitat recorded in the ecological study area is not considered to be important to the species' long-term survival in the locality due to the highly degraded nature of the habitat and the presence of more suitable foraging habitat in the local area and region.

(D) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

There is no critical habitat declared for the ecological study area.

(E) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

No recovery plan or threat abatement plan has been prepared for the threatened micro-bats that could potentially occur in the ecological study area.

(F) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The proposed action is not a defined Key Threatening Process or likely to exacerbate the impact of any Key Threatening Process in the ecological study area.

Conclusion

The proposed modification will not result in a significant impact on the green and golden bell frog or threatened micro-bats potentially occurring in the ecological study area. The proposed modification includes a commitment to the rehabilitation of the ecological study area following mining activities using native tree species, and pasture species known to occur in the local area, resulting in no net loss of floristic diversity or fauna habitat as a result of the proposed modification.

APPENDIX 8

Greenhouse Gas and Energy
Assessment

umwelt

Inspired people | Dedicated team
Quality outcomes

Xstrata Mt Owen

Ravensworth East Resource Recovery Project Greenhouse Gas and Energy Assessment

October 2012

Ravensworth East Resource Recovery Project Greenhouse Gas and Energy Assessment

October 2012

Prepared by

Umwelt (Australia) Pty Limited

on behalf of

Xstrata Mt Owen

Project Director:	**Michelle Kirkman**
Project Manager:	**Tim Browne**
Report No:	**3081/R02/Final**
Date:	**October 2012**

Newcastle

PO Box 3024
75 York Street
Teralba, NSW 2284
Ph: 02 4950 5322
www.umwelt.com.au

TABLE OF CONTENTS

APPENDICES

1.0 Assessment Objectives

The following Greenhouse Gas and Energy Assessment (GHGEA) evaluates the greenhouse gas and energy use implications of the proposed modification. The scope of the GHGEA includes:

- an estimation of the total greenhouse gas emissions and energy use associated with the proposed modification;
- an estimation of the impact of the proposed modification's emissions on national and international greenhouse gas emission targets; and
- detailing measures to mitigate the potential greenhouse gas impacts of the proposed modification.

2.0 Methodology

The GHGEA is based on the methodologies and emission factors contained in the *National Greenhouse Accounts (NGA) Factors* (Department of Climate Change and Energy Efficiency (DCCEE), 2011).

Scope 1 and 2 emissions were calculated based on the methodologies and emission factors contained in the NGA Factors 2011 (Department of Climate Change and Energy Efficiency (DCCEE 2011)). Specifically, Scope 1 fugitive emissions from the coal seams to be mined have been calculated using a state based emission factor (i.e. using the Method 1 approach as described in the NGA Factors 2011).

Scope 3 emissions associated with product transport were calculated based on emission factors contained in the *National Greenhouse Gas Inventory: Analysis of Recent Trends and Greenhouse Gas Indicators* (Australian Greenhouse Office 2007). Other Scope 3 emissions were calculated using methodologies and emission factors contained in the NGA Factors 2011 (DCCEE 2011).

2.1 Assessment Boundaries

The GHGEA assessment boundary is determined by the proposed modification's activities. The proposed modification plans to recover a coal resource, using common open cut mining methods, which will involve trucks, bulldozers, drills, graders and excavators. The proposed modification will utilise the existing Mt Owen Coal Handling and Preparation Plant (CHPP) and transport infrastructure. Products will be transported to Newcastle via rail, and then shipped to international markets. The proposed modification will not require the construction of new infrastructure.

The assessment includes all relevant direct (Scope 1) greenhouse gas emissions, including:

- fugitive emissions of methane from coal seams; and
- on-site liquid fuel (diesel) combustion.

The assessment also includes all relevant indirect (Scope 2 and 3) greenhouse gas emissions, including:

- electricity use by the CHPP (Scope 2);
- emissions attributable to the extraction, production and transportation of liquid fuels combusted on-site (Scope 3);
- emissions attributable to the extraction, production and transmissions of electricity consumed on-site (Scope 3);
- product transport (Scope 3); and
- product use (Scope 3).

2.1.1 Data Exclusions

The proposed modification will not change many ancillary aspects of the Mt Owen Complex operations. The emission sources listed in **Table 2.1** have been excluded from the GHGEA, as the proposed modification will not change the activities that generate the excluded emission sources.

Table 2.1 – Data Exclusions

Emissions source	Scope	Description	Reason for exclusion
Combustion of fuel for energy	Scope 1	• Diesel use for closure and rehabilitation. • Small qualities of fuels such as petrol.	Accurate data is not available. Unlikely to change as a result of the proposed modification.
Industrial processes	Scope 1	• Sulphur hexafluoride (high voltage switch gear). • Hydrofluorcarbon (commercial and industrial refrigeration).	Unlikely to change as a result of the proposed modification.
Waste water handling (industrial)	Scope 1	• Methane emissions from waste water management.	Unlikely to change as a result of the proposed modification.
Electricity use	Scope 2	• Grid electricity used for administration and lighting.	Unlikely to change as a result of the proposed modification.
Solid waste	Scope 3	• Solid waste to landfill.	Unlikely to change as a result of the proposed modification.
Business travel	Scope 3	• Employees travelling for business purposes.	Unlikely to change as a result of the proposed modification.
Employee travel	Scope 3	• Employees travelling between their place of residence and the Mt Owen site.	Unlikely to change as a result of the proposed modification.

2.2 Data Sources

The calculations in this report are based on activity data projections developed by XMO and estimated from other Xstrata Coal operations. Activity data used to calculate emissions from fugitives, electricity consumption, product transport and product use have been provided by XMO. Diesel use activity data has been estimated based on the proposed modification's mine plan and comparable diesel burn rates (litres/hr) for similar equipment estimated at another Xstrata Coal site.

3.0 Impact Assessment Results

3.1 Greenhouse Gas Projections

The following assumptions were made to estimate the proposed modification's greenhouse gas emissions:

- 100 per cent of product coal is thermal quality and will be combusted by electricity generators;
- all product coal is exported;
- all product coal is transported approximately 98 kilometres to the port of Newcastle via train; and
- all product coal is shipped an average of 9,500 kilometres to either Japan or Korea.

The proposed modification's greenhouse gas emissions are summarised in **Table 3.1**. Greenhouse gas forecasts are based on the proposed modification extracting approximately 5.8 million run of mine (ROM) tonnes over 6 years.

Table 3.1 – Life of Mine Greenhouse Gas Projections

Scope	Emission Source	Emission Totals (t CO_2-e)
Scope 1	Diesel use – Stationary	124,391.00
	Fugitive emissions	258,221.00
	Total Scope 1	**382,612.00**
Scope 2	Electricity use	16,261.00
	Total Scope 2	**16,261.00**
Scope 3	Product use	9,414,199.00
	Product transport – rail	1,979.00
	Product transport – ship	447,620.00
	Extraction, production and transport of purchased fuels consumed - Diesel	9,486.00
	Extraction, production and transport of purchased fuels consumed - Electricity	3,107.00
	Total Scope 3	**9,876,391.00**
Total Proposed Modification Emissions		**10,275,264.00**

The proposed modification is forecast to generate approximately 385,000 t CO_2-e Scope 1 emissions from combusting diesel and releasing fugitive emissions during its six year operation phase. Annual average Scope 1 emissions are forecast at approximately 64,000 t CO_2-e per annum. Annual average Scope 1 emission estimates for the proposed modification should not be used to benchmark annual performance, as annual emissions will vary significantly due to normal variations in annual activity.

Fugitive emissions forecasts are highly uncertain due to the uncertainty associated with the method for calculating fugitive emissions from open cut coal mines. Large uncertainty values (i.e. 30-40 per cent) are normally associated with greenhouse gas estimates for open cut operations, especially if fugitive emission calculations have been completed using the default emission factors. The default open cut fugitive emission factors have an uncertainty value of 50 per cent (NGERS Technical Guidelines 2011), which dominates the combined Scope 1 uncertainty calculations. The large uncertainty value for open cut fugitive emissions acknowledges the inherent variability of fugitive greenhouse gases in an open cut environment, and the difficulty in trying to measure fugitive emission over such a disperse source.

The proposed modification is forecast to be associated with approximately 16,500 t CO_2-e Scope 2 emissions from consuming electricity during its operation phase. Annual average Scope 2 emissions are forecast at approximately 2,750 t CO_2-e per annum.

The proposed modification is forecast to be associated with approximately 9,900,000 t CO_2-e Scope 3 emissions during its operation phase. Scope 3 emissions will be generated by third parties during product transport and consumption activities (electricity generators). Annual average Scope 3 emissions are forecast at approximately 1,650,000 t CO_2-e per annum.

Table 3.1 demonstrates that the proposed modification's greenhouse gas inventory is dominated by Scope 3 emissions. Approximately 96 per cent of the proposed modification's greenhouse gas emissions occur downstream of the proposed modification, and are generated by third parties. Scope 1 emissions account for approximately 4 per cent of the greenhouse gases associated with the proposed modification.

Scope 2 and 3 emissions have been included in the GHGEA to demonstrate the potential upstream and downstream impacts of the proposed modification. All Scope 2 and 3 emissions identified in the GHGEA are attributable to, and may be reported by, other sectors.

3.2 Maximum Annual Greenhouse Gas Emissions

The Ravensworth East Mine has the approval to extract up to 4 million ROM tonnes per annum. The maximum greenhouse gas emissions associated with the proposed modification, at an annual extraction rate of 4 M ROM tonnes, are forecast to be approximately 7,165,000 t CO_2-e per annum. The proposed modification is forecast to generate approximately 267,000 t CO_2-e Scope 1 emissions per annum at its maximum extraction rate. While Ravensworth East Mine has approval to extract up to 4 million ROM tonnes per annum, it is planned to extract approximately 1.2 million ROM tonnes per annum from the RERR mining area.

3.3 Energy Use

The proposed modification is forecast to require approximately 1,856,000 GJ of energy from diesel and grid electricity over six years of operation. Annual average energy consumption is forecast at 310,000 GJ per annum.

The industry average energy use for open cut coal mines in Australia ranges between 430–660 Megajoules (MJ)/Product tonne (AGSO 2000). The current Glendell open cut operation has an average energy use intensity of approximately 340 MJ/Product Tonne, based on 2009/10–2010/11 data.

The proposed modification is forecast to produce approximately 3,800,000 product tonnes over its six year operation, which converts to an energy use intensity of approximately 490 MJ/Product Tonne. The forecast energy use intensity of the proposed modification is higher than Glendell as the proposed modification has a higher strip ratio. The forecast energy use intensity of the proposed modification is still within the normal operating range for Australian open cut coal mines.

4.0 Impact Assessment Summary

The greenhouse gas emissions generated by the proposed modification have the potential to impact the physical environment and the greenhouse gas reduction objectives of state, national and international governing bodies. The following section makes the distinction between environment impacts and impacts on policy objectives.

4.1 Environmental Impact

The proposed modification's greenhouse gas emissions will have a disperse impact as they are highly mobile and are generated up and down the supply chain. Greenhouse gas emissions primarily alter the atmospheric concentration of carbon dioxide and methane. The secondary impacts of greenhouse gas emissions include; global warming, ocean acidification and carbon fertilisation of flora. The tertiary impacts of greenhouse gas emissions (i.e. climate change) may have many ramifications for the natural and built environment.

The proposed modification's direct emissions are forecast to be approximately 64,000 t CO_2 –e per annum.

Approximately 40-50 per cent of the proposed modification's carbon dioxide emissions are expected to impact the atmosphere and become a 'greenhouse gas' (i.e. causing radiative forcing). The remaining 50-60 per cent of the proposed modification's CO_2 emissions are expected to be absorbed by the ocean and cycled through land biota (Knorr 2009, Raupach *et al* 2008). The airborne fraction (i.e. the proportion of CO_2 that remains in the atmosphere) of the carbon dioxide emitted from the proposed modification is likely to remain in the atmosphere for a long period. The 2007 Intergovernmental Panel on Climate Change (IPCC) policy makers summary report states that 'about half' of a CO_2 pulse to the atmosphere is removed over a timescale of 30 years; a further 30 per cent is removed within a few centuries; and the remaining 20 per cent will stay in the atmosphere for many thousands of years (Archer *et al* 2009).

To put the proposed modification's emissions into perspective, global greenhouse gas emissions are forecast to be 46,000,000,000 t CO_2-e by 2020 (Sheehan *et at* 2008). During operation, the proposed modification will contribute approximately 0.00014 per cent to the global emissions per annum (based on its projected scope 1 emissions). The scope 2 and 3 emissions associated with the proposed modification should not be considered in a global context, as global projections only represent scope 1 emissions (that is the sum of all individual emission sources).

4.2 Impact on National Policy Objectives

The Federal Government has committed to reduce Australia's greenhouse gas emissions to 25 per cent below 2000 levels by 2020 if the world agrees to an ambitious global deal to stabilise levels of greenhouse gases in the atmosphere at 450 parts per million CO_2 -e or lower (DCCEE 2010).

If international agreement is unable to be reached on a 450 parts per million target, Australia will still reduce its emissions by between 5 and 15 per cent below 2000 levels by 2020 (DCCEE 2010).

The Clean Energy Future legislation has been developed to assist Australia meet its national greenhouse gas reduction targets. This legislation provides the basis for a carbon pricing mechanism, and creates a market based incentive to reduce greenhouse gas emissions.

If Australia is to meet the 5 per cent reduction target, the nation will be generating approximately 525 Mt CO_2-e per annum by 2020 (DCCEE 2012). To reach the 2020 target, national modelling estimates that Australia will have to save approximately 160 million t CO_2-e between 2012 and 2020 (DCCEE 2012). The proposed modification's total Scope 1 emissions of approximately 400,000 t CO_2-e are unlikely to make a significant impact on Australia's ability to save 160 million t CO_2-e by 2020.

4.3 Impact on International Objectives

Australia's international objectives align with its national objectives. As discussed in **Section 4.3**, the proposed modification is unlikely to limit the Federal Government achieving its national/international 5 per cent greenhouse gas reduction target.

5.0 Greenhouse Gas and Energy Mitigation Measures

5.1 Sustainable Development Policy

The Xstrata Coal Sustainable Development Policy states in part.

> 'We aim to preserve the long term health, function and viability of the natural environments affected by our operations. To achieve this:
>
> - we act as responsible stewards of our owners assets and operate to leading practice and environmental standards;
> - we eliminate, mitigate or remediate the environmental impacts of our activities;
> - we continually improve the efficiency with which we use raw materials, energy and natural resources;
> - we reduce our direct and indirect greenhouse gas emissions and work with other organisations, governments and groups to address climate change; and
> - we work with our stakeholders to mitigate the environmental impacts of our product life cycle and supply chain.'

Xstrata Coal's specific greenhouse gas mitigation measures are discussed in the following sections.

5.2 Current Management Measures

Xstrata Glendell (Glendell) is committed to the Xstrata Coal Sustainable Development Policy, which specifically requires on-going consideration of greenhouse gas emissions and energy use. To assist Xstrata Coal meet its Sustainable Development Policy, Glendell must prepare Annual Sustainable Development Plans and adhere to Sustainable Development Standards and Protocols.

Glendell has an obligation to adhere to legal requirements to manage greenhouse gas emissions and energy use. The *Energy Efficiency Opportunities Act 2006* and the *Energy and Utilities Administration Act 1987* require Glendell to participate in the Energy Efficiency Opportunities (EEO) and Energy Savings Action Plan (ESAP) Programs respectively.

5.2.1 Energy Efficiency

Glendell will mitigate Scope 1 and 2 emissions through energy efficiency initiatives. The energy efficiency of mining operations is driven by energy use and productivity. Energy efficiency is maximised when highly efficient equipment is operated at optimal capacity. Through implementation of its *Air Quality and Greenhouse Gas Management Plan* (Xstrata Coal 2011) Glendell will manage energy efficiency through the following initiatives:

- optimising the design of haul roads to minimise the distance travelled between the pit and the ROM stockpiles and overburden dumping locations;
- minimising the re-handling of material (that is, coal, overburden and topsoil);
- managing truck payloads to utilise the tray space without overloading; and
- maintaining the mine fleet in good operating order.

Glendell will continue to participate in the EEO and ESAP Programs.

5.2.1.1 Energy Efficiency Opportunities

Xstrata Coal's operations in Australia fall under two controlling corporations, AZSA Holdings Pty Limited and Xstrata Holdings Pty Limited. All coal operations in NSW are part of AZSA Holdings Pty Limited. Controlling corporations that use more than 0.5 petajoules (PJ) of energy per year must participate in the EEO Program. AZSA Holdings triggers the energy use thresholds of the EEO Program and it is therefore required to undertake energy efficiency assessments and report the progress of energy efficiency projects. Glendell currently complete energy efficiency assessments, undertake energy efficiency planning and assist AZSA Holdings Pty Limited to report on the progress of nominated energy efficiency projections. Glendell will continue to participate in the EEO Program and undertake the following activities to improve energy use efficiency:

- evaluate actual energy use for the proposed modification;
- identify and investigate potential energy efficiency opportunities; and
- implement, track, communicate and report on energy efficiency opportunities.

5.2.1.2 Energy Savings Action Plans (ESAPs)

Glendell is listed on the Energy Savings Order and must develop ESAPs under the *Energy and Utilities Administration Act 1987*. Glendell currently develops ESAPs in accordance with the Guidelines for Energy Savings Action Plans and the current process will continue and incorporate the energy use activities for the proposed modification. Glendell's current ESAP can be found as an Appendix to the *Air Quality and Greenhouse Gas Management Plan* (Xstrata Coal 2011).

Glendell will continue to monitor energy use to evaluate ESAPs every four years and submit ESAP progress reports annually.

5.2.2 Measures Specific to the Proposed Modification

A core aspect of the proposed modification rationale is to optimise the efficient extraction of a valuable resource, by redeploying and utilising existing plant and equipment. The proposed modification has a number of features which will reduce the greenhouse gas emission intensity of the coal produced, compared to a similar product produced at a green field site. These features include:

- The proposed modification is within an existing mine site, will utilise existing infrastructure and it will not require the construction of a Mining Infrastructure Area, CHPP and transport infrastructure; and
- The proposed modification will redeploy existing plant and equipment rather than purchasing new equipment.

The proposed modification will also provide a source of overburden material to rehabilitate the West Pit, which will reduce emissions associated with hauling overburden from off site. While this aspect will not directly mitigate the emissions associated with the proposed modification, it will help Glendell mitigate the greenhouse gas emissions across the Mt Owen Complex.

5.2.3 Scope 3 Emissions

Glendell is not in a position to manage Scope 3 emissions directly, however, Xstrata Coal manages a significant product stewardship and market development program which aims to mitigate the downstream impacts of its products.

The Xstrata Coal Climate Change Strategy includes a number of product stewardship and market development commitments. These commitments include:

- contributing to the research, development and demonstration of low emissions technologies;
- developing strategic alliances in the area of capacity building to support the long term commercial application of low emission technologies;
- understanding the full 'lifecycle' emissions of products, including exploration, mining, processing, refining, fabricating, use and disposal;
- incorporating lifecycle analysis into business planning, product procurement and project management processes;
- working with government and key stakeholders to understand and adapt to the potential physical impacts of climate change;
- developing alliances and collaborating with customers, both domestic and international, in demonstrating the sustainable use of coal through new power generation technologies;
- establishing and formalising the process for the development of a $20 million Xstrata Coal GHG Budgeted program to be spent over a period of five years to support a range of internal and external funded initiatives which will support Low Emission Technologies, Coal Beneficiation and GHG Abatement;
- supporting ongoing projects like CS Energy Oxyfuel;
- progressing the Wandoan Carbon Transport and Storage Project (CTSCo); and
- continuing to investigate the participation in other projects that encourage and promote Low Emission Technology Deployment Measurement and Evaluation.

6.0 Conclusion

The Ravensworth East Resource Recovery proposed modification is a relatively small thermal coal proposal that will produce valuable energy commodities over six years. The proposed modification's forecast energy use intensity is considered to fall within the normal range when compared with similar operations across Australia. The proposed modification will utilise existing infrastructure at the Mt Owen Complex, which means the proposed modification will not generate the construction related emissions associated with an equivalent green field site. The proposed modification should also allow the existing CHPP to run at optimal capacity and maximise energy use efficiency.

The proposed modification is expected to generate approximately 66,750 t CO_2-e of Scope 1 and 2 emissions per annum, which is relatively small for a coal mine. Scope 1 emissions forecast for the proposed modification will vary significantly between reporting periods due to normal variations in annual activity. Fugitive emissions forecasts are also highly uncertain due to the uncertainty associated with the method for calculating open cut emissions. The Scope 1 emissions forecast in this report should not be used to benchmark annual greenhouse gas performance of the proposed modification, especially if future greenhouse gas reporting calculates fugitive emissions using the Method 2 approach described in the NGERS Technical Guidelines.

The proposed modification will be required to comply with National greenhouse and energy use legislation, as the proposed modification is part of a facility that triggers the NGERS reporting thresholds. The proposed modification would trigger NGERS reporting thresholds in its own right and would rank amongst Australia's 500 largest greenhouse gas emitters if it was a stand-alone facility. Glendell will manage Scope 1 and 2 emissions through energy efficiency initiatives (identified via EEO and ESAP) and improving fugitive emission reporting.

The proposed modification's products are expected to generate approximately 9,500,000 t CO_2-e as they are consumed by electricity generators. Approximately 96 per cent of the total greenhouse gas emissions detailed in **Table 3.1** will occur downstream of the proposed modification, and beyond the operational control of the Glendell. Xstrata Coal's Product Stewardship Program will continue to invest in managing downstream emissions.

The GHGEA found that the proposed modification is unlikely to impact national greenhouse gas policy objectives due to the relatively small contribution the proposed modification will make to national emissions.

7.0 References

Archer, D., Elby, M., Brovkin, V., Ridgwell, A., Cao, L., Mikolajewicz, U., Caldeira, K., Matsumoto, K., Munhoven, G, Montoenegro, A and Tokos, K. (2009). Atmospheric lifetime of fossil fuel carbon dioxide. *Annual Review of earth and Planetary Sciences 2009.* 37:117-34.

Australian Greenhouse Office (2007). National Greenhouse Gas Inventory: Analysis of Recent Trends and Greenhouse Gas Indicators.

Australian Geological Survey Organisation (AGSO) (2000). Energy/Greenhouse Benchmarking Study of Coal Mining Industry.

Department of Climate Change (2007). Australia's national greenhouse accounts. National Inventory Report 2007 Volume 1.

Department of Climate Change (2010). Australia on track to meet Kyoto Protocol target. Media Release, Senator Penny Wong, Minister for Climate Change, Energy Efficiency and Water (27 May 2010).

Department of Climate Change and Energy Efficiency (2011). National Greenhouse Accounts (NGA*)* Factors, Department of Climate Change and Energy Efficiency, Canberra.

Department of Climate Change and Energy Efficiency (2012). Fact Sheet: Australia's Emission Reduction Targets.

Department of Energy, Utilities and Sustainability (2005). Guidelines for Energy Savings Action Plans.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate Change 2007: Synthesis Report.

Knorr, W. (2009). Is the airborne fraction of anthropogenic CO_2 emissions increasing? *Geophysical Research Letters* VOL. 36, 2009.

NGGI (2010). National Greenhouse gas Inventory. http://www.ageis.greenhouse.gov.au/.

Raupach, M., Canadell, J and Le Qu´er´e, C. (2008). Anthropogenic and biophysical contributions to increasing atmospheric CO_2 growth rate and airborne fraction. *Biogeosciences Discuss.,* 5, 2867–2896, 2008.

Sheehan, P., Jones, R., Jolley, A. Preston, B.L., Durack, P.J., Islam, S.M.N. and Whetton, P.H. (2008). Climate change and the new world economy: Implications for the nature and policy responses. *Global Environmental Change* 18: 380 – 396.

WRI/WBCSD (2004). The Greenhouse Gas Protocol: The GHG Protocol for Modified RDC Accounting. World Resources Institute and the World Business Council for Sustainable Development, Switzerland.

Xstrata Coal (2011). Mt Owen Complex Air Quality and Greenhouse Gas Management Plan.

APPENDIX A

Total Proposed Modification
Greenhouse Gas Emissions

Appendix A

Total Proposed Modification Greenhouse Gas Emissions

Operational Sources	Activity Data	Activity Unit	Energy Content	Emission Factors			
				CO_2	CH_4	NO_2	Total GHG
			GJ	(Kg/GJ)	(Kg/GJ)	(Kg/GJ)	(t CO_2-e)
Diesel use – Stationary	46,368	kL	1,789,805	69.2	0.1	0.2	124,391
Fugitive Emissions	5,738,244	ROM tonnes	-	45	-	-	258,221
Total Scope 1							**382,612**
Electricity	18,375,800	kWh	66,100	246	-	-	16,261
Total Scope 2							**16,261**
Product use	3,739,519	tonnes	108,072,099	87.11	-	-	9,414,199
Product transport – Rail	366,472,823	TKm	-	0.0054	-	-	1,979
Product transport – Ship	35,525,426,700	TKm	-	0.0126	-	-	447,620
Emissions associated with diesel use	1,789,805	GJ	-	5.3	-	-	9,486
Emissions associated with electricity use	66,100	GJ	-	47	-	-	3,107
Total Scope 3							**9,876,391**
Total Proposed Modification Emissions							**10,275,264**

APPENDIX B

Maximum Annual GHG
Emissions at Potential
Extraction Capacity

Appendix B

Maximum Annual GHG Emissions at Potential Extraction Capacity

Operational Sources	Activity Data	Activity Unit	Energy Content	Emission Factors			
				CO_2	CH_4	NO_2	Total GHG
			GJ	(Kg/GJ)	(Kg/GJ)	(Kg/GJ)	(t CO_2-e)
Diesel use – Stationary	32,400	kL	1,250,640	69.2	0.1	0.2	86,919
Fugitive Emissions	4,000,000	ROM tonnes	-	45	-	-	180,000
Total Scope 1							**266,919**
Electricity	12,788,000	kWh	46,000	246	-	-	11,316
Total Scope 2							**11,316**
Product use	2,606,720	tonnes	75,334,208	87.11	-	-	6,562,390
Product transport – Rail	255,458,560	TKm	-	0.0054	-	-	1,379
Product transport – Ship	24,763,840,000	TKm	-	0.0126	-	-	312,024
Emissions associated with diesel use	1,250,640	GJ	-	5.3	-	-	6,628
Emissions associated with electricity use	46,000	GJ	-	47	-	-	2,162
Total Scope 3							**6,884,583**
Total Operational Emissions							**7,162,818**