Mount Thorley Operations 2014

3

Environmental Impact Statement

Prepared for Mt Thorley Operations Pty Limited | June 2014

VOLUME 3 — Appendices G to J

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EMM
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Appendix G

Air quality and greenhouse gas study

Appendix G — Air quality and greenhouse gas study

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AIR QUALITY AND GREENHOUSE GAS ASSESSMENT
MOUNT THORLEY OPERATIONS 2014

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12 June 2014

Job Number 14010272

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Air Quality and Greenhouse Gas Assessment Mount Thorley Operations 2014

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EXECUTIVE SUMMARY

This assessment investigates the potential air quality effects and calculates the greenhouse gas emissions that may arise as a result of the proposed modifications to the Mount Thorley Operations. The Mount Thorley Operations is located in the Hunter Valley, NSW and is operated by Coal & Allied on behalf of Mount Thorley Joint Venture. The mine currently operates under Development Consent No. DA 34/95.

The assessment is prepared in general accordance with the applicable regulatory requirements and guidelines and forms part of the environmental impact statement prepared for the development application. Environmental impacts are assessed against relevant criteria developed as benchmarks set to protect the overall health and amenity of the general community.

The existing environmental condition of the area is typical of the Hunter Valley region with common wind flows aligned along a northwest to southeast flow. The ambient air quality in the area is generally fair considering the various industrial and commercial activities of the region.

The assessment has focused on three indicative mine plan years chosen to represent a range of potential impacts over the life of the mining operation with reference to surrounding operations in the area which would also contribute to dust emissions in each year. Air dispersion modelling with the CALPUFF modelling suite is utilised in conjunction with estimated emission rates for air pollutants generated by the various activities. Best practice mitigation and management measures are considered to ameliorate any potential adverse air quality impacts and respond to government and community concerns regarding the regional air quality in the Hunter Valley.

The assessment predicts potential dust impacts at mine-owned assessment locations, two privately owned assessment locations in Warkworth, and the Warkworth community hall. These three non-mine owned properties are within the area encompassed by the acquisition zone of neighbouring mines (although not all properties are explicitly identified). All of the affected properties would also be afforded acquisition rights should the proposal proceed.

The assessment indicates that adverse air quality impacts are unlikely from diesel combustion and whilst blasting has potential to lead to impacts in the late afternoon periods, this would be averted with appropriate management measures that prevent blasting under impacting conditions.

The calculated annual greenhouse gas emissions for the MTO is 0.472Mt CO_2-e and is equivalent to approximately 0.1 per cent and 0.3 per cent of the total Australian and NSW greenhouse gas emissions respectively.

Overall the assessment indicates that whilst adverse air quality impacts may arise at a small number of assessment locations due to the proposal, these can be managed and mitigated effectively.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Mount Thorley Operations (MTO) is an open cut coal mine approximately 10.5 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). The site currently operates under Development Consent No. DA 34/95 (the development consent) issued by the then Minister for Planning on 22 June 1996 under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Immediately to the north is Warkworth Mine. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for all the operations. Equipment, personnel, water, rejects and coal preparation are all shared between the mines. The MTW operations involve an existing operation of approximately 1,300 persons, which includes full-time personnel and a small number of short-term contractors. Ownership of the two mines remains separate.

Mining activities approved under DA 34/95 have mostly been completed with the exception of Loders Pit and Abbey Green North Pit (AGN) with rehabilitation well-progressed on the east of the site. Run-of-mine (ROM) coal from MTO is transported to either the MTO or Warkworth Mine coal preparation plant (CPP) for processing. Extraction of coal from other pits has been completed; overburden emplacement is ongoing. Product coal from the CPPs is transported via conveyor to the Mount Thorley Coal Loader (MTCL). Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The MTO 2014 (the proposal) seeks an approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

1.1 Project description

MTO has approval to mine until 22 June 2017 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in 2015, operations at MTO are forecast to continue to the end of 2035, an 18 year extension over the current approval. The proposal seeks a continuation of all aspects of MTO as it presently operates and extends or alters them, including:

- mining in Loders Pit and AGN Pit. Mining in Loders Pit is expected to be completed in approximately 2020. Mining in AGN Pit is yet to commence; however, it is anticipated to take approximately two years and be completed before 2022;
- transfer of overburden between MTO and Warkworth Mine to assist in rehabilitation and development of the final landform;
- maintain existing extraction rate of 10 million tonnes per year (Mtpa) of ROM coal;
- maintain and upgrade to the integrated MTW water management system (WMS), including:
  - upgrade to the approved discharge point and rate of discharge into Loders Creek from 100Ml/d to 300Ml/d via the Hunter River Salinity Trading Scheme (HRSTS);

  - ability to transfer and accept mine water from neighbouring operations (ie Bulga Coal Complex, Wambo Mine, Warkworth Mine and Hunter Valley Operations);
  - increase in the storage capacity of the southern out-of-pit (SOOP) dam from 1.6 giga litres (GL) to 2.2GL
- maintain and upgrade to the integrated MTW tailings management:
  - including use of the northern part of Loders Pit as a TSF after completion of mining; and
  - Wall lift to Centre Ramp Tailings Facility to approximately RL150
- upgrade to the MTO CPP to facilitate an increase in maximum throughput to 18Mtpa with the ability to receive this coal from Warkworth Mine;
- acknowledge all approved interactions with Bulga Coal Complex; and
- continuation of coal transfer between Warkworth Mine and MTO and transportation of coal via the MTCL to Port of Newcastle.
- All activities, including coal extraction will be within disturbance areas approved under the existing development consent.

The proposal is shown in **Figure 1-1**.

1.2 Report purpose

This air quality impact and greenhouse gas assessment has been prepared in general accordance with the Secretary's Requirements and the New South Wales (NSW) Environment Protection Authority (EPA) document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**). The assessment forms part of the environmental impact statement prepared in support of the development application for the proposal.

The assessment investigates the potential for adverse air quality impacts occurring at surrounding assessment locations as a result of the proposal. Air dispersion modelling is utilised in conjunction with estimated emission rates of air pollutants and the consideration of mitigation measures in ameliorating any potential air quality impacts.

This report comprises of:

- A review of the existing environment surrounding the proposal;
- A description of the dispersion modelling approach used to assess potential impacts;
- The results of the dispersion modelling;
- A discussion of the potential air quality impacts as a result of the proposal;
- An estimation of the greenhouse gas emissions generated; and
- Measures to avoid or mitigate potential air quality impacts.

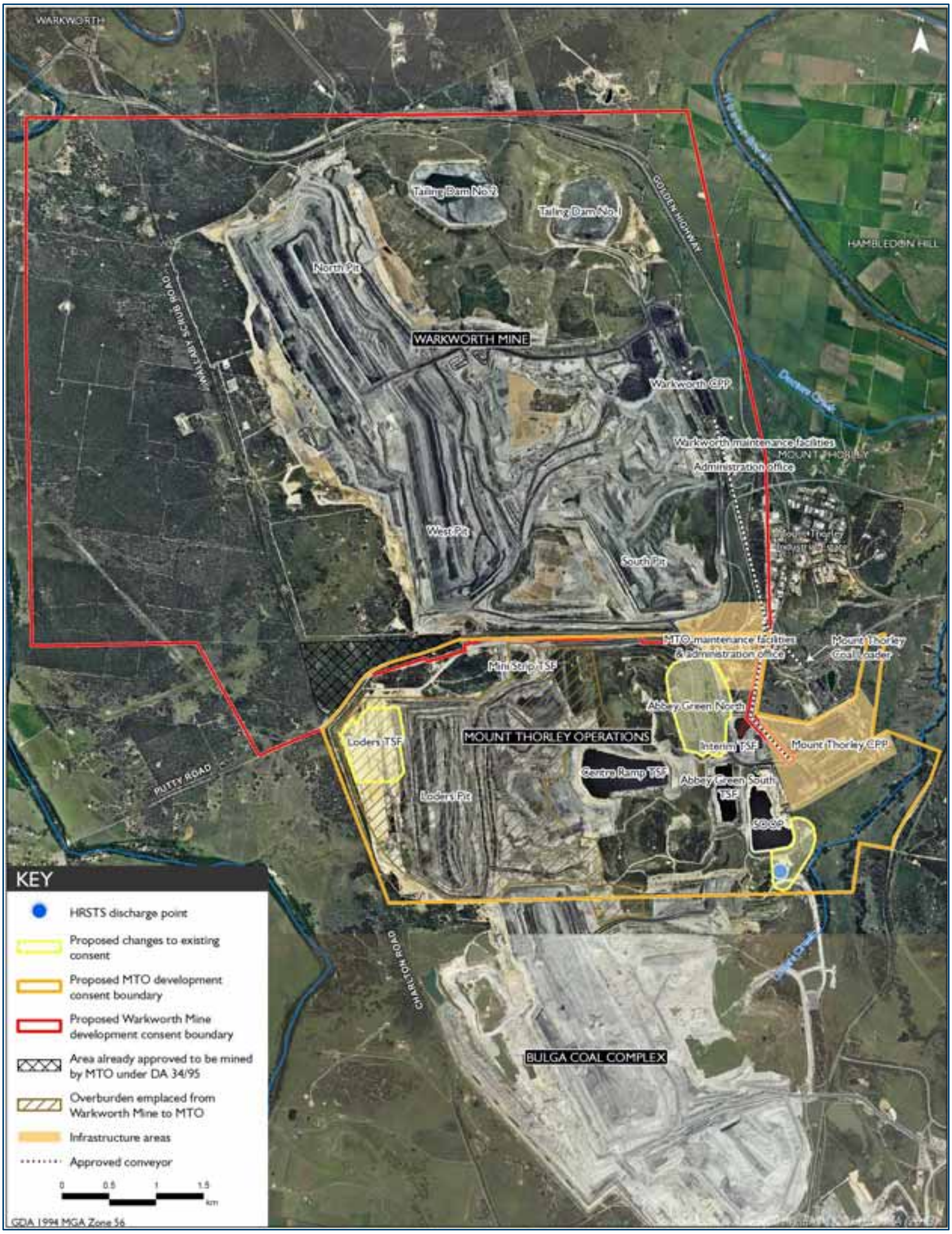

Figure 1-1: The proposal

2 LOCAL SETTING

The area surrounding MTO is comprised of various open cut coal mining operations, agriculture, forest, national park and rural residential areas.

Figure 2-1 presents the location of the proposal in relation to the neighbouring coal mining operations and the assessment locations of relevance to this study. **Appendix A** provides a detailed list of all the assessment locations considered in this report.

Figure 2-2 presents a three-dimensional (3D) visualisation of the topography in the vicinity of MTO. The surrounding topography is characterised by the steep escarpment to the west and south which forms part of the Wollemi National Park and the Pokolbin State Forest respectively. To the north and east, the terrain is generally open to form the Hunter Valley. In the general vicinity of MTO, the terrain is typical of grassland and woodland with moderately hilly terrain. The complex terrain features of the surrounding area have a significant effect on the local wind distribution patterns.

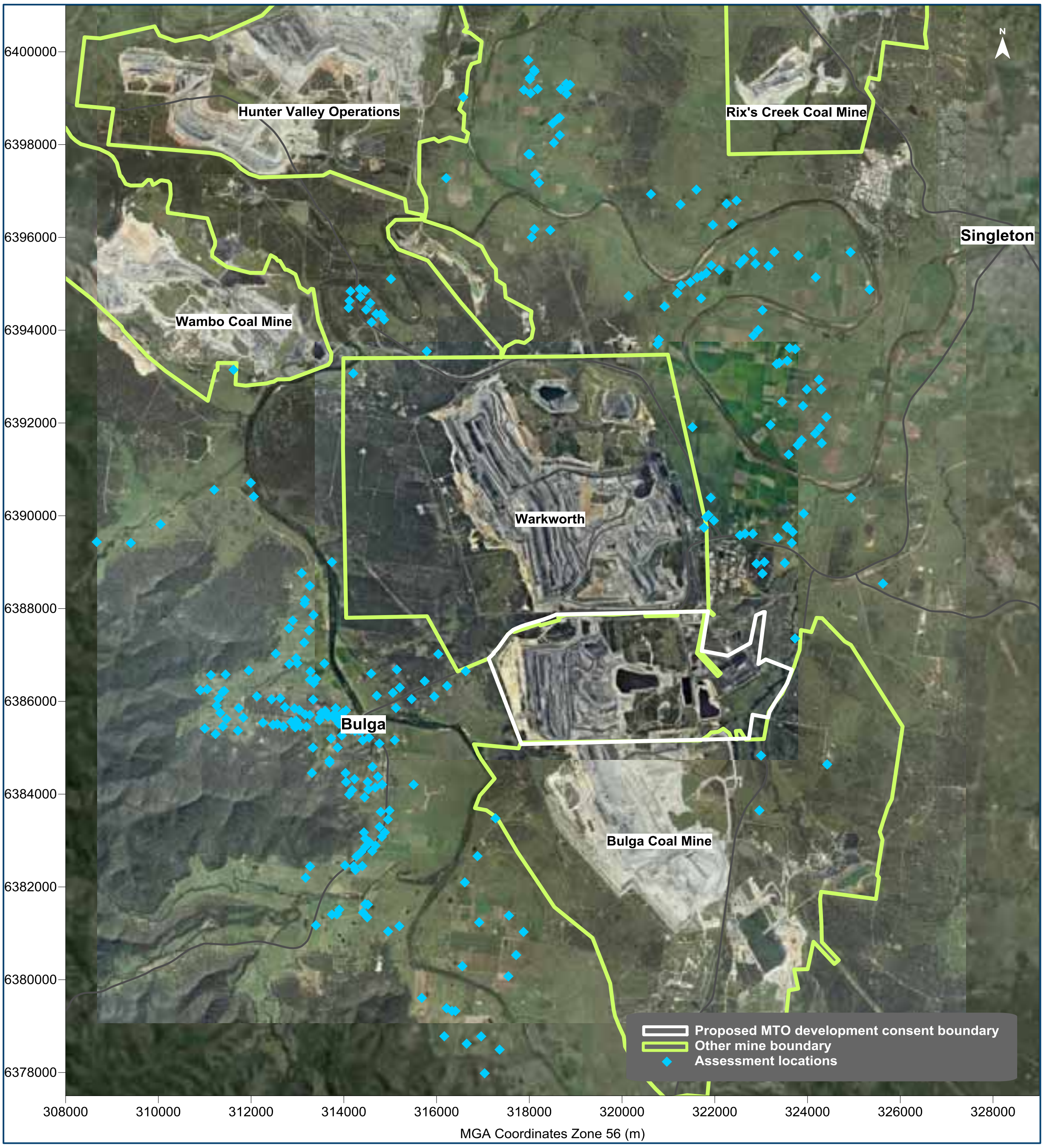

Figure 2-1: Proposal setting

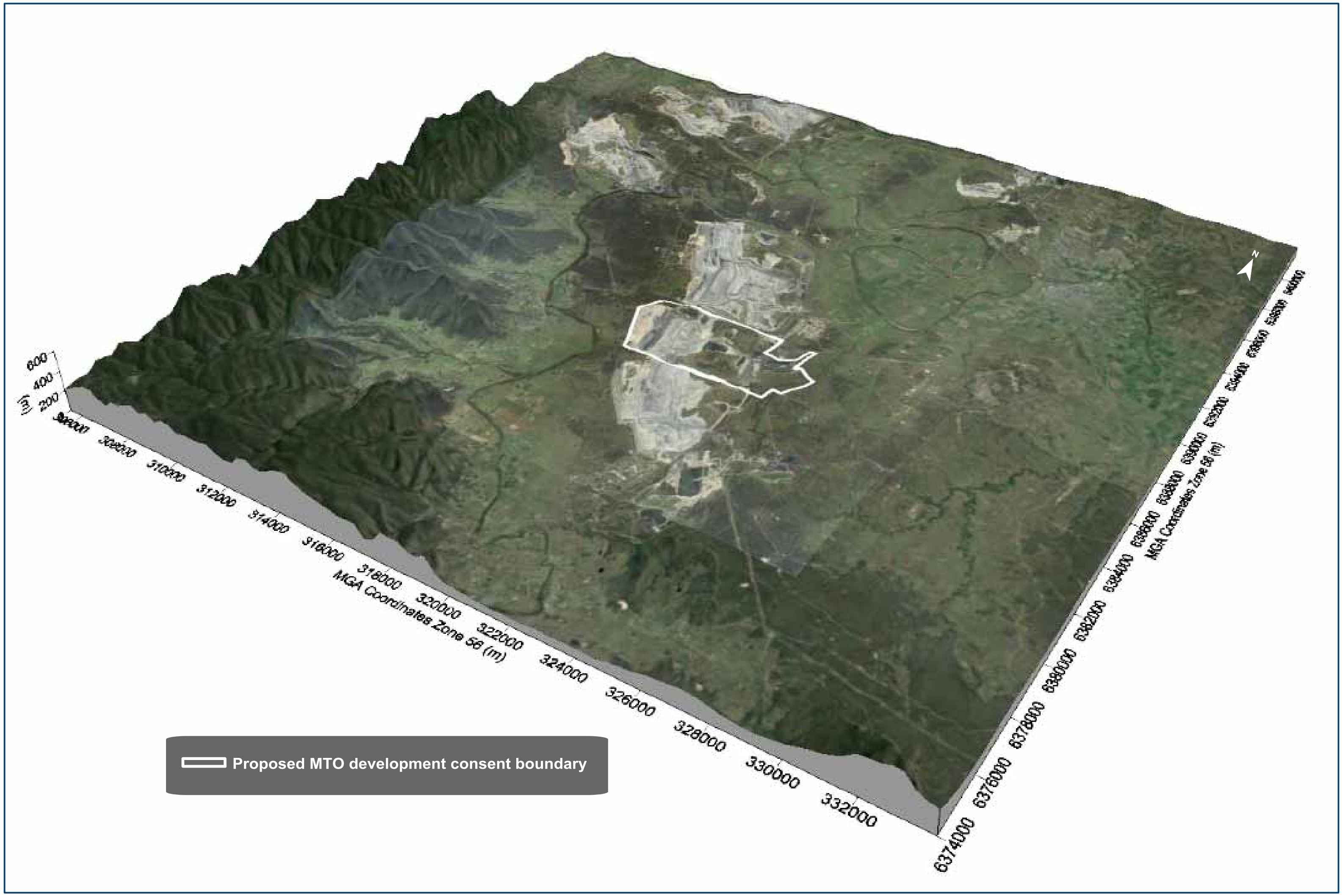

Figure 2-2: Topography surrounding the proposal

3 AIR QUALITY ASSESSMENT CRITERIA

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the proposal and the applicable air quality criteria.

3.1 Particulate matter

Particulate matter refers to particles of varying size and composition. The air quality goals relevant to this assessment refer to three classes of particulate matter based on the sizes of the particles. The first class is referred to as Total Suspended Particulate matter (TSP) which measures the total mass of all particles suspended in air. The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice, particles larger than 30 to 50µm settle out of the atmosphere too quickly to be regarded as air pollutants.

The second and third class are sub-classes of TSP, namely PM_{10}, particulate matter with aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with aerodynamic diameters of 2.5µm or less.

Mining activities generate particles in all the above size categories. The great majority of the particles generated are due to the abrasion or crushing of rock and coal and general disturbance of dusty material. These particulate emissions will be generally larger than 2.5µm as these fine sub-2.5µm particles are usually generated through combustion processes or as secondary particles formed from chemical reactions rather than through mechanical processes that dominate emissions on mine sites.

Combustion particulates can be more harmful to human health as the particles have the ability to penetrate deep into the human respiratory system as they are small and can be comprised of acidic and carcinogenic substances.

A study of the particle size distribution from mine dust sources in 1986 conducted by the State Pollution Control Commission (SPCC) found that of approximately 120 samples showed $PM_{2.5}$ comprised 4.7 per cent of the TSP, and PM_{10} comprised 39.1 per cent of the TSP in the samples (**SPCC, 1986**). The emissions of $PM_{2.5}$ occurring from mining activities are small in comparison to the total dust emissions and in practice, the concentrations of $PM_{2.5}$ in the vicinity of mining dust sources are likely to be low.

3.1.1 NSW EPA impact assessment criteria

Table 3-1 summarises the air quality goals that are relevant to this study as outlined in the NSW EPA document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**). The air quality goals for total impact relate to the total dust burden in the air and not just the dust from the proposal. Consideration of background dust levels needs to be made when using these goals to assess potential impacts.

Table 3-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90µg/m³
PM_{10}	Annual	Total	30µg/m³
	24 hour	Total	50µg/m³
Deposited dust	Annual	Incremental	2g/m²/month
		Total	4g/m²/month

Source: **NSW DEC, 2005**

The criterion for 24-hour average PM_{10} originates from the National Environment Protection Measure (NEPM) goals (**NEPC, 1988**). These goals apply to the population as a whole, and are not recommended to be applied to "hot spots" such as locations near industry, busy roads or mining. However, in the absence of alternative measures, NSW EPA does apply the criteria to assess the potential for impacts to arise at such locations.

The NEPM permits five days annually above the 24-hour average PM_{10} criterion to allow for bush fires and similar events. Similarly, it is normally the case that days, where ambient dust levels are affected by such events, are excluded from assessment as per the NSW EPA criterion.

It is important to note the Mining SEPP non-discretionary standard for air quality is a PM_{10} annual average criterion of 30µg/m^3 and a key matter for consideration.

3.1.2 NSW Planning & Infrastructure private residential property acquisition criterion for particulate matter

While the NSW EPA applies the maximum 24-hour average PM_{10} level in any year to assess the potential for impacts from a project, the NSW Planning & Infrastructure (P&I) in contemporary planning approvals has invoked requirements for acquisition and negotiated agreements with private residential landowners if there are systemic exceedances of the NSW EPA criterion. In the context of impact assessments for approval of new projects and modifications to existing projects, this is interpreted to mean where the NSW EPA criterion is exceeded on more than five days in any year (a 98.6 percentile level of compliance). This P&I criterion and other relevant criteria are outlined in **Table 3-2**.

Table 3-2: P&I private residential property acquisition criteria for particulate matter

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90µg/m^3
PM_{10}	Annual	Total	30µg/m^3
	24 hours	Incremental	50µg/m^3
Deposited dust	Annual	Incremental	2g/m^2/month
		Total	4g/m^2/month

3.1.3 $PM_{2.5}$ concentrations

The NSW EPA currently does not have impact assessment criteria for $PM_{2.5}$ concentrations; however the National Environment Protection Council (NEPC) has released a variation to the NEPM (**NEPC, 2003**) to include advisory reporting standards for $PM_{2.5}$ (see **Table 3-3**).

The advisory reporting standards for $PM_{2.5}$ are a maximum 24-hour average of 25µg/m^3 and an annual average of 8µg/m^3, and as with the NEPM goals, apply to the average, or general exposure of a population, rather than to "hot spot" locations.

Table 3-3: Advisory standard for $PM_{2.5}$ concentrations

Pollutant	Averaging Period	Criterion
$PM_{2.5}$	24 hours	25µg/m^3
	Annual	8µg/m^3

Source: **NEPC, 2003**

3.2 Other air pollutants

Emissions of other air pollutants will also potentially arise from mining operations such as the diesel powered equipment used on-site. Emissions from diesel powered equipment generally include carbon monoxide (CO), nitrogen dioxide (NO_2) and other pollutants, such as sulphur dioxide (SO_2).

CO is colourless, odourless and tasteless and generated from the incomplete combustion of fuels when carbon molecules are only partially oxidised. It can reduce the capacity of blood to transport oxygen in humans resulting in symptoms of headache, nausea and fatigue.

NO_2 is reddish-brown in colour (at high concentrations) with a characteristic odour and can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NO_X). These gases form when fuel is burned at high temperatures, mainly from motor vehicles, power generators and industrial boilers (**USEPA 2011**). NO_X may also be generated by blasting activities. It is important to note that when formed, NO_2 is generally a small fraction of the total NO_X generated.

Sulphur dioxide (SO_2) is a colourless, toxic gas with a pungent and irritating smell. It commonly arises in industrial emissions due to the sulphur content of the fuel. SO_2 can have impacts upon human health and the habitability of the environment for flora and fauna. SO_2 emissions are a precursor to acid rain, which can be an issue in the northern hemisphere; however it is not known to have any widespread impact in NSW, and is generally only associated with large industrial activities. Due to its potential to impact on human health, sulphur is actively removed from fuel to prevent the release and formation of SO_2. The sulphur content of Australian diesel is controlled to a low level by national fuel standards. Therefore the emissions of SO_2 generated from diesel powered equipment at mine sites are generally considered to be too low to generate any significant off-site pollutant concentrations and have not been assessed further in this study.

Table 3-4 summarises the air quality goals for CO and NO_2 assessed in this report.

Table 3-4: NSW EPA air quality impact assessment criteria of air toxics

Pollutant	Averaging period	Criterion
Carbon monoxide (CO)	15 minute	100mg/m²
	1 hour	30mg/m²
	8 hour	10mg/m²
Nitrogen dioxide (NO_2)	1 hour	246µg/m³
	Annual	62µg/m³

Source: **NSW DEC, 2005**

4 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the area surrounding MTO.

4.1 Local climate

Long term climate data collected at the nearest Bureau of Meteorology (BoM) station, Jerrys Plains Post Office (Station Number 061086), are summarised in **Table 4-1** and **Figure 4-1**. Climatic parameters have been collected from the Jerrys Plains Post Office over a 45 to 128 year period. These data assist in characterising the local climatic conditions based on the long term meteorological parameters. The Jerrys Plains Post Office is located approximately 20km northwest of Warkworth Mine.

The data indicates that January is the hottest month with a mean maximum temperature of 31.7ºC and July is the coldest month with a mean minimum temperature of 3.8ºC.

Relative humidity levels exhibit variability over the day and seasonal fluctuations. Mean 9am relative humidity levels range from 59 per cent in October to 80 per cent in June. Mean 3pm relative humidity levels vary from 42 per cent in October – December to 54 per cent in June.

Rainfall peaks during the summer months and declines during winter. The data show January is the wettest month with an average rainfall of 77.7mm over 6.4 days and August is the driest month with an average rainfall of 36.1mm over 5.2 days.

Wind speeds during the warmer months have a greater spread between the 9am and 3pm conditions compared to the colder months. The mean 9am wind speeds range from 8.6km/h in April to 11.7km/h in September. The mean 3pm wind speeds vary from 11.0km/h in May to 14.7km/h in September.

Table 4-1: Monthly climate statistics summary – Jerrys Plains Post Office

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean max. temperature (ºC)	31.7	30.9	28.9	25.3	21.3	18.0	17.4	19.4	22.9	26.2	29.1	31.2
Mean min. temperature (ºC)	17.2	17.1	15.0	11.0	7.4	5.3	3.8	4.4	7.0	10.3	13.2	15.7
Rainfall												
Rainfall (mm)	77.7	73.1	59.1	44.0	40.7	48.1	43.4	36.1	41.7	51.9	61.9	67.5
Mean No. of rain days (≥1mm)	6.4	6.0	5.8	4.9	4.9	5.5	5.2	5.2	5.2	5.8	6.2	6.3
9am conditions												
Mean temperature (ºC)	23.4	22.7	21.2	18.0	13.6	10.6	9.4	11.4	15.3	19.0	21.1	23.0
Mean relative humidity (%)	67	72	72	72	77	80	78	71	65	59	60	61
Mean wind speed (km/h)	9.6	9.0	8.8	8.6	9.0	9.4	10.6	11.0	11.7	10.9	10.5	9.9
3pm conditions												
Mean temperature (ºC)	29.8	28.9	27.2	24.1	20.1	17.1	16.4	18.2	21.2	24.2	26.9	29.0
Mean relative humidity (%)	47	50	49	49	52	54	51	45	43	42	42	42
Mean wind speed (km/h)	13.2	13.0	12.4	11.3	11.0	11.5	13.0	14.3	14.7	14.1	14.2	14.2

Source: **Bureau of Meteorology, 2014**

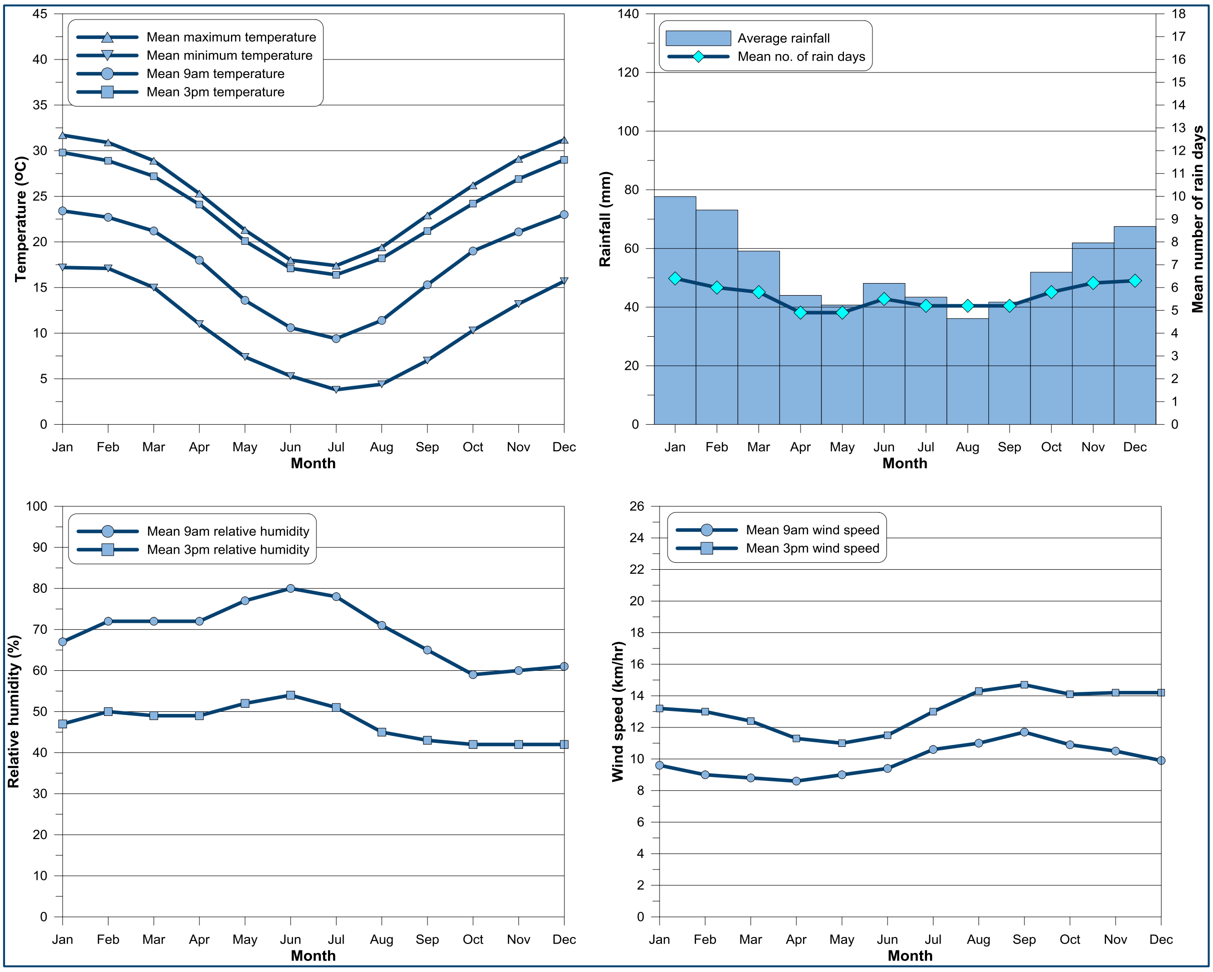

Figure 4-1: Monthly climate statistics summary – Jerrys Plains Post Office

4.2 Local meteorological conditions

MTW operate the Charlton Ridge meteorological station to assist with environmental management of site operations. The location of this station is shown in **Figure 4-2**.

Annual and seasonal windroses prepared from the available data collected for the 2012 period are presented in **Figure 4-3**.

Analysis of the windroses shows that the most common winds on an annual basis are from the south-southeast and south. Very few winds originate from the northeast and southwest sectors. In the summertime the wind predominately occurs from the south-southeast. The autumn distribution is similar to the annual distribution pattern. During winter, winds from the south-southeast and northwest dominate the distribution with some winds from the south. In the spring time, the majority of winds are from the south-southeast with varied winds from east-southeast, south and northwest.

Figure 4-2: Charlton Ridge meteorological station

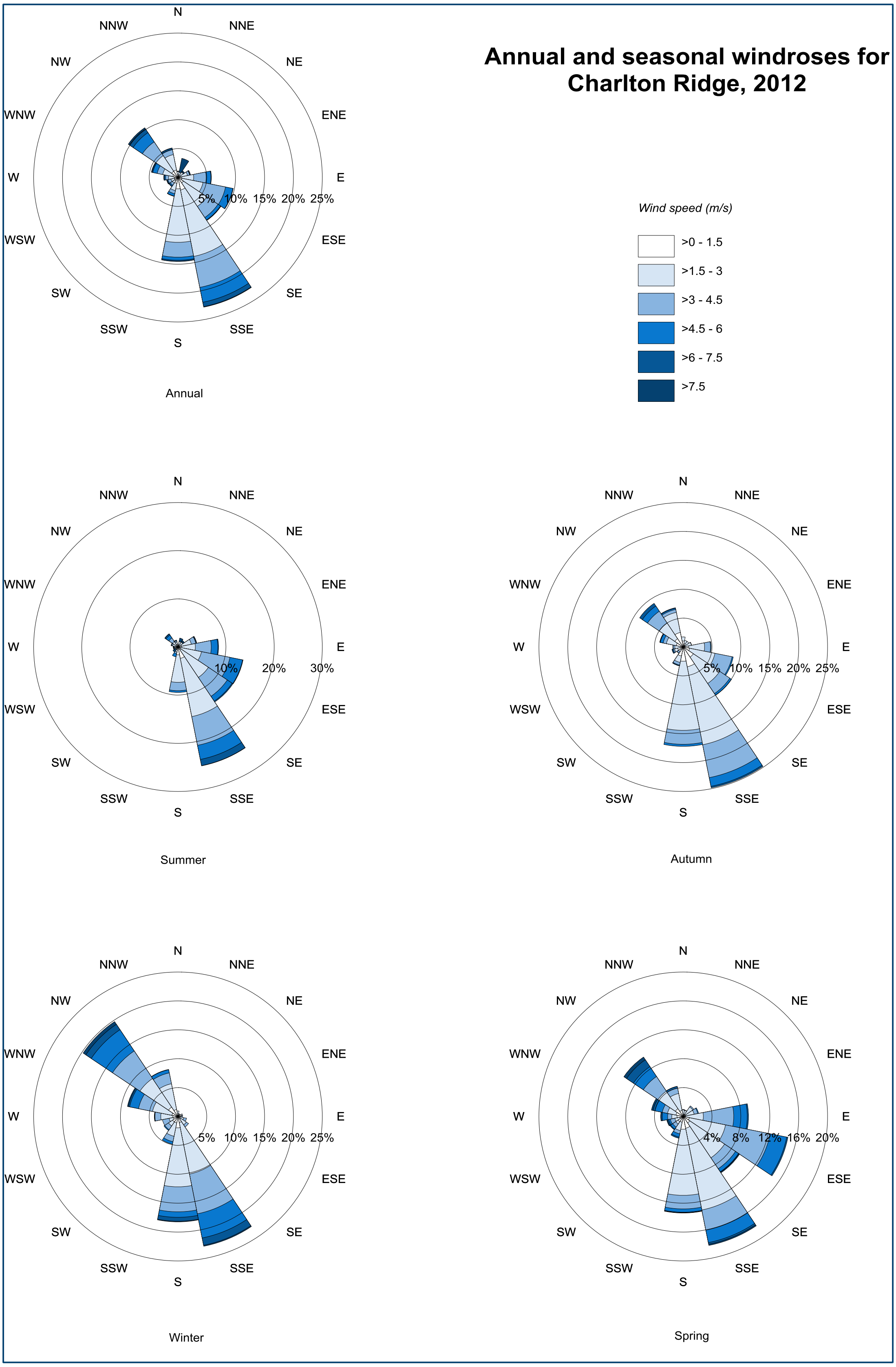

Figure 4-3: Annual and seasonal windroses for Charlton Ridge weather station (2012)

4.3 Ambient air quality

The main sources of particulate matter in the wider area include active mining, agricultural activities, emissions from local anthropogenic activities such as motor vehicle exhaust and domestic wood heaters, urban activity and various other commercial and industrial activities. Other pollutant emissions considered in the study include NO_2 and CO, which can potentially arise from mining operations such as the diesel powered equipment used on site and methane flaring operations, and power generation, including the Liddell, Bayswater and Redbank power stations. This section reviews the ambient monitoring data collected from a number of ambient monitoring locations in the vicinity of MTO.

The air quality monitors reviewed in this assessment include 12 Tapered Element Oscillating Microbalances (TEOMs), 11 High Volume Air Samplers (HVAS) measuring either TSP or PM_{10}, 13 dust deposition gauges and three NO_2 monitors surrounding MTO.

Table 4-2 lists the monitoring stations reviewed in this section which includes data from surrounding mining operations and the NSW EPA stations. **Figure 4-4** shows the approximate location of each of the monitoring stations reviewed in this assessment. **Appendix B** provides a summary of the mining operations monitoring data reviewed in this assessment.

Table 4-2: Summary of ambient monitoring stations

Monitoring site ID	Type	Monitoring data review period
Bulga	TEOM	January 2010 – December 2013
Wallaby Scrub Road	TEOM	January 2010 – December 2013
Warkworth	TEOM	January 2010 – December 2013
Knodlers Lane	TEOM	November 2011 – December 2013
Maison Dieu	TEOM	January 2010 – December 2013
MTIE	TEOM	January 2010 – December 2013
Bulga (NSW EPA)	TEOM	August 2011 – March 2014
Warkworth (NSW EPA)	TEOM	December 2011 – March 2014
Maison Dieu (NSW EPA)	TEOM	March 2011 – March 2014
Singleton NW (NSW EPA)	TEOM	July 2011 – March 2014
Singleton (NSW EPA)	TEOM	December 2010 – March 2014
Mt Thorley (NSW EPA)	TEOM	July 2011 – March 2014
MTO PM10	HVAS – PM_{10}	January 2012 – December 2013
WML PM10	HVAS – PM_{10}	August 2012 – December 2013
Knodlers Lane PM10	HVAS – PM_{10}	January 2012 – December 2013
Long Point PM10	HVAS – PM_{10}	Jan-Feb 2012 – Oct-Dec 2013
MTIE PM10	HVAS – PM_{10}	January 2012 – February 2013
Loders Creek PM10	HVAS – PM_{10}	March 2013 – December 2013
MTO TSP	HVAS – TSP	January 2012 – December 2013
WML TSP	HVAS – TSP	January 2012 – December 2013
Warkworth TSP	HVAS – TSP	January 2012 – December 2013
Long Point TSP	HVAS – TSP	October 2013 – December 2013
Loders Creek TSP	HVAS – TSP	March 2013 – December 2013
DW21A	Dust gauge	January 2012 – December 2013
Warkworth	Dust gauge	January 2012 – December 2013
DL30	Dust gauge	January 2012 – December 2013
DL22	Dust gauge	January 2012 – December 2013
Knodlers Lane	Dust gauge	January 2012 – December 2013
DL21	Dust gauge	January 2012 – December 2013

Monitoring site ID	Type	Monitoring data review period
DL14	Dust gauge	January 2012 – December 2013
D122	Dust gauge	January 2012 – December 2013
DW15	Dust gauge	January 2012 – December 2013
DW20A	Dust gauge	January 2012 – December 2013
DW14	Dust gauge	January 2012 – December 2013
D125	Dust gauge	January 2012 – December 2013
D124	Dust gauge	January 2012 – December 2013
Beresfield (NSW EPA)	NO_2 monitor	January 2008 – January 2014
Muswellbrook (NSW EPA)	NO_2 monitor	November 2011 – January 2014
Singleton (NSW EPA)	NO_2 monitor	November 2011 – January 2014

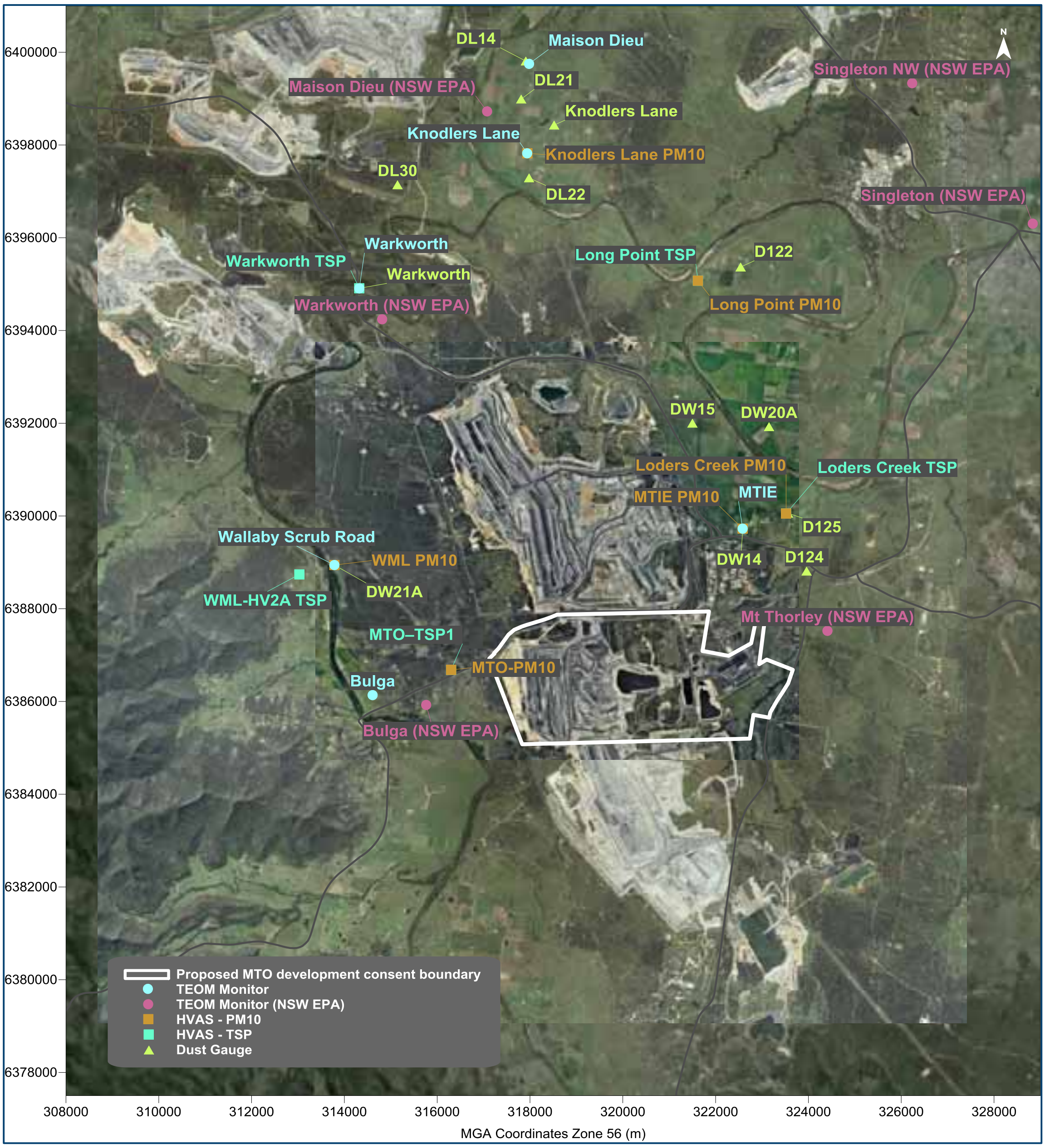

Figure 4-4: Monitoring locations

4.3.1 PM_{10} monitoring - TEOMs

Ambient PM_{10} monitoring using TEOMs is conducted by MTW and Hunter Valley Operations and NSW EPA at various locations surrounding MTO. The location of each of these monitors is shown in **Figure 4-4**. The monitoring data includes all emission sources in the vicinity of MTO.

4.3.1.1 MTW and Hunter Valley Operations

A summary of the available data collected from MTW and Hunter Valley Operations monitors from January 2010 to December 2013 is presented in **Table 4-3**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-5**.

Table 4-3 indicates that the annual average PM_{10} concentrations for each of the monitoring stations were below the relevant criterion of 30µg/m^3 and that the maximum 24-hour average PM_{10} concentrations were on occasion above 50µg/m^3 on days during the monitoring period. Further details regarding individual elevated days of dust concentrations are described in the Annual Environmental Management Report (Annual Review) for the mining operations.

It can be seen from **Figure 4-5** that PM_{10} concentrations are nominally highest in the spring and summer months with the warmer weather raising the potential for drier ground elevating the occurrence of windblown dust, bushfires and pollen levels.

The yellow shaded band in **Figure 4-5** represents the period containing the data used to make the assessment of cumulative impacts. It can be seen that this period has the highest baseline PM_{10} levels in Bulga village and does not contain the anomalous high peaks that occurred during the bushfire period in late 2013 or the relatively low levels that occurred in Bulga village in 2013.

Table 4-3: Summary of PM_{10} levels from MTW and Hunter Valley Operations TEOM monitoring (µg/m^3)

	2010	2011	2012	2013
	Annual average			
Bulga	12.8	12.9	14.3	13.3
Knodlers Lane(1)	-	9.2	18.1	18.9
Wallaby Scrub Road	13.4	13.0	16.6	15.9
Maison Dieu	17.1	18.2	21.4	21.5
MTIE	22.2	19.9	24.9	27.5
Warkworth	11.2	13.7	16.5	18.2
	Maximum 24-hour average			
Bulga	39.5	42.8	56.1	78.8
Knodlers Lane(1)	-	15.6	56.3	62.1
Wallaby Scrub Road	45.6	54.0	46.0	72.0
Maison Dieu	77.0	64.7	76.0	74.7
MTIE	85.0	76.0	77.0	103.0
Warkworth	32.0	44.6	41.2	58.0

(1)Data available from November 2011

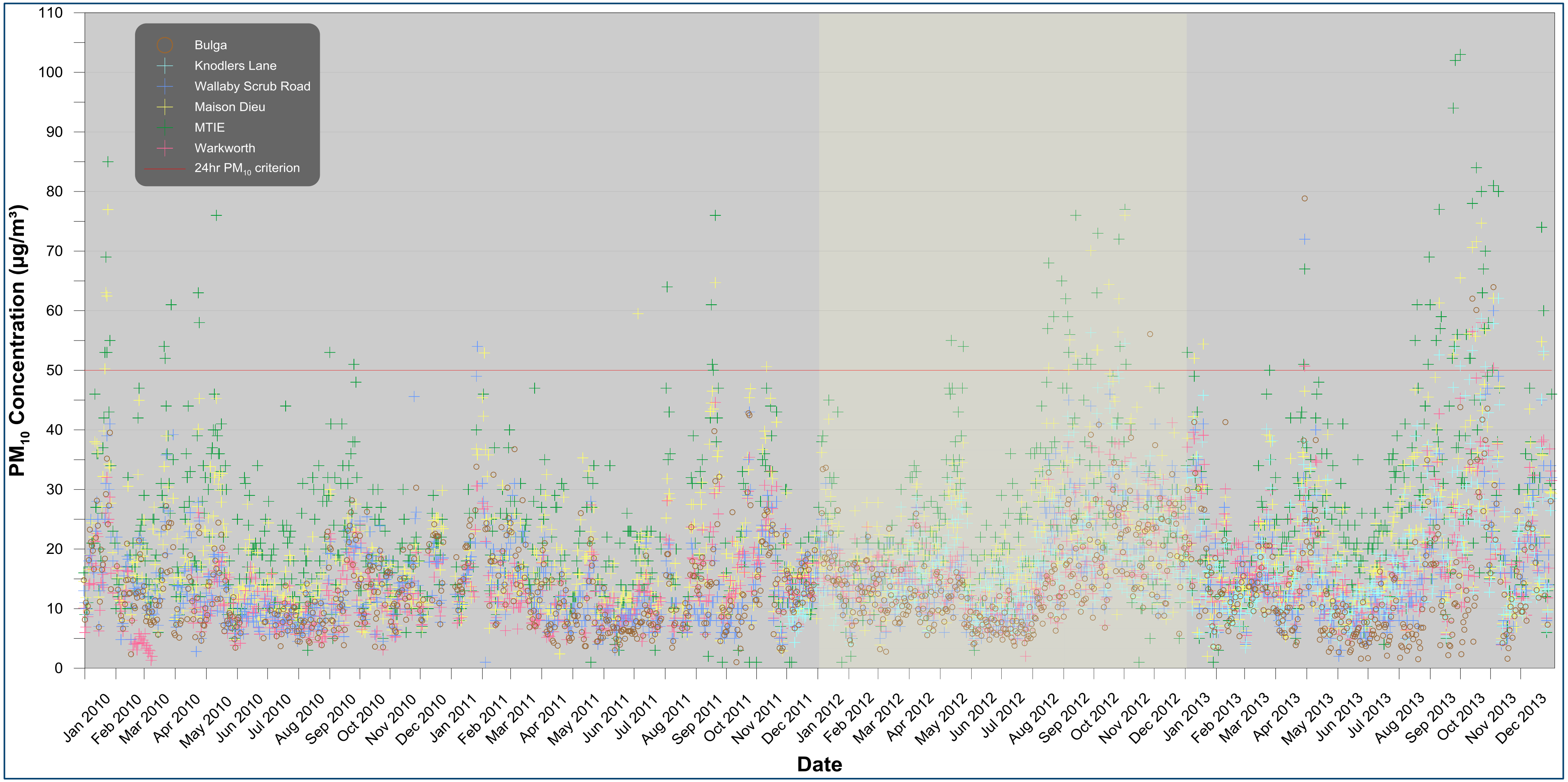

Figure 4-5: TEOM 24-hour average PM_{10} concentrations at MTW and Hunter Valley Operations monitors

4.3.1.2 NSW EPA

A summary of the available data from the NSW EPA monitoring stations is presented in **Table 4-4**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-6**.

A review of **Table 4-4** indicates that the annual average PM_{10} concentrations for each monitoring station were below the relevant criterion on 30µg/m^3. The maximum 24-hour average PM_{10} concentrations recorded at these stations were found to exceed the relevant criterion of 50µg/m^3 at times during the review period.

Figure 4-6 shows a relatively similar trend to the MTW and Hunter Valley Operations TEOM station data (shown in **Figure 4-5**). Variation between the monitoring data sites are largely attributed to the proximity of these monitors to various dust sources located in the surrounding area.

Table 4-4: Summary of PM_{10} levels from NSW EPA TEOM monitoring (µg/m^3)

	2010	2011	2012	2013	2014(1)
	Annual average				
Bulga(2)	-	16.8	18.7	19.2	23.9
Singleton(3)	20.0	19.8	22.3	23.3	21.4
Maison Dieu(4)	-	22.1	25.8	25.8	23.7
Singleton NW(5)	-	24.8	25.9	25.9	20.0
Mount Thorley(5)	-	22.5	24.8	24.7	19.0
Warkworth(6)	-	19.7	21.1	21.5	28.4
	Maximum 24-hour average				
Bulga(2)	-	41.6	55.1	88.4	54.3
Singleton(3)	32.8	60.5	63.6	62.7	45.3
Maison Dieu(4)	-	78.3	87.7	84.2	53.1
Singleton NW(5)	-	72.2	85.2	91.7	45.4
Mount Thorley(5)	-	58.5	88.7	88.3	46.1
Warkworth(6)	-	26	49.9	65.4	67.9

(1)Data available till March 2014
(2)Data available from August 2011
(3)Data available from December 2010
(4)Data available from March 2011
(5)Data available from July 2011
(6)Data available from December 2011

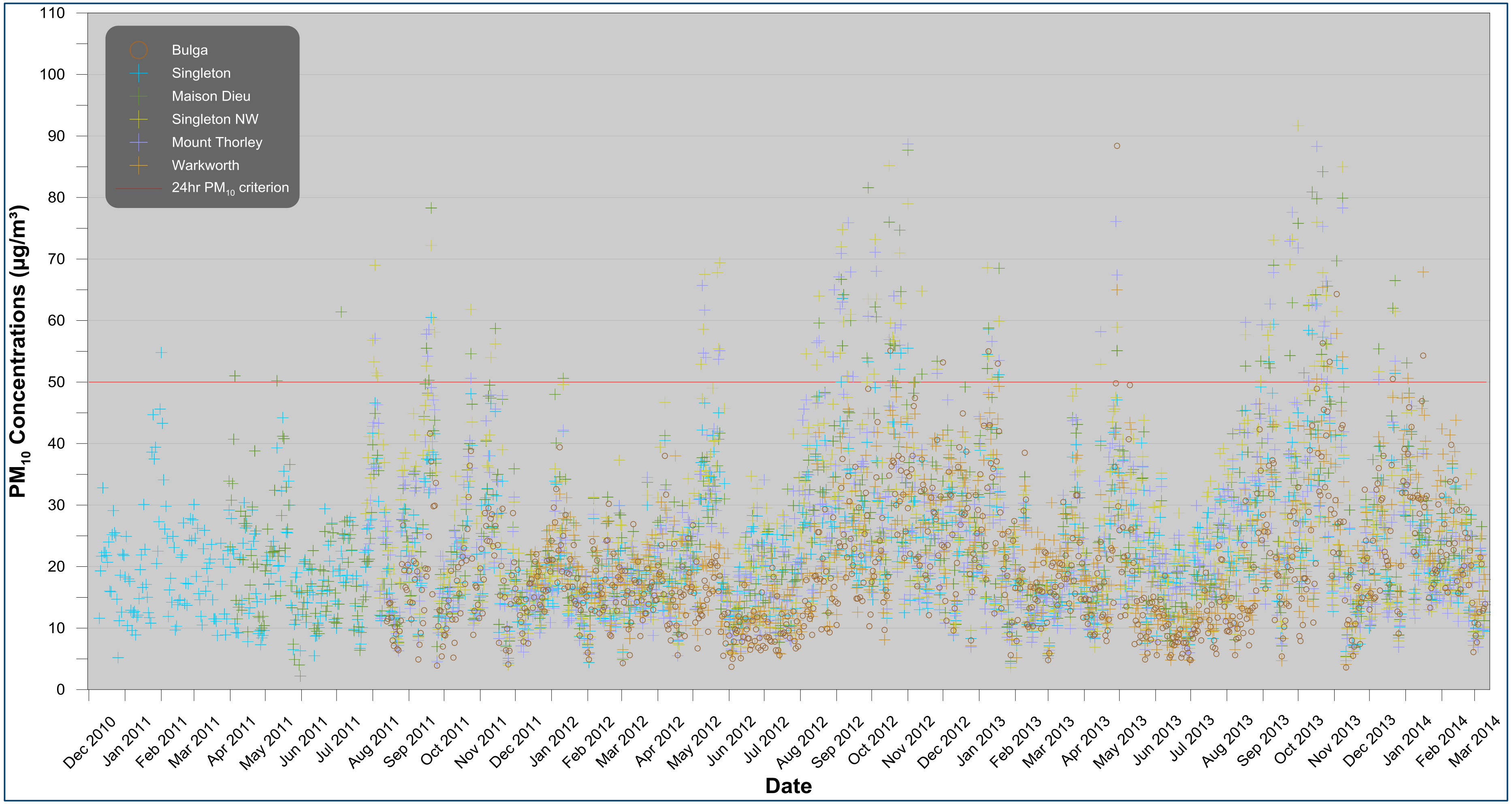

Figure 4-6: TEOM 24-hour average PM_{10} concentrations at NSW EPA monitors

4.3.2 PM_{10} monitoring - HVAS

A summary of the PM_{10} levels from the six HVAS monitoring stations is presented in **Table 4-5**. Recorded 24-hour average PM_{10} concentrations are presented in **Figure 4-7**. The data in **Table 4-5** indicate that the annual average PM_{10} concentrations for each of the monitoring stations were below the relevant criterion of 30µg/m³ for the years reviewed. The maximum 24-hour average concentrations exceed the relevant criterion of 50µg/m³ at these monitors and this can generally be attributed to events such as bushfires, dust storms, localised sources and dust emissions as a result of mining activity. Further details regarding individual elevated days of dust concentrations are described in the Annual Review for the mining operations.

The seasonal trends in PM_{10} concentrations can be seen in **Figure 4-7**, elevated days tend to occur in the warmer months with regional events indicated by most monitors showing elevated levels over the same period.

Table 4-5: Summary of PM_{10} levels from HVAS monitoring (µg/m³)

	Annual average		Maximum 24-hour average	
	2012	2013	2012	2013
Loders Creek PM10[(1)]	-	26.6	-	74
MTIE PM10[(2)]	27.9	21.1	98	58
MTO PM10	17.3	17.4	54	67
WML PM10[(3)]	17.5	13.5	43	47
Knodlers Lane PM10	20.8	24.9	59	84
Long Point PM10[(4)]	8.7	21.4	16	45

(1) Data available from March 2013
(2) Data available till February 2013
(3) Data available from August 2012
(4) Data available from Jan to Feb 2012 and Oct to Dec 2013

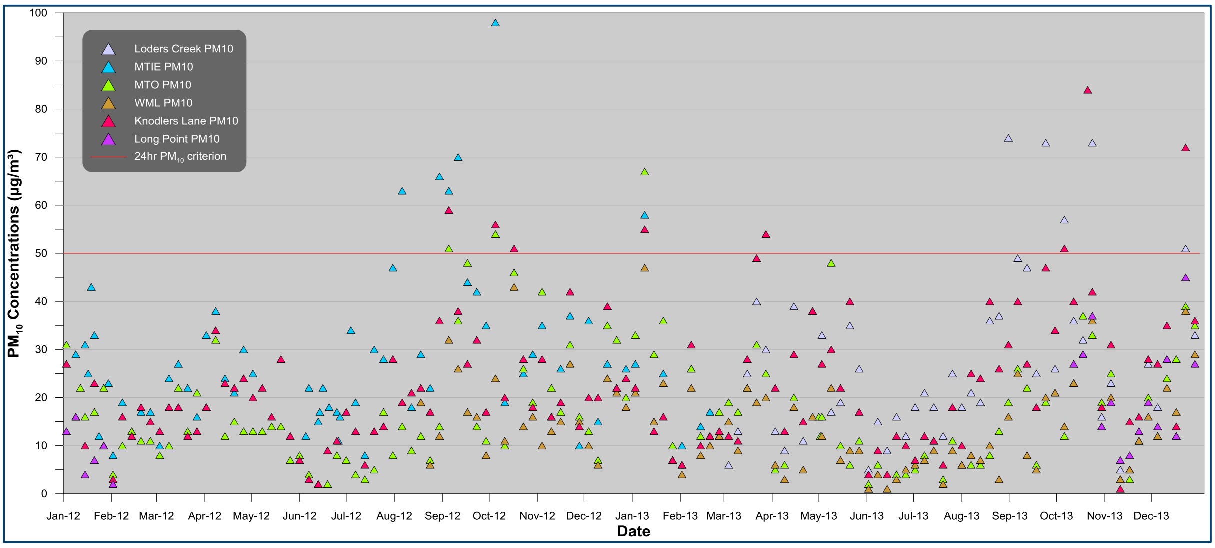

Figure 4-7: HVAS 24-hour average PM_{10} concentrations

4.3.3 TSP monitoring

TSP monitoring data are available from the five HVAS monitors surrounding MTO (see **Figure 4-4**). A summary of the results collected between January 2012 and December 2013 at these stations is shown in **Table 4-6**. Recorded 24-hour average TSP concentrations are presented in **Figure 4-8**.

The monitoring data presented in **Table 4-6** indicate that the annual average TSP concentrations for each monitoring station were less than the criterion of 90µg/m³. **Figure 4-8** shows that the recorded 24-hour average TSP concentrations at each monitor are generally consistent and follow a similar trend. The Loders Creek monitor shows slightly higher concentrations compared with the other monitoring locations and may be influenced by local sources.

Table 4-6: Summary of annul average TSP levels from HVAS monitoring (µg/m³)

	2012	2013
Loders Creek TSP(1)	-	71.6
MTO TSP	58.0	56.1
WML TSP	46.4	41.9
Warkworth TSP	50.7	55.7
Long Point TSP(2)	-	61.9

(1)Data available from March 2013

(2)Data available from October 2013

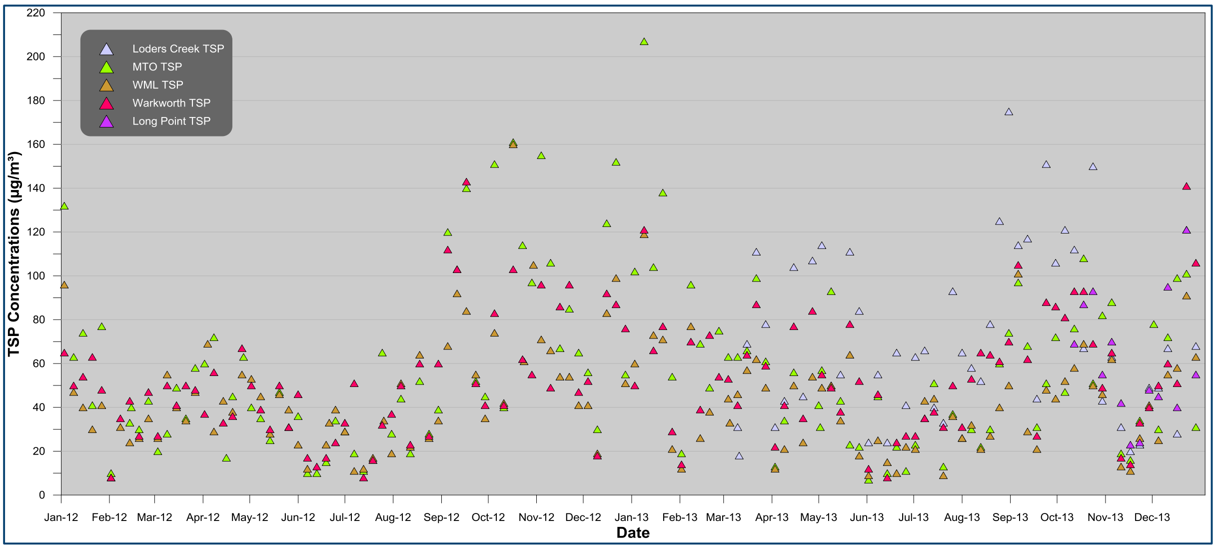

Figure 4-8: HVAS 24-hour average TSP concentrations

4.3.4 Dust deposition monitoring

The location of the dust deposition monitoring sites reviewed in this assessment are shown in **Figure 4-4**. **Table 4-7** summarises the annual average deposition levels at each gauge during 2012 and 2013.

Field notes accompanying the monitoring indicate that some of the samples were contaminated with materials such as bird droppings, insects or plant matter. This is a relatively common occurrence for this type of monitoring, and accordingly, contaminated samples have been excluded from the reported annual average results.

All gauges recorded an annual average insoluble deposition level below the criterion of 4g/m^2/month and in general, the air quality in terms of dust deposition is considered good.

Table 4-7: Annual average dust deposition (g/m²/month)

	2012	2013
DW21A	2.5	2.4
Warkworth	3.4	3.3
DL30	2.9	2.6
DL22	2.1	1.9
Knodlers Lane	1.3	1.1
DL21	3.0	2.3
DL14	2.2	1.8
D122	2.3	1.6
DW15	3.9	3.1
DW20A	1.2	1.4
DW14	2.1	2.8
D125	1.7	1.9
D124	2.0	1.7

4.3.5 Nitrogen dioxide

Figure 4-9 presents the maximum daily 1-hour average NO_2 concentrations from the Beresfield, Muswellbrook and Singleton NSW EPA monitoring sites from 2008 to January 2014. As shown in **Figure 4-9**, the Muswellbrook and Singleton monitoring sites were commissioned in November 2011 and data are only available after this date for these locations.

Ambient air quality monitoring data collected at these locations would include emissions from sources such as the Liddell, Bayswater and Redbank power stations, methane gas flaring operations at mining operations as well as other various combustion sources.

The monitoring data recorded are well below the NSW EPA 1-hour average goal of 246µg/m^3 during this period at all of the monitors. The data in **Figure 4-9** indicate that levels of NO_2 are relatively low compared to the criterion level and show a seasonal fluctuation.

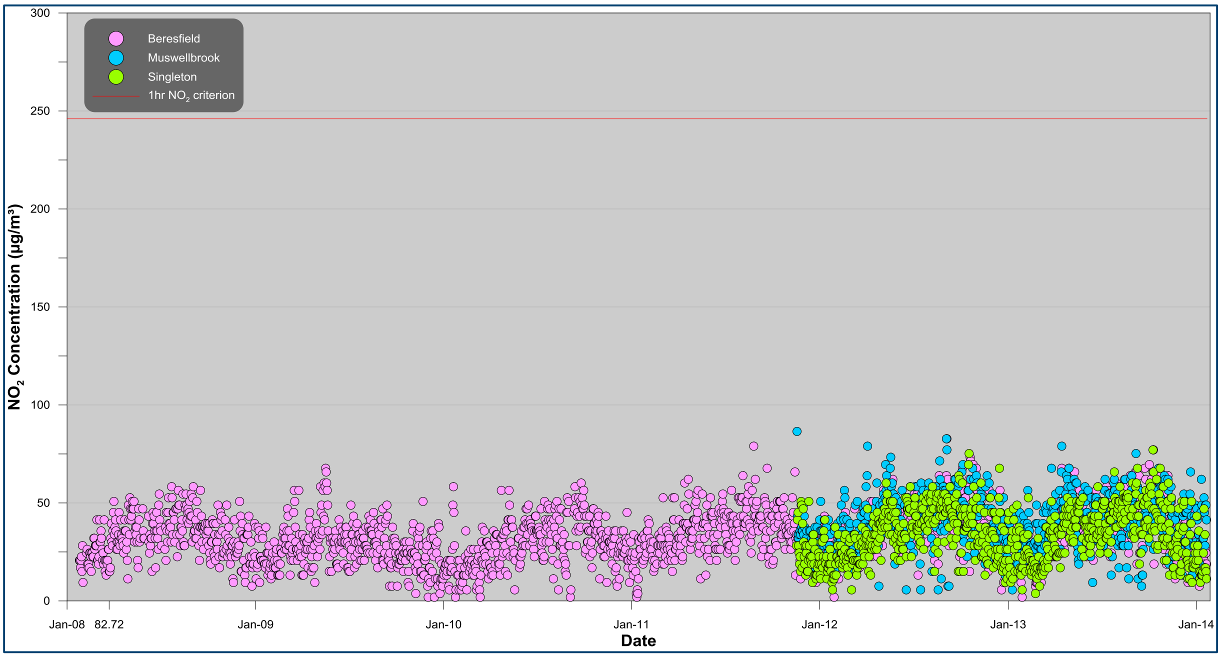

Figure 4-9: Daily 1-hour maximum NO_2 concentrations – Beresfield, Muswellbrook and Singleton

4.3.6 Carbon monoxide

The NSW EPA monitoring sites at Beresfield, Muswellbrook and Singleton do not record ambient concentrations of CO. Combustion activities are the cause of CO emissions and spatially there is very little such activity in the area apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low.

Ambient air quality goals for CO are set at higher concentration levels than NO_2 goals. Based on the NO_2 monitoring data which are low compared to the goals, and consideration of the typical mix of ambient pollutant levels, the indication is that ambient levels of CO would similarly also be well below the air quality goals.

5 MODELLING SCENARIOS

The assessment considers three indicative mine plan years (Year 3, 9 and 14) chosen to represent a range of potential impacts over the life of the proposal by reference to the location of the operations and the potential to generate dust in each year.

Indicative mine plans for each of the respective years are presented in **Figure 5-1**.

The indicative Year 3 mine plan shows MTO and the Warkworth Mine continuing the general progression of the mines in a westerly direction. With ROM extraction occurring at both MTO and Warkworth Mine. Some of the overburden generated from Warkworth Mine is hauled through the proposed underpass beneath Putty Road to MTO. The approved emplacement and subsequent rehabilitation at the Common Boundary Landform development along the southern boundary of MTO with Bulga Mine Complex will be undertaken and completed. The rehabilitation works will continue to progress from east to west as the landform is completed.

The indicative Year 9 mine plan shows mining at MTO is completed and overburden material from Warkworth Mine continues to be emplaced into the Loders Pit void. It is expected that AGN will commence mining in 2018 or 2019 and be completed within approximately two years before becoming a tailings storage facility (TSF) as approved. For modelling purposes and to ensure a worst case scenario is captured the assessment has conservatively assumed that mining in AGN is still taking place in 2023, however in practice it is likely to be completed and being used as a TSF before 2023. The mining of AGN will have required the removal of some areas of existing northern vegetation which will have been re-established in non-tailings areas by this stage. The MTO emplacement areas will be progressively rehabilitated with the advancement of completed landform from east to west.

The indicative Year 14 mine plan shows mining reaching near to its westernmost extent in Warkworth Mine. The MTO area is almost completely rehabilitated with remaining activities consisting of the operation of the MTO CPP and the final void being used for tailings storage.

The air quality environment in the vicinity of Bulga village and for the receptors generally to the west and south west of the proposal is likely to improve beyond Year 14. This arises as the dust emissions from the other mines in the area show reductions in emissions and/ or move further away from the assessment locations.

The emissions reductions beyond Year 14 occur as mining activity/ footprints reduce and also as some of the mines' consents expire. It should however be noted that all of the neighbouring mines were included in the modelling assessment for Year 14 (even those without a consent or known plans to operate at this time).

Dust emissions and impacts from the Bulga Coal Mine would progressively reduce at the majority of the assessment locations as the proposed operation moves to the east (away from assessment locations) and its emissions and footprint reduce over time.

During all indicative years extracted ROM coal is hauled to and processed at either the Warkworth Mine or MTO CPPs. Completed overburden emplacement areas are progressively rehabilitated commensurate with the mine progression.

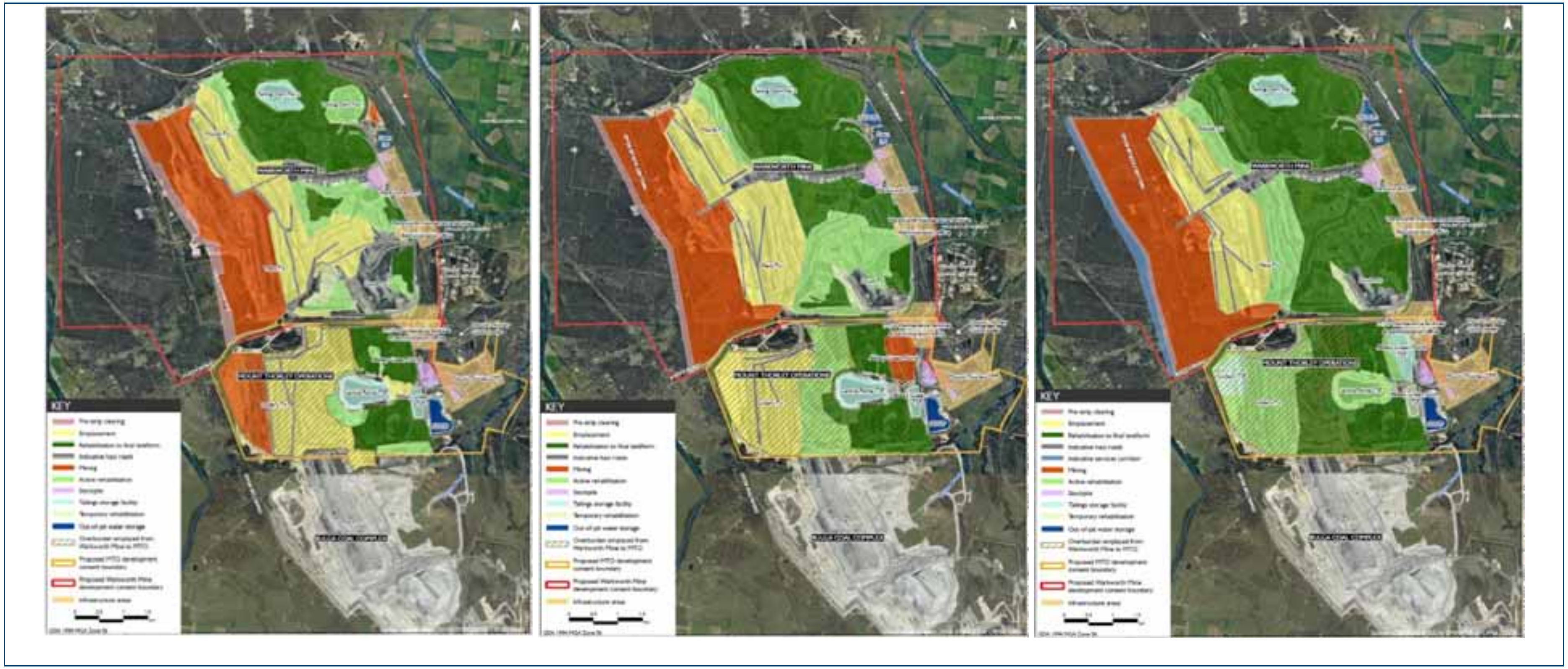

Figure 5-1: Indicative Year 3, 9 and 11 mine plans for the proposal

5.1 Emission estimation

5.1.1 The proposal

For each of the three indicative years selected to represent the key stages over the life of the proposal, the rate of dust emission has been calculated by analysing the various types of dust generating activities taking place in each year and applying suitable emission factors.

The emission factors applied are considered the most applicable and representative factor available for calculating the dust generation rates for the proposed activities. The emission factors were sourced mainly from studies supported by the US EPA and from Australian studies and site specific data where possible. Total dust emissions from all significant dust generating activities for the proposal are presented in **Table 5-1**. Detailed emission inventories and emission estimation calculations are presented in **Appendix C**.

The estimated dust emissions presented in **Table 5-1** reflect the application of best practice dust mitigation currently being implemented at MTW in accordance with its Air Quality Management Plan (AQMP) and Pollution Reduction Program (PRP) (refer to **Section 6**). The dust control measures are described in the following section.

Table 5-1: Estimated emission for the proposal (kg of TSP)

Activity	Year 3	Year 9	Year 14
OB - Drilling	3,827	-	-
OB - Blasting	98,214	-	-
OB - Dragline	227,330	-	-
OB - Loading OB to haul truck	71,694	-	-
OB - Hauling to emplacement area – from MTO	617,750	-	-
OB - Hauling to emplacement area - from Warkworth	149,803	615,215	-
OB - Emplacing at area	111,814	82,384	-
OB - Dozers in pit	222,959	-	-
OB - Dozers on dump and rehab	89,626	99,642	-
CL - Drilling	279	-	-
CL - Blasting	3,979	-	-
CL - Dozers ripping/pushing/clean-up	48,714	-	-
CL - Loading ROM coal to haul truck	202,661	-	-
CL - Hauling ROM to hopper - Mt Thorley CPP	134,122	-	-
CL - Hauling Warkworth ROM to hopper - Mt Thorley CPP	81,541	161,979	188,301
CPP - Unloading ROM to hopper - Mt Thorley CPP	30,399	-	-
CPP - Unloading Warkworth ROM to hopper - Mt Thorley CPP	29,300	51,877	63,048
CPP - Rehandle ROM at hopper - Mt Thorley CPP	11,940	10,375	12,610
CPP - Dozer pushing ROM coal - Mt Thorley CPP	42,997	42,997	42,997
CPP - Dozer pushing Product coal - Mt Thorley CPP	13,593	13,593	13,593
CPP - Loading Product coal to stockpile - Mt Thorley CPP	580	504	612
CPP - Loading Product coal to train - Mt Thorley CPP	232	202	245
CPP - Loading rejects - Mt Thorley CPP	335	238	331
CPP - Hauling rejects - Mt Thorley CPP	12,908	9,169	63,846
CPP - Hauling rejects from Warkworth - Mt Thorley CPP	22,193	20,131	46,582
CPP - Unloading rejects - Mt Thorley CPP	742	686	726
CPP - Conveying to train load out from Mt Thorley CPP	318	318	318
WE - Overburden emplacement areas - Mt Thorley	705,978	492,801	-
WE - Open pit - Mt Thorley	520,144	-	-

Activity	Year 3	Year 9	Year 14
WE - ROM stockpiles - Mt Thorley	30,748	20,901	20,901
WE - Product stockpiles - Mt Thorley	24,743	24,743	24,743
Grading roads	22,157	22,157	22,157
ABBEY GREEN NORTH*			
Drilling overburden	-	5,900	-
Blasting overburden	-	31,300	-
Dozers on overburden dumps	-	54,500	-
Dozers on overburden assisting excavators	-	55,400	-
Loading overburden to trucks	-	50,500	-
Hauling overburden to waste dump	-	720,000	-
Unloading overburden to waste dump	-	50,500	-
Dozers working on coal	-	5,690	-
Loading coal to trucks	-	169,000	-
Hauling coal to the MTCPP	-	78,900	-
Unloading coal to hopper	-	25,000	-
Re-handle coal at the ROM hopper	-	2,500	-
Loading coal to stockpiles	-	1,130	-
Loading coal to trains	-	791	-
WE - Waste emplacement 1	-	258,000	-
WE - Waste emplacement 2	-	63,900	-
WE - Pit	-	278,000	-
WE - ROM stockpile	-	2,580	-
WE - Product stockpile	-	875	-
Grading roads	-	1,120	-
Total	**3,533,619**	**3,525,498**	**501,011**

OB – overburden, CL – coal, CPP – coal preparation plant, WE – wind erosion
*PAEHolmes (2009)

5.1.2 Other mining operations

In addition to the estimated dust emissions from the proposal, emissions from all nearby approved mining operations were also modelled, per their current consent (or current proposed project), to assess potential cumulative dust effects. Emissions estimates from these sources were derived from information provided in the air quality assessments available in the public domain at the time of modelling. These estimates are likely to be conservative, as in many cases, mines do not continually operate at the maximum extraction rates assessed in their respective environmental assessments. This is evident when examining Reviews for coal mines in the Hunter Valley that typically show that the mines actual rate of activity is below the approved level of activity. **Table 5-2** summarises the emissions adopted in this assessment for each of the nearby mining operations.

Table 5-2: Estimated emissions from nearby mining operations (kg of TSP)

Mining operation	Year 3	Year 9	Year 14
Warkworth Mine[(1)]	9,756,076	11,966,083	13,027,625
Bulga Coal Mine[(2)]	10,004,386	7,762,460	6,736,792
Wambo Coal Mine[(3)]	4,186,080	4,186,080	4,186,080
Hunter Valley Operations[(4)]	9,029,790	7,568,834	7,568,834
Rix's Creek Coal Mine[(5)(6)]	3,396,250	6,113,250	2,173,600

[(1)]Todoroski Air Sciences (2014)
[(2)]Pacific Environment Limited (2013)
[(3)]Holmes Air Sciences (2003)
[(4)]Holmes Air Sciences (2008)
[(5)] Holmes Air Sciences (1994)
[(6)]AECOM (2013)

It is noted that only a Preliminary Environmental Assessment (**AECOM, 2013**) has been lodged at this stage for the Rix's Creek Mine Continuation of Mining Project, and not a full environmental assessment. Estimates of the potential dust emissions included in the cumulative assessment have been made based on the indicative production rate of this project.

Further, it is noted that consents for some mining operations would expire at some stage during the proposal. However to assess potential worst case cumulative dust effects, it has been assumed that these operations would continue until the end of the proposal. This also adds considerable conservatism to the model predictions.

Emissions from nearby mining operations would contribute to the background level of dust in the area surrounding the proposal, and these emissions were explicitly included in the modelling assessment. Additionally, there would be numerous smaller or very distant sources that contribute to the total background dust level. Modelling these sources explicitly is impractical; however, the residual level of dust due to all other such non-modelled sources has been included in the cumulative results, and the method for doing this is discussed further in **Section 7**.

6 DUST MITIGATION AND MANAGEMENT

6.1 Dust management

MTO and Warkworth Mine have integrated their management of air quality and operate per an integrated MTW AQMP.

The possible range of air quality mitigation measures that are feasible and can be applied to achieve a standard of mine operation consistent with current best practice for the control of dust emissions from coal mines in NSW has been carefully considered in the implementation of such measures at MTW.

The measures applied to MTW reflect those outlined in the recent NSW EPA document, "*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*", prepared by Katestone Environmental (**Katestone, 2010**), and also imposed on mines in the current NSW EPA PRP's that relate to haul road emissions, and dust mitigation in response to adverse weather conditions. Dust management practices are in place at MTO that also respond to government and community concerns regarding the impacts of mining on regional air quality in the Hunter Valley.

These measures include implementation of best practice management techniques to reduce dust, and staff guidance for the visual identification and hence control of dust. Other measures include alarms based on monitoring to manage potentially rising dust levels and to help prevent or reduce potential impacts. Operational measures such as enforcing a cessation of particular operations during periods of high dust provide additional assistance in reducing the potential dust impacts.

MTW utilises meteorological forecast data to guide the day to day planning of mining operations. These systems identify potentially adverse conditions that may arise over the coming day, giving MTW time to prepare in advance means to mitigate dust appropriately.

The NSW EPA has also placed a PRP on the MTO Environment Protection Licence which requires identification and assessment of the practicality of implementing further best practice measures. The best practice controls currently implemented were considered in this assessment. Where applicable these controls have been applied in the dust emission estimates as shown in **Appendix C**.

The operation of dust mitigation and management measures commensurate with best practice is a key aspect of MTO operations. An outline of such measures is set out in the air quality chapter in the main body of the EIS, and the overall approach is detailed in the air quality and greenhouse gas management plan. This is available on the company's website: http://www.riotintocoalaustralia.com.au/documents/MTW_Air_Quality_and_Greenhouse_Gas_Management_(Approved_31Jan2013).pdf . It should be noted that attainment of best practice requires ongoing improvement and thus the current best practice mitigation and dust management measures are likely to improve over time, as they are regularly reviewed and updated through the management plan framework.

6.2 Monitoring network

The MTW air quality monitoring network, is illustrated in **Figure 4-4**. The network of monitors surround the mine operation and are positioned in areas representative of the surrounding assessment locations.

This network is augmented by ambient air quality monitoring stations operated by the NSW EPA and provide an extensive network of stations from which to measure ambient air quality.

Air quality monitoring at MTW is supplemented with portable real-time PM_{10} monitoring and visual surveillance to support the reactive air quality management system. The monitors are portable to enable relocation as mining and seasonal conditions change. These monitors are aimed for use as a warning tool for mine operations and provide advance warning of degrading air quality which serves to prompt appropriate actions. Visual surveillance monitoring is also used in the network to assist with identification of problem dust sources, informing a management response and verifying the effectiveness of controls implemented.

7 DISPERSION MODELLING APPROACH

7.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach.

For this assessment the CALPUFF modelling suite is applied to dispersion modelling. The CALPUFF model is an advanced "puff" model that can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a 3D, hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with methods provided in the NSW EPA document "*Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*" (**TRC**, **2011**).

7.2 Modelling methodology

Modelling was undertaken using a combination of the CALPUFF Modelling System and TAPM. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

TAPM is a prognostic air model used to simulate the upper air data for CALMET input. The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for 3D simulations. The model predicts the flows 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.

CALMET is a meteorological model that uses the geophysical information and observed/simulated surface and upper air data as inputs and develops wind and temperature fields on a three-dimensional gridded modelling domain.

CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion processes along the way. It typically uses the 3D meteorological field generated by CALMET.

CALPOST is a post processor used to process the output of the CALPUFF model and produce tabulations that summarise the results of the simulation.

7.2.1 Meteorological modelling

The TAPM model was applied to the available data to generate a 3D upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is 32deg38min south and 151deg5min east. The simulation involved four nesting grids of 30km, 10km, 3km and 1km with 35 vertical grid levels.

CALMET modelling used a nested approach where the 3D wind field from the coarser grid outer domain is used as the initial (or starting) field for the finer grid inner domains. This approach has several advantages over modelling a single domain. Observed surface wind field data from the near field as well as from far field monitoring sites can be included in the model to generate a more representative 3D wind field for the modelled area. Off domain terrain features for the finer grid domain can be allowed to take effect within the finer domain, as would occur in reality, also the coarse scale wind flow fields give a better set of starting conditions with which to operate the finer grid run.

The CALMET initial domain was run on a 150 x 150km grid with a 3km grid resolution and refined for a second domain on a 50 x 50km grid with a 1km grid resolution and further refined for a final domain on a 30 x 30km grid with a 0.3km grid resolution.

The available meteorological data for January 2012 to December 2012 from ten nearby meteorological monitoring sites were included in the simulation. The 2012 calendar year was chosen as a representative meteorological year based on a long-term meteorological analysis.

Table 7-1 outlines the parameters used from each station. The 3D upper air data was sourced from TAPM output. Further detail regarding input variables are presented in **Appendix D**.

Table 7-1: Surface observation stations

Weather station	Parameters
Charlton Ridge Weather Station	Wind speed, wind direction, temperature, humidity.
Cheshunt Weather Station	Wind speed, wind direction, temperature, humidity.
HVO Corp Weather Station	Wind speed, wind direction, temperature, humidity.
Cessnock Airport Automatic Weather Station (BoM) (Station No. 061260)	Wind speed, wind direction, temperature, humidity, sea level pressure.
Merriwa (Roscommon) Weather Station (BoM) (Station No, 061287)	Wind speed, wind direction, temperature, humidity, sea level pressure, cloud height, cloud amount.
Murrurundi Gap Automatic Weather Station (BoM) (Station No. 061392)	Wind speed, wind direction, temperature, humidity, sea level pressure, cloud height, cloud amount.
Paterson (Tocal) Automatic Weather Station (BoM) (Station No. 061250)	Wind speed, wind direction, temperature, humidity.
Scone Airport Automatic Weather Station (BoM) (Station No. 061363)	Wind speed, wind direction, temperature, humidity, sea level pressure.
Williamtown RAAF (BoM) (Station No. 061078)	Wind speed, wind direction, temperature, humidity, sea level pressure, cloud height, cloud amount.
Nullo Mountain Automatic Weather Station (BoM) (Station No. 062100)	Wind speed, wind direction, temperature, humidity.

Local land use and detailed topographical information including local mine topography was included in the simulation to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas, as shown in **Figure 7-1**.

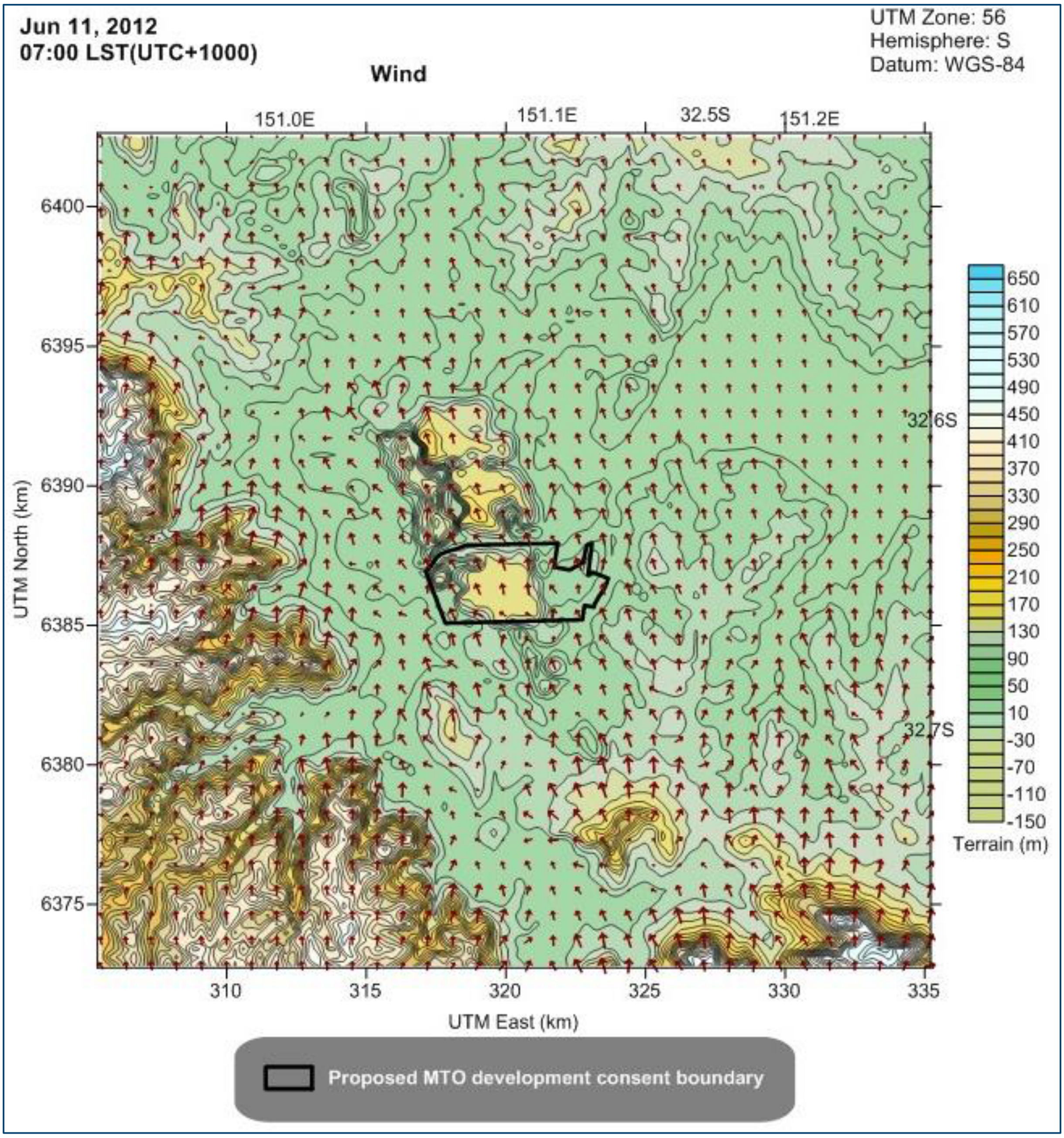

Figure 7-1: Representative snapshot of wind field for the proposal

CALMET generated meteorological data was extracted from a central point within the CALMET domain and is graphically represented in **Figure 7-2** and **Figure 7-3**.

Figure 7-2 presents annual and seasonal windroses extracted from one central point in the CALMET domain. On an annual basis, winds from the south-southeast are most frequent. During summer, winds from the south-southeast dominate the distribution with a spread of winds from the southeast quadrant. The autumn wind distribution shows the majority of winds originating from the south-southeast and south with some winds from the northwest. In winter, winds from the northwest are the most predominant. In spring, the wind distribution is more varied compared to the other seasons with winds from the northwest and southeast quadrants.

Overall the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds. This is evident as the windroses based on the CALMET data also compare well with the windroses generated with the measured data, as presented in **Figure 4-3**.

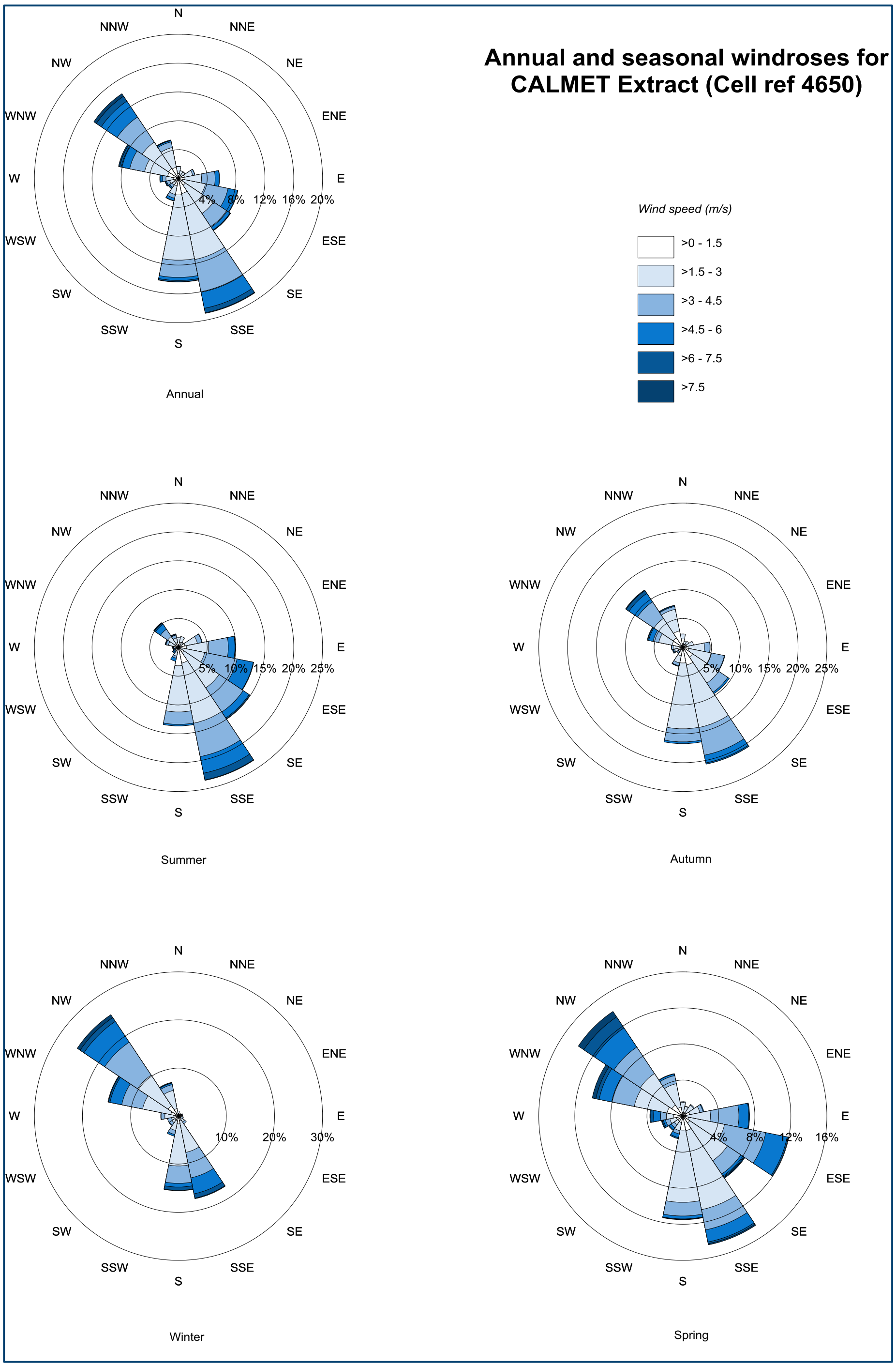

Figure 7-2: Windroses from CALMET extract (Cell ref 4650)

Figure 7-3 includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and shows sensible trends considered to be representative of the area.

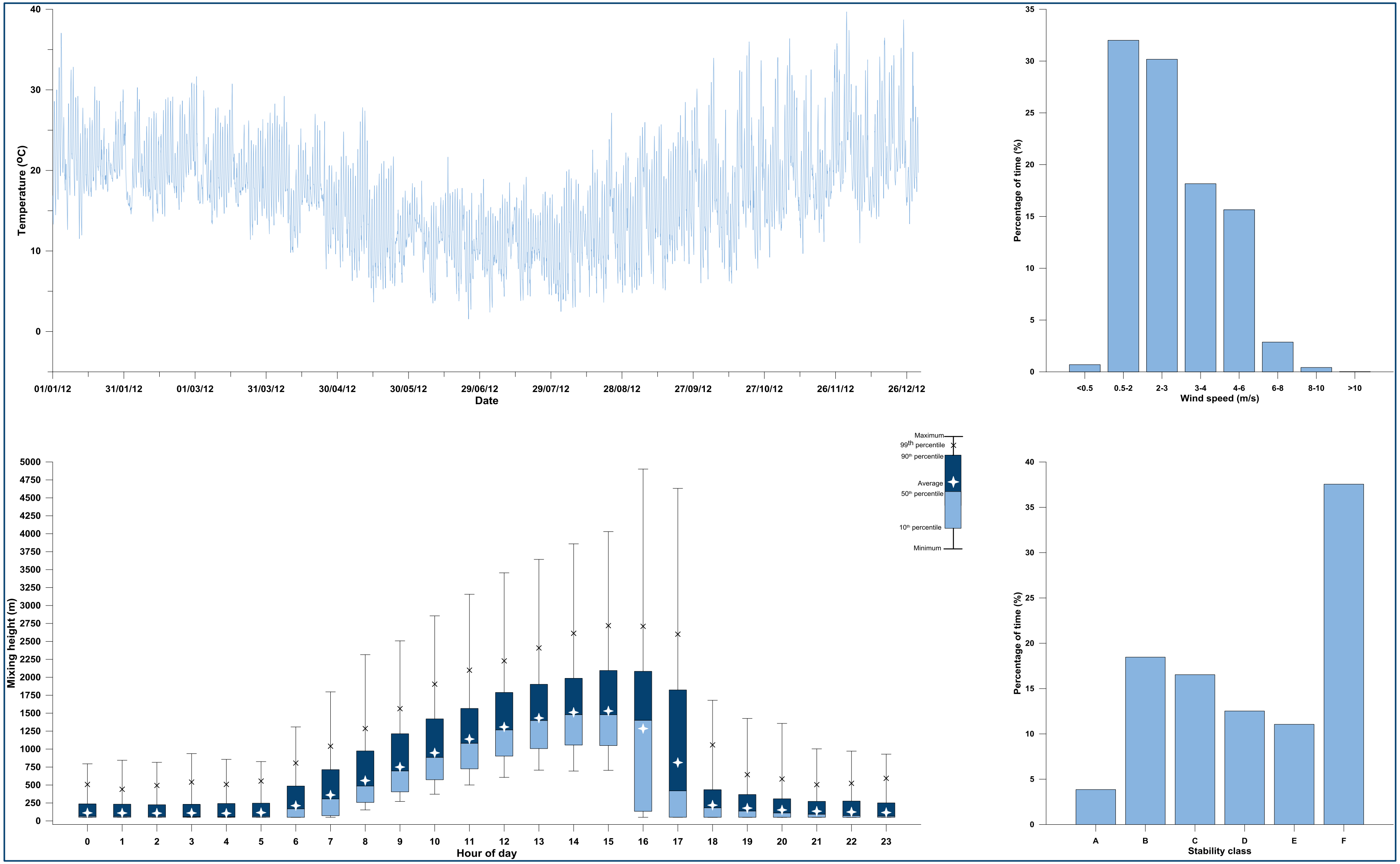

Figure 7-3: Meteorological analysis of CALMET extract (Cell ref 4650)

7.2.2 Dispersion modelling

CALPUFF modelling is based on the application of three particle size categories fine particulates, coarse matter and rest. The distribution of particles for each particle size category was derived from measurements in the **SPCC (1986)** study and is presented in **Table 7-2**.

Emissions from each activity in **Table 5-1** were represented by a series of volume sources and included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source. It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

Table 7-2: Distribution of particles

Particle category	Size range	Distribution[1]
Fine particulates	0 to 2.5 µm	4.68% of TSP
Coarse matter	2.5 to 10 µm	34.4% of TSP
Rest	10 to 30 µm	60.92% of TSP

[1] Particle distribution sourced from **SPCC (1986)**

Each particle-size category is modelled separately and later combined to predict short term and long term average concentrations for $PM_{2.5}$, PM_{10}, and TSP. Dust deposition was predicted using the proven dry deposition algorithm within the CALPUFF model. Particle deposition is expressed in terms of atmospheric resistance through the surface layer, deposition layer resistance and gravitational settling (**Slinn and Slinn, 1980** and **Pleim et al., 1984**). Gravitational settling is a function of the particle size and density, simulated for spheres by the Stokes equation (**Gregory, 1973**).

CALPUFF is capable of tracking the mass balance of particles emitted into the modelling domain. For each hour CALPUFF tracks the mass emitted, the amount deposited, the amounts remaining in the surface mixed layer or the air above the mixed layer, and the amount advected out of the modelling domain. The versatility to address both dispersion and deposition algorithms in CALPUFF, combined with the 3D meteorological and land use field generally result in a more accurate model prediction compared to other Gaussian plume models (**Pfender et al 2006**).

8 ACCOUNTING FOR BACKGROUND DUST LEVELS

Other significant dust generating sources surrounding the proposal were explicitly included in the model, including Warkworth, Bulga, Wambo, Hunter Valley Operations and Rix's Creek coal mines. These mining operations are the nearest significant operations and variously contribute to particulate matter concentrations near the proposal. **Section 5** outlines how dust emissions from these sources have been accounted for in the modelling to assess cumulative effects.

Other dust generating activities in the surrounding area would also contribute to existing dust levels and an allowance for this contribution as well as contributions from other non-modelled dust sources is included in the assessment.

The contribution to the prevailing background dust levels of other non-modelled dust sources was estimated by modelling the past (known) mining activities (including Warkworth, Bulga, Wambo, Hunter Valley Operations and Rix's Creek coal mines) during January 2012 to December 2012 and comparing model predictions with the actual measured data from the corresponding monitoring stations. The average difference between the measured and predicted PM_{10}, TSP and deposited dust levels from each of the monitoring points was considered to be the contribution from other non-modelled dust sources, and was added to the future predicted values to account for the background dust levels (not already in the model and due to the numerous non-modelled dust sources).

This approach is preferable to modelling the proposal alone and adding a single constant background level at all points across the modelling domain to estimate cumulative impacts. This is because the approach includes modelling of other major sources (ie mines) that more reliably represent the higher dust levels near such sources, and also accounts for the seasonal and time varying changes in the background levels that arise from these major dust sources. In addition, to account for any underestimation from not including every source (as it's not possible to do that reasonably), the relatively smaller contribution arising from the other non-modelled dust sources, as determined above, was added to the results to obtain the most accurate predictions of future cumulative impacts across the modelled domain.

Using the approach described above, the estimated annual average contribution from other non-modelled dust sources in the surrounding area was found to be:

- PM_{10} – 6.9µg/m^3;
- TSP – 23.1µg/m^3; and,
- Deposited dust – 1.7g/m^2/month.

It is important that the above values are not confused with measured background levels, background levels excluding only the proposal, or the change in existing levels as a result of the proposal. The values above are not background levels in that sense, but are the residual, small amount of the background dust that is not accounted for directly in the air dispersion modelling.

To account for background levels when assessing total (cumulative) 24-hour average PM_{10} impacts, the mine only incremental levels are added to the total measured ambient dust levels (per the NSW EPA contemporaneous assessment guidance). Further details regarding the total cumulative 24-hour average PM_{10} impacts are provided in **Section 8.5**.

Predicted incremental (proposal alone) and total (cumulative) concentrations and dust deposition levels for short and long term averaging periods are presented in tabular format as well as contour plots in the following section of this report.

9 DISPERSION MODELLING RESULTS

The dispersion model predictions for each of the indicative mine plan years are presented in this section. The results show the estimated maximum 24-hour average and annual average $PM_{2.5}$ concentrations, maximum 24-hour and annual average PM_{10} concentrations, annual average TSP concentrations and annual average dust (insoluble solids) deposition (DD) rates for the proposal operating in isolation (the incremental impact) and with other sources (the total (cumulative) impact).

It is important to note that when assessing impacts for a maximum 24-hour average PM_{10} concentration; the predictions show the highest modelled predicted 24-hour average PM_{10} concentrations that occur at each point within the modelling domain for the worst day (a 24-hour period) over the one year modelling period. When assessing the total (cumulative) 24-hour average PM_{10} impacts based on model predictions, challenges arise as the predicted impacts are often overestimated by the model's inability to consider spatial and temporal variability in reality. Furthermore, the difficulties associated with identification and quantification of emissions from non-modelled sources over the 24-hour period result in additional complications. The potential 24-hour average PM_{10} impacts need to be calculated differently to annual average impacts and therefore the predicted total (cumulative) impacts for maximum 24-hour average PM_{10} concentrations have been addressed specifically in **Section 8.5**.

Each of the potential assessment locations shown in **Figure 2-1** and listed in **Appendix A** were assessed individually as discrete receptors with the predicted results presented in tabular form for each of the indicative mine plan years.

For sources not explicitly included in the model, and to fully account for all cumulative dust levels, the unaccounted fractions of background dust levels (which arise from the other non-modelled sources) as described in **Section 7**, were added to the model predictions with the results presented in the following sections for each of the indicative mine plan years.

Associated isopleth diagrams of the dispersion modelling results are presented in **Appendix E**.

9.1 Year 3 results

Table 9-1 presents the model predictions at each of the assessment locations. The values presented in bold indicate predicted values above the relevant criteria. The assessment locations highlighted in grey are identified as mine-owned assessment locations, and those highlighted in orange are privately-owned assessment locations already in the acquisition zone for other mine operations.

Figure E-1 to **Figure E-9** in **Appendix E** present isopleth diagrams of the predicted modelling results for each of the assessed pollutants in Year 3.

Table 9-1: Modelling predictions for Year 3 of the proposal

Assessment location ID	$PM_{2.5}$ ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)		TSP ($\mu g/m^3$)	DD ($g/m^2/month$)	PM_{10} ($\mu g/m^3$)	TSP ($\mu g/m^3$)	DD ($g/m^2/month$)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
1	1	0	4	1	1	0.02	10	28	1.80
2	1	0	4	1	1	0.02	10	29	1.81
3	1	0	4	1	1	0.02	10	29	1.83
4	1	0	4	1	1	0.02	10	29	1.83
5	1	0	4	1	1	0.02	10	29	1.83
6	1	0	4	1	1	0.02	10	29	1.83
7	1	0	4	1	1	0.02	10	29	1.84
8	1	0	5	1	1	0.03	11	29	1.86
9	1	0	4	1	1	0.02	10	29	1.86
10	1	0	5	1	2	0.03	11	30	1.85
11**	1	0	10	1	2	0.06	14	36	2.03
12	1	0	6	1	1	0.04	11	31	1.92
13	1	0	7	1	2	0.05	12	31	1.89
14	1	0	6	1	2	0.04	12	31	1.94
15	1	0	6	1	2	0.04	12	31	1.95
16	1	0	6	1	2	0.06	12	32	1.92
17	1	0	8	1	3	0.07	12	32	1.92
18	1	0	6	1	2	0.04	12	32	1.96
19	1	0	8	1	3	0.08	12	33	1.93
20	1	0	7	1	2	0.04	12	32	1.97
21	1	0	7	1	3	0.07	12	33	1.94
22	1	0	6	1	2	0.04	12	32	1.97
23	1	0	5	1	1	0.03	12	32	1.95
24	1	0	9	2	3	0.08	13	33	1.95
25	2	0	15	2	3	0.08	13	34	1.98
26	1	0	6	1	2	0.04	12	32	1.98
27	1	0	11	2	3	0.09	13	33	1.96
28	1	0	4	1	1	0.02	11	31	1.91
29	1	0	11	2	3	0.09	13	33	1.96
30	1	0	8	1	3	0.07	13	33	1.97
31	1	0	8	2	3	0.07	13	33	1.97
32	1	0	10	2	3	0.09	13	34	1.96
33	1	0	8	1	2	0.06	13	33	1.99
34	2	0	15	2	3	0.09	13	34	1.98
35	1	0	8	2	3	0.07	13	34	1.98
36	1	0	6	1	2	0.04	12	33	1.98
37	1	0	11	2	3	0.10	13	34	1.97
38	1	0	7	1	2	0.04	13	33	1.99
39	1	0	7	1	2	0.05	13	33	1.99
40	1	0	7	1	2	0.05	13	34	2.00
41	1	0	4	1	1	0.02	11	31	1.91
42	2	0	12	2	3	0.10	14	35	1.99
43	1	0	7	1	2	0.05	13	33	2.00

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
44	1	0	7	1	2	0.05	13	34	2.00
45	1	0	5	1	1	0.03	12	32	1.97
46	1	0	7	1	2	0.05	13	34	2.01
47	1	0	8	1	2	0.05	13	34	2.01
48	1	0	8	1	3	0.06	14	35	2.02
49	1	0	8	1	2	0.05	13	34	2.01
50	1	0	7	1	2	0.05	13	34	2.01
51	2	0	17	2	4	0.12	16	39	2.10
52	1	0	6	1	2	0.04	13	33	1.99
53	1	0	7	1	2	0.05	13	34	2.01
54	1	0	5	0	1	0.02	11	31	1.90
55	1	0	8	2	3	0.06	14	35	2.03
56	1	0	7	1	2	0.05	13	34	2.01
57	1	0	7	1	2	0.05	13	34	2.02
58	1	0	9	2	3	0.07	14	36	2.03
59	1	0	8	1	2	0.05	14	35	2.02
60	1	0	8	1	2	0.05	14	35	2.02
61	1	0	5	0	1	0.02	11	31	1.90
62	1	0	8	1	2	0.05	14	35	2.03
63	1	0	9	1	3	0.06	14	36	2.04
64	1	0	9	1	3	0.06	14	36	2.04
65	1	0	9	2	3	0.06	14	36	2.04
66	1	0	8	1	2	0.05	14	35	2.03
67	1	0	5	0	0	0.01	10	28	1.81
68	1	0	9	2	3	0.06	14	36	2.04
69	1	0	8	1	2	0.05	14	35	2.04
70	1	0	4	0	0	0.01	10	28	1.81
71	1	0	9	1	2	0.05	14	36	2.04
72	1	0	9	1	2	0.05	14	36	2.04
73	1	0	8	1	2	0.04	14	35	2.02
74	1	0	6	1	1	0.02	12	31	1.91
75	1	0	9	1	2	0.05	14	36	2.04
76	1	0	6	1	1	0.02	12	33	1.97
77	1	0	9	1	2	0.07	**32**	68	2.91
78	1	0	9	1	2	0.11	**32**	69	3.40
79**	1	0	10	1	2	0.07	**32**	68	2.88
80	1	0	5	0	1	0.01	11	29	1.84
81	2	0	17	3	6	0.17	17	41	2.14
82	1	0	6	1	1	0.02	12	32	1.94
83**	1	0	10	1	2	0.07	**32**	67	2.85
84	1	0	5	0	1	0.01	11	30	1.86
86	1	0	9	1	2	0.04	14	36	2.05
87	3	0	21	3	6	0.16	17	41	2.17
89	1	0	5	0	1	0.01	11	30	1.86

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
90	1	0	10	1	2	0.07	30	65	2.88
91**	1	0	10	1	2	0.08	30	65	2.92
92**	1	0	5	0	1	0.01	11	31	1.88
93	1	0	11	1	2	0.09	30	65	3.04
94**	1	0	11	1	2	0.07	30	64	2.91
95	2	0	13	2	3	0.06	16	39	2.11
96**	2	0	11	1	2	0.09	30	64	3.02
97	3	1	25	4	7	0.20	19	45	2.25
98	3	0	26	4	7	0.17	19	45	2.25
99**	2	0	12	1	2	0.10	30	65	3.20
100	3	1	20	4	7	0.20	19	45	2.21
101	3	1	24	4	8	0.22	20	46	2.28
102	2	0	12	1	2	0.10	30	65	3.26
103**	1	0	8	1	1	0.02	14	35	2.00
104	4	1	31	5	9	0.26	22	49	2.38
105	1	0	11	1	2	0.08	30	64	3.05
106	4	1	31	6	11	0.33	23	52	2.45
107	5	1	41	7	13	0.40	25	56	2.59
108	4	1	36	8	14	0.47	26	57	2.60
109**	2	0	16	2	4	0.15	**59**	**122**	**5.19**
110	6	1	49	9	17	0.52	28	62	2.73
111	1	0	4	0	0	0.01	10	28	1.83
112	9	2	**67**	15	28	0.91	**37**	79	3.16
113**	1	0	5	0	1	0.01	11	31	1.95
114	2	0	15	1	1	0.04	26	55	2.79
115**	1	0	8	1	1	0.02	19	45	2.45
116	1	0	6	1	1	0.04	21	47	2.43
117	1	0	6	1	1	0.02	21	47	2.58
118	1	0	6	1	1	0.03	21	47	2.53
118	1	0	6	1	1	0.03	21	47	2.53
119	1	0	5	1	1	0.03	21	46	2.41
120	1	0	4	0	1	0.02	18	42	2.38
121	1	0	4	1	1	0.02	19	43	2.43
122	1	0	4	0	1	0.02	18	41	2.34
123	1	0	4	1	1	0.02	18	42	2.37
124	1	0	4	0	1	0.02	18	41	2.32
125	1	0	5	1	1	0.03	23	50	2.36
126	1	0	6	1	2	0.03	**36**	73	2.59
127	0	0	4	1	1	0.01	18	40	2.14
128	1	0	5	1	1	0.02	25	53	2.33
129	1	0	5	1	1	0.02	21	47	2.25
130	1	0	5	1	1	0.02	20	45	2.21
131	1	0	9	1	3	0.05	28	60	2.47
133	0	0	4	0	1	0.01	16	38	2.08

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
134	1	0	5	1	1	0.02	19	43	2.17
135	2	0	18	3	5	0.10	28	60	2.65
136	2	0	18	3	5	0.10	28	60	2.63
137	1	0	5	1	1	0.02	18	41	2.14
138	2	0	16	2	4	0.08	28	61	2.61
139	1	0	5	1	1	0.02	19	42	2.16
140	2	0	17	3	5	0.10	26	57	2.58
141	0	0	4	0	1	0.01	15	36	2.03
142	1	0	5	1	1	0.02	17	40	2.12
143	1	0	5	1	1	0.02	17	39	2.10
144	1	0	10	3	4	0.08	23	51	2.43
145**	2	1	14	4	7	0.20	**36**	76	3.07
146	1	0	9	2	4	0.07	23	50	2.40
147	1	0	8	1	1	0.03	17	39	2.09
148	1	0	9	2	3	0.05	21	47	2.30
149	1	0	10	2	3	0.05	21	46	2.32
150	1	0	8	1	2	0.04	20	45	2.25
151**	1	0	9	2	3	0.06	24	53	2.52
152	1	0	7	1	1	0.02	16	38	2.06
153	1	0	8	1	2	0.04	19	44	2.24
154**	1	0	7	1	2	0.04	19	44	2.22
155	1	0	5	1	1	0.02	15	36	2.02
156	1	0	5	1	1	0.02	15	35	2.01
157	1	0	5	1	1	0.02	14	35	2.00
158	1	0	10	1	1	0.03	27	58	3.59
160	1	0	6	0	1	0.02	18	42	2.48
161	1	0	6	0	1	0.02	17	40	2.33
162	1	0	6	0	1	0.02	17	41	2.35
163	1	0	5	0	1	0.02	17	39	2.25
165	1	0	6	1	1	0.03	21	47	2.43
167	0	0	4	0	1	0.01	14	35	1.99
168	0	0	3	0	1	0.01	14	35	1.97
169	1	0	4	0	1	0.01	15	36	2.03
170	0	0	4	0	1	0.01	15	36	2.00
172	1	0	5	1	1	0.01	16	38	2.07
173	1	0	5	1	1	0.01	16	38	2.06
174	1	0	5	0	1	0.01	15	36	2.01
175	1	0	4	0	1	0.01	14	35	2.00
176	1	0	4	0	1	0.01	14	35	1.99
177	1	0	5	0	1	0.01	14	34	1.98
178	1	0	4	0	1	0.01	14	34	1.95
179	1	0	4	0	1	0.01	13	33	1.95
180	1	0	7	1	1	0.02	14	35	2.00
181	1	0	7	1	1	0.02	15	36	2.02

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
182	1	0	7	1	1	0.02	14	35	2.01
183	1	0	8	1	1	0.02	15	37	2.04
184	1	0	6	1	1	0.02	14	35	2.02
185	1	0	7	1	1	0.02	15	36	2.03
186	1	0	7	1	1	0.02	15	36	2.04
187	1	0	7	1	1	0.02	15	36	2.03
188	1	0	5	1	1	0.02	15	36	2.03
189**	1	0	6	1	2	0.03	18	41	2.15
190	1	0	8	1	2	0.04	20	45	2.25
191	1	0	7	1	1	0.02	16	37	2.06
192	1	0	8	1	1	0.03	16	39	2.09
193	0	0	2	0	0	0.00	8	25	1.74
194**	0	0	3	0	0	0.01	9	26	1.77
195**	1	0	4	0	0	0.01	9	27	1.79
196**	1	0	4	0	0	0.01	9	27	1.77
197	0	0	3	0	0	0.01	9	26	1.76
198**	0	0	2	0	0	0.01	8	26	1.75
199	0	0	1	0	0	0.00	8	24	1.72
200	0	0	2	0	0	0.00	8	25	1.73
201	0	0	2	0	0	0.00	8	25	1.73
202	0	0	2	0	0	0.00	8	25	1.73
203	0	0	2	0	0	0.00	8	25	1.73
204	0	0	2	0	0	0.00	8	25	1.73
205	0	0	2	0	0	0.00	8	25	1.73
206	0	0	2	0	0	0.00	8	25	1.73
207	0	0	2	0	0	0.00	8	25	1.73
208	0	0	3	0	0	0.00	8	25	1.74
209**	3	0	20	3	5	0.18	**32**	67	2.84
210	1	0	9	1	3	0.06	14	35	2.03
211	1	0	9	2	3	0.06	14	36	2.04
215	1	0	8	1	3	0.07	13	33	1.98
217	1	0	5	1	1	0.03	11	30	1.89
218	1	0	4	1	1	0.03	10	29	1.82
219	1	0	4	1	1	0.02	10	29	1.81
220	1	0	4	1	1	0.02	10	29	1.82
221	1	0	3	0	1	0.01	10	28	1.80
222	1	0	3	0	1	0.01	10	28	1.81
223	1	0	4	0	1	0.02	10	28	1.83
224	1	0	3	0	1	0.02	10	29	1.84
225	1	0	4	1	1	0.03	11	30	1.89
226	1	0	4	1	1	0.03	11	30	1.91
227	1	0	4	1	1	0.03	11	30	1.91
228	1	0	4	1	1	0.03	11	30	1.92
229	1	0	5	1	1	0.03	11	31	1.94

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
230	1	0	4	1	1	0.03	11	31	1.93
231	1	0	5	1	1	0.03	12	31	1.94
234	1	0	5	0	1	0.01	11	30	1.88
235	1	0	5	0	1	0.01	11	30	1.87
236	1	0	6	1	1	0.02	12	31	1.91
237	1	0	5	0	1	0.01	11	30	1.86
238	1	0	5	0	1	0.01	11	30	1.87
243	1	0	5	0	1	0.01	10	29	1.83
244	0	0	4	0	1	0.01	17	39	2.20
245	1	0	4	0	1	0.02	17	39	2.20
246	0	0	4	0	1	0.01	16	38	2.15
247	0	0	4	0	1	0.01	16	38	2.14
248	1	0	5	0	1	0.01	14	35	1.99
249	1	0	4	0	1	0.01	14	34	1.97
250	0	0	4	0	1	0.01	13	33	1.93
251	0	0	4	0	1	0.01	13	32	1.92
252	1	0	6	1	1	0.02	12	32	1.93
253	1	0	5	1	1	0.03	12	31	1.95
254	1	0	5	0	1	0.01	11	31	1.90
255	1	0	7	1	3	0.07	12	33	1.93
256	1	0	5	0	1	0.02	17	39	2.21
257	0	0	4	0	1	0.01	17	39	2.17
258	1	0	5	0	1	0.02	17	39	2.24
259	1	0	6	1	1	0.03	21	46	2.51
260	1	0	5	0	1	0.02	18	41	2.35
261	1	0	6	0	1	0.02	18	42	2.43
262	1	0	6	1	2	0.03	**34**	69	2.54
263	1	0	8	1	1	0.02	16	38	2.07
264	2	0	12	1	2	0.11	**31**	66	3.41
265	1	0	6	1	1	0.02	21	46	2.57
266	1	0	5	1	1	0.04	10	29	1.88
267	0	0	3	1	1	0.03	10	28	1.83
268	0	0	3	1	1	0.03	9	27	1.80
269**	1	0	9	1	2	0.05	12	32	1.96
270**	1	0	9	1	2	0.06	15	36	2.04
271**	1	0	6	1	1	0.02	**44**	88	3.00
903	1	0	4	0	1	0.01	10	29	1.82
904	0	0	3	0	0	0.01	9	27	1.77
905	0	0	3	0	0	0.00	9	26	1.75
909	1	0	4	0	0	0.01	10	28	1.80
911	0	0	3	0	0	0.00	9	26	1.76
915	1	0	11	3	5	0.08	23	52	2.46
917	1	0	4	0	0	0.01	10	28	1.80
918	1	0	4	0	0	0.01	10	28	1.81

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
919	1	0	5	1	1	0.03	12	32	1.96
920	1	0	8	1	2	0.05	14	35	2.03
921	1	0	4	1	1	0.02	11	30	1.90
922	1	0	3	0	1	0.01	10	29	1.85
923	0	0	2	0	0	0.00	8	25	1.74
926	0	0	3	0	0	0.00	8	26	1.75
927a	1	0	3	0	0	0.01	9	27	1.77
927b	1	0	3	0	0	0.01	9	27	1.77
927c	1	0	4	0	0	0.01	9	27	1.78
927d	0	0	2	0	0	0.00	8	26	1.75
927e	0	0	2	0	0	0.00	9	26	1.75
927f	0	0	2	0	0	0.00	9	26	1.75
927g	0	0	2	0	0	0.00	8	25	1.73
927h	0	0	2	0	0	0.00	8	25	1.74
927i	0	0	2	0	0	0.00	8	25	1.74
927j	0	0	2	0	0	0.00	8	25	1.74
928	1	0	4	0	0	0.01	9	27	1.78
929	1	0	4	0	0	0.01	10	28	1.80
932	1	0	6	1	1	0.02	15	37	2.03
936	1	0	4	0	0	0.01	9	27	1.79
937a	1	0	6	1	1	0.02	16	37	2.06
937b	1	0	6	1	1	0.02	15	37	2.04
937c	1	0	6	1	1	0.01	15	36	2.01
937d	1	0	6	1	1	0.02	15	37	2.04
937e	1	0	6	1	1	0.02	15	37	2.04
941**	2	0	12	1	2	0.10	30	65	3.27

*Advisory NEPM reporting standard applicable to the population as a whole

**Other mine owned property

9.1.1 Predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations

Figure E-1 and **Figure E-2** show the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations for Year 3 due to emissions from the proposal. The results in **Table 9-1** indicate that all assessment locations are predicted to experience a maximum 24-hour average and annual average concentration below the advisory reporting standards of 25µg/m³ and 8µg/m³, respectively in Year 3.

9.1.2 Predicted maximum 24-hour and annual average PM_{10} concentrations

Figure E-3 shows the predicted maximum 24-hour average PM_{10} concentrations for Year 3 due to emissions from the proposal. The results in **Table 9-1** indicate that all assessment locations with the exception of assessment location 112 are predicted to experience maximum 24-hour average PM_{10} concentrations below the relevant criterion of 50µg/m³ in Year 3.

An analysis of the number of days that the P&I acquisition criterion of 50µg/m^3 would be exceeded at this assessment location is presented in **Table 9-2**. The analysis indicates that assessment location 112 would experience levels systemically above the criterion (eg on more than five days).

Table 9-2: Analysis of Year 3 – maximum 24-hour average PM_{10} concentrations

Assessment location ID	Number of days over 50µg/m^3
112	**6**

Results for the total (cumulative) impact for maximum 24-hour average PM_{10} concentrations are discussed in **Section 9.5**.

Figure E-4 shows the predicted annual average PM_{10} concentrations for Year 3 due to emissions from the proposal. **Figure E-5** shows the predicted total impact from the proposal and other sources. The results in **Table 9-1** indicate that assessment locations 77, 78, 79, 83, 109, 112, 126, 145, 209, 262, 264 and 271 are predicted to experience annual average PM_{10} concentrations above the relevant criterion of 30µg/m^3 in Year 3. All assessment locations are mine-owned with the exception of assessment locations 77, 102 and 264. Assessment locations 77 and 102 are in the acquisition zone under the current development consent.

It is noted that assessment locations 209 and 271 are largely unaffected by activity from the proposal. These locations would be influenced by other dust sources in the area as indicated by the low incremental predictions due to the proposal in **Table 9-1**.

9.1.3 Predicted annual average TSP concentrations

Figure E-6 shows the predicted annual average TSP concentrations for Year 3 due to emissions from the proposal. **Figure E-7** shows the predicted total impact from the proposal and other sources. The results in **Table 9-1** indicate that all assessment locations are predicted to experience annual average TSP concentrations below the relevant criterion of 90µg/m^3 in Year 3, with the exception of assessment location 109. Assessment location 109 is a mine-owned property.

9.1.4 Predicted annual average dust deposition levels

Figure E-8 shows the predicted annual average dust deposition levels for Year 3 due to emissions from the proposal. **Figure E-9** shows the predicted total impact from the proposal and other sources.

The results in **Table 9-1** indicate that all of the assessment locations are predicted to experience incremental annual average dust deposition levels below the relevant criterion of 2g/m^2/month in Year 3. All of the assessment locations with the exception of assessment location 109 are predicted to experience total annual average dust deposition levels below the relevant criterion of 4g/m^2/month in Year 3 from the proposal and other sources. Assessment location 109 is a mine-owned property.

9.2 Year 9 results

Table 9-3 presents the model predictions at each of the assessment locations, the values presented in bold indicate predicted values above the relevant criteria. The assessment locations highlighted in grey are identified as mine-owned assessment locations, and those highlighted in orange are privately-owned assessment locations already in the acquisition zone for other mine operations.

Figure E-10 to **Figure E-18** in **Appendix E** present isopleth diagrams of the predicted modelling results for each of the assessed pollutants in Year 9.

Table 9-3: Modelling predictions for Year 9 of the proposal

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
1	1	0	4	1	1	0.02	10	28	1.79
2	1	0	4	1	1	0.02	10	28	1.79
3	1	0	4	1	1	0.02	10	28	1.81
4	1	0	3	0	1	0.02	10	28	1.81
5	1	0	4	1	1	0.02	10	28	1.81
6	1	0	4	1	1	0.02	10	28	1.81
7	1	0	3	0	1	0.02	10	28	1.81
8	1	0	4	1	1	0.02	10	29	1.83
9	1	0	4	0	1	0.02	10	28	1.83
10	1	0	5	1	1	0.03	11	29	1.83
11**	1	0	8	1	2	0.06	15	37	2.06
12	1	0	5	1	1	0.03	11	30	1.88
13	1	0	5	1	2	0.04	11	31	1.87
14	1	0	5	1	1	0.03	11	30	1.89
15	1	0	5	1	1	0.03	11	30	1.90
16	1	0	5	1	2	0.05	12	31	1.89
17	1	0	6	1	2	0.06	12	32	1.91
18	1	0	5	1	1	0.03	11	30	1.91
19	1	0	7	1	2	0.06	12	33	1.92
20	1	0	5	1	1	0.03	11	31	1.92
21	1	0	6	1	2	0.05	12	32	1.91
22	1	0	5	1	1	0.03	11	31	1.92
23	1	0	4	1	1	0.03	11	30	1.90
24	1	0	7	1	2	0.07	13	33	1.93
25	1	0	10	1	2	0.06	14	35	2.01
26	1	0	5	1	1	0.03	12	31	1.92
27	1	0	8	1	2	0.07	13	34	1.96
28	1	0	4	0	1	0.02	11	30	1.87
29	1	0	8	1	2	0.07	13	34	1.97
30	1	0	7	1	2	0.05	12	32	1.93
31	1	0	7	1	2	0.06	12	33	1.93
32	1	0	8	1	2	0.07	13	34	1.95
33	1	0	7	1	2	0.04	12	32	1.93

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
34	1	0	10	1	2	0.07	14	35	2.01
35	1	0	7	1	2	0.06	13	33	1.94
36	1	0	5	1	1	0.03	12	31	1.93
37	1	0	8	1	2	0.07	13	34	1.97
38	1	0	5	1	1	0.03	12	31	1.93
39	1	0	6	1	2	0.04	12	32	1.93
40	1	0	6	1	2	0.04	12	32	1.94
41	1	0	4	0	1	0.01	11	30	1.87
42	1	0	9	1	3	0.07	13	34	1.96
43	1	0	6	1	2	0.04	12	32	1.94
44	1	0	6	1	2	0.04	12	32	1.94
45	1	0	4	1	1	0.02	11	31	1.91
46	1	0	6	1	2	0.04	12	32	1.94
47	1	0	6	1	2	0.04	12	33	1.95
48	1	0	6	1	2	0.05	13	33	1.95
49	1	0	6	1	2	0.04	13	33	1.95
50	1	0	5	1	2	0.04	12	32	1.94
51	2	0	13	2	3	0.10	17	40	2.16
52	1	0	5	1	1	0.03	12	32	1.93
53	1	0	5	1	2	0.04	12	33	1.95
54	1	0	4	0	1	0.01	11	30	1.87
55	1	0	6	1	2	0.05	13	33	1.96
56	1	0	5	1	2	0.04	12	33	1.95
57	1	0	5	1	2	0.04	13	33	1.95
58	1	0	6	1	2	0.05	13	34	1.97
59	1	0	5	1	2	0.04	13	33	1.95
60	1	0	5	1	2	0.04	13	33	1.95
61	1	0	4	0	1	0.01	11	30	1.87
62	1	0	6	1	2	0.04	13	33	1.96
63	1	0	6	1	2	0.04	13	34	1.97
64	1	0	6	1	2	0.04	13	34	1.96
65	1	0	6	1	2	0.05	13	34	1.97
66	1	0	6	1	2	0.04	13	34	1.96
67	1	0	4	0	0	0.01	10	28	1.80
68	1	0	6	1	2	0.05	13	34	1.97
69	1	0	6	1	2	0.04	13	34	1.96
70	1	0	3	0	0	0.01	10	28	1.79
71	1	0	6	1	2	0.04	13	34	1.97
72	1	0	6	1	2	0.04	13	34	1.97
73	1	0	6	1	1	0.03	13	33	1.95
74	1	0	5	0	1	0.01	11	30	1.88
75	1	0	6	1	2	0.04	13	34	1.97
76	1	0	5	1	1	0.02	12	31	1.91
77	1	0	8	1	2	0.08	**36**	75	3.15

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
78	1	0	6	1	2	0.09	**55**	**110**	**4.86**
79**	1	0	8	1	2	0.07	**35**	73	3.09
80	1	0	4	0	0	0.01	10	29	1.82
81	2	0	12	2	4	0.13	16	40	2.08
82	1	0	5	0	1	0.01	12	31	1.90
83**	1	0	8	1	2	0.07	**34**	71	3.03
84	1	0	5	0	1	0.01	11	29	1.84
86	1	0	7	1	2	0.03	13	34	1.98
87	1	0	10	2	4	0.11	16	39	2.08
89	1	0	4	0	1	0.01	11	29	1.84
90	1	0	9	1	2	0.07	**32**	68	3.06
91**	1	0	9	1	2	0.08	**32**	69	3.12
92**	1	0	4	0	1	0.01	11	30	1.85
93	1	0	9	1	2	0.09	**33**	69	3.30
94**	1	0	9	1	2	0.08	**31**	67	3.08
95	1	0	8	1	2	0.04	15	37	2.02
96**	1	0	9	1	2	0.09	**31**	67	3.23
97	1	0	12	2	5	0.14	18	42	2.14
98	1	0	11	2	4	0.12	18	42	2.12
99**	1	0	10	1	2	0.10	**32**	68	3.44
100	2	0	14	3	5	0.15	19	44	2.15
101	2	0	12	3	5	0.16	19	44	2.17
102	1	0	10	1	2	0.10	**31**	67	3.46
103**	1	0	6	1	1	0.02	13	33	1.94
104	2	0	13	3	6	0.17	20	46	2.22
105	1	0	8	1	2	0.07	28	61	2.94
106	2	0	16	4	7	0.22	22	50	2.30
107	2	0	15	4	7	0.25	22	50	2.36
108	2	1	20	4	9	0.29	28	61	2.52
109**	2	0	14	2	3	0.11	**35**	75	3.64
110	2	1	19	5	9	0.34	25	56	2.48
111	1	0	3	0	0	0.01	10	28	1.83
112	3	1	29	7	15	0.53	**34**	72	2.82
113**	1	0	4	0	1	0.01	11	30	1.94
114	1	0	9	1	2	0.04	22	49	2.57
115**	1	0	6	1	1	0.02	18	42	2.33
116	1	0	8	1	2	0.06	20	45	2.32
117	1	0	8	1	2	0.04	19	44	2.44
118	1	0	9	1	2	0.05	19	44	2.40
118	1	0	9	1	2	0.05	19	44	2.40
119	1	0	10	2	2	0.06	19	44	2.30
120	1	0	8	1	2	0.03	17	40	2.27
121	1	0	8	1	2	0.04	18	41	2.31
122	1	0	7	1	2	0.03	17	39	2.24

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
123	1	0	8	1	2	0.03	17	40	2.27
124	1	0	7	1	2	0.03	17	39	2.23
125	2	0	13	2	4	0.06	20	44	2.20
126	2	0	14	3	4	0.07	23	49	2.26
127	1	0	8	1	2	0.03	17	39	2.08
128	2	0	14	2	3	0.05	19	44	2.17
129	2	0	14	2	3	0.04	18	41	2.13
130	2	0	13	2	2	0.04	17	40	2.10
131	3	1	21	4	6	0.09	24	53	2.28
133	1	0	10	1	2	0.02	16	37	2.03
134	1	0	12	1	2	0.03	17	39	2.08
135	6	1	44	9	14	0.20	30	62	2.59
136	5	1	42	8	13	0.19	29	60	2.56
137	1	0	10	1	2	0.03	16	38	2.06
138	4	1	32	6	10	0.15	27	57	2.47
139	1	0	10	1	2	0.03	16	39	2.07
140	5	1	40	7	12	0.17	27	57	2.50
141	1	0	9	1	1	0.02	16	36	1.99
142	1	0	9	1	2	0.03	16	37	2.05
143	1	0	9	1	2	0.02	16	37	2.03
144	3	0	21	4	6	0.09	21	46	2.30
145**	4	1	33	7	12	0.27	**41**	85	3.12
146	3	0	19	3	5	0.08	20	45	2.26
147	2	0	15	2	2	0.03	16	37	2.02
148	2	0	17	3	4	0.07	19	43	2.18
149	3	0	23	3	5	0.08	19	44	2.22
150	2	0	16	2	4	0.06	18	41	2.13
151**	3	0	22	3	6	0.12	23	51	2.42
152	2	0	13	1	2	0.03	15	36	2.00
153	2	0	17	2	4	0.06	18	41	2.14
154**	2	0	16	2	3	0.06	17	40	2.12
155	1	0	11	1	1	0.02	14	35	1.98
156	1	0	10	1	1	0.02	14	34	1.97
157	1	0	10	1	1	0.02	14	34	1.96
158	1	0	6	1	1	0.04	24	53	3.25
160	1	0	7	1	1	0.03	17	40	2.36
161	1	0	7	1	1	0.03	17	39	2.25
162	1	0	7	1	1	0.03	17	39	2.26
163	1	0	7	1	1	0.03	17	38	2.19
165	1	0	9	1	2	0.06	19	44	2.32
167	1	0	6	1	1	0.01	15	35	1.96
168	1	0	5	1	1	0.01	15	35	1.95
169	1	0	7	1	1	0.02	15	36	1.99
170	1	0	6	1	1	0.01	15	36	1.97

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
172	1	0	8	1	2	0.02	15	36	2.02
173	1	0	8	1	2	0.02	15	36	2.01
174	1	0	7	1	1	0.02	14	35	1.97
175	1	0	7	1	1	0.02	14	35	1.97
176	1	0	6	1	1	0.01	14	34	1.96
177	1	0	6	1	1	0.01	14	34	1.95
178	1	0	5	1	1	0.01	14	35	1.94
179	1	0	6	1	1	0.01	14	34	1.93
180	1	0	11	1	1	0.02	14	34	1.96
181	2	0	12	1	2	0.02	14	35	1.98
182	2	0	12	1	1	0.02	14	34	1.97
183	2	0	13	1	2	0.02	14	35	1.99
184	2	0	12	1	2	0.02	14	34	1.97
185	2	0	12	1	2	0.03	14	35	1.98
186	2	0	12	1	2	0.03	14	35	1.99
187	1	0	11	1	2	0.03	14	35	1.99
188	1	0	10	1	2	0.03	14	35	1.98
189**	2	0	13	2	3	0.05	16	38	2.06
190	2	0	16	2	4	0.06	18	41	2.13
191	2	0	14	1	2	0.03	15	36	2.00
192	2	0	15	1	2	0.03	15	37	2.02
193	0	0	2	0	0	0.00	8	25	1.74
194**	0	0	2	0	0	0.01	9	26	1.78
195**	0	0	3	0	0	0.01	9	27	1.80
196**	0	0	3	0	0	0.01	9	27	1.78
197	0	0	2	0	0	0.01	9	26	1.76
198**	0	0	2	0	0	0.00	8	26	1.75
199	0	0	1	0	0	0.00	8	25	1.72
200	0	0	2	0	0	0.00	8	25	1.73
201	0	0	2	0	0	0.00	8	25	1.73
202	0	0	1	0	0	0.00	8	25	1.73
203	0	0	1	0	0	0.00	8	25	1.73
204	0	0	2	0	0	0.00	8	25	1.73
205	0	0	2	0	0	0.00	8	25	1.73
206	0	0	2	0	0	0.00	8	25	1.73
207	0	0	2	0	0	0.00	8	25	1.73
208	0	0	2	0	0	0.00	8	25	1.74
209**	2	0	12	3	4	0.14	**35**	72	2.92
210	1	0	6	1	2	0.04	13	34	1.96
211	1	0	6	1	2	0.04	13	34	1.97
215	1	0	7	1	2	0.05	12	32	1.93
217	1	0	4	1	1	0.03	11	29	1.86
218	1	0	4	1	1	0.02	10	29	1.81
219	1	0	4	1	1	0.02	10	28	1.80

Assessment location ID	PM$_{2.5}$ (µg/m³)		PM$_{10}$ (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM$_{10}$ (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
220	1	0	4	0	1	0.02	10	28	1.80
221	1	0	3	0	1	0.01	9	27	1.79
222	1	0	3	0	1	0.01	9	27	1.79
223	1	0	3	0	1	0.01	10	28	1.81
224	1	0	3	0	1	0.01	10	28	1.82
225	1	0	4	0	1	0.02	10	29	1.86
226	1	0	4	1	1	0.02	10	29	1.87
227	1	0	4	1	1	0.02	11	29	1.87
228	1	0	4	1	1	0.02	11	29	1.88
229	1	0	4	1	1	0.03	11	30	1.89
230	1	0	4	1	1	0.02	11	30	1.89
231	1	0	4	1	1	0.03	11	30	1.90
234	1	0	4	0	1	0.01	11	29	1.85
235	1	0	4	0	1	0.01	10	29	1.84
236	1	0	5	0	1	0.01	11	30	1.87
237	1	0	4	0	1	0.01	10	29	1.83
238	1	0	5	0	1	0.01	11	29	1.85
243	1	0	3	0	0	0.01	10	29	1.82
244	1	0	7	1	1	0.03	17	38	2.13
245	1	0	7	1	1	0.03	17	38	2.14
246	1	0	6	1	1	0.03	16	38	2.10
247	1	0	7	1	1	0.03	17	38	2.10
248	1	0	6	1	1	0.02	14	34	1.96
249	1	0	5	1	1	0.01	14	35	1.95
250	1	0	6	0	1	0.01	15	35	1.94
251	1	0	7	0	1	0.01	14	34	1.92
252	1	0	5	0	1	0.01	11	31	1.89
253	1	0	4	1	1	0.03	11	30	1.90
254	1	0	5	0	1	0.01	11	30	1.86
255	1	0	6	1	2	0.05	12	32	1.91
256	1	0	6	1	1	0.03	16	38	2.16
257	1	0	7	1	1	0.03	17	38	2.12
258	1	0	6	1	1	0.03	16	38	2.18
259	1	0	9	1	2	0.05	19	43	2.37
260	1	0	7	1	1	0.03	17	39	2.26
261	1	0	7	1	1	0.03	17	40	2.32
262	2	0	14	3	4	0.06	22	48	2.25
263	2	0	14	1	2	0.03	15	36	2.01
264	1	0	10	1	2	0.11	**32**	68	3.58
265	1	0	8	1	2	0.04	19	44	2.43
266	0	0	4	1	1	0.04	11	29	1.89
267	0	0	2	0	1	0.03	10	28	1.84
268	0	0	2	0	1	0.02	10	28	1.80
269**	1	0	7	1	1	0.05	13	33	1.99

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
270**	1	0	7	1	2	0.05	15	38	2.08
271**	1	0	4	1	1	0.02	**46**	**92**	3.08
903	1	0	3	0	0	0.01	10	28	1.81
904	0	0	3	0	0	0.00	9	26	1.77
905	0	0	3	0	0	0.00	8	26	1.75
909	1	0	3	0	0	0.01	9	27	1.79
911	0	0	3	0	0	0.00	9	26	1.76
915	3	1	23	4	6	0.10	21	47	2.33
917	1	0	3	0	0	0.01	10	28	1.79
918	1	0	3	0	0	0.01	10	28	1.80
919	1	0	4	1	1	0.02	11	31	1.91
920	1	0	6	1	2	0.04	13	33	1.96
921	1	0	4	0	1	0.01	11	29	1.86
922	0	0	3	0	1	0.01	10	28	1.83
923	0	0	2	0	0	0.00	8	25	1.75
926	0	0	2	0	0	0.00	8	26	1.75
927a	0	0	3	0	0	0.00	9	27	1.77
927b	0	0	3	0	0	0.00	9	26	1.77
927c	0	0	3	0	0	0.00	9	27	1.77
927d	0	0	2	0	0	0.00	8	25	1.75
927e	0	0	2	0	0	0.00	8	26	1.75
927f	0	0	2	0	0	0.00	8	26	1.75
927g	0	0	2	0	0	0.00	8	25	1.73
927h	0	0	2	0	0	0.00	8	25	1.74
927i	0	0	2	0	0	0.00	8	25	1.74
927j	0	0	2	0	0	0.00	8	25	1.74
928	0	0	3	0	0	0.01	9	27	1.78
929	1	0	3	0	0	0.01	9	27	1.79
932	1	0	11	1	2	0.03	14	35	1.99
936	1	0	3	0	0	0.01	9	27	1.78
937a	1	0	8	1	2	0.02	15	36	2.00
937b	1	0	8	1	1	0.02	15	35	1.99
937c	1	0	7	1	1	0.02	14	35	1.97
937d	1	0	11	1	2	0.02	15	35	1.99
937e	1	0	11	1	2	0.02	14	35	1.99
941**	1	0	10	1	2	0.10	**31**	67	3.46

*Advisory NEPM reporting standard applicable to the population as a whole
**Other mine owned property

9.2.1 Predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations

Figure E-10 and **Figure E-11** show the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations for Year 9 due to emissions from the proposal. The results in **Table 9-3** indicate that all assessment locations are predicted to experience a maximum 24-hour average and annual average concentrations below the advisory reporting standards of 25µg/m³ and 8µg/m³, respectively in Year 9.

9.2.2 Predicted maximum 24-hour and annual average PM_{10} concentrations

Figure E-12 shows the predicted maximum 24-hour average PM_{10} concentrations for Year 9 due to emissions from the proposal. The results in **Table 9-3** indicate that all assessment locations are predicted to experience maximum 24-hour average PM_{10} concentrations below the relevant criterion of 50µg/m^3 in Year 9.

Results for the total (cumulative) impact for maximum 24-hour average PM_{10} concentrations are discussed in **Section 9.5**.

Figure E-13 shows the predicted annual average PM_{10} concentrations for Year 9 due to emissions from the proposal. **Figure E-14** shows the predicted total impact from the proposal and other sources. The results in **Table 9-3** indicate that assessment locations 77, 78, 79, 83, 90, 91, 93, 94, 96, 99, 102, 109, 112, 145, 209, 264, 271 and 941 are predicted to experience annual average PM_{10} concentrations above the relevant criterion of 30µg/m^3 in Year 9. All assessment locations are mine-owned with the exception of assessment locations 77, 102 and 264. Assessment locations 77 and 102 are in the acquisition zone under the current development consent.

It is noted that assessment locations 145, 209 and 271 are largely unaffected by activity from the proposal. These locations would be influenced by other dust sources in the area as indicated by the incremental predictions due to the proposal in **Table 9-3**.

9.2.3 Predicted annual average TSP concentrations

Figure E-15 shows the predicted annual average TSP concentrations for Year 9 due to emissions from the proposal. **Figure E-16** shows the predicted total impact from the proposal and other sources. The results in **Table 9-3** indicate that assessment locations 78 and 271 are predicted to experience annual average TSP concentrations above the relevant criterion of 90µg/m^3 in Year 9. Assessment locations 78 and 271 are mine-owned properties.

It is noted that assessment location 271 is largely unaffected by activity from the proposal. This location would be influenced by other dust sources in the area as indicated by the incremental predictions due to the proposal in **Table 9-3**.

9.2.4 Predicted annual average dust deposition levels

Figure E-17 shows the predicted annual average dust deposition levels for Year 9 due to emissions from the proposal. **Figure E-18** shows the predicted total impact from the proposal and other sources.

The results in **Table 9-3** indicate that all assessment locations are predicted to experience incremental annual average dust deposition levels below the relevant criterion of 2g/m^2/month in Year 9. Assessment location 78 is predicted to experience total annual average dust deposition levels above the relevant criterion of 4g/m^2/month in Year 9 from the proposal and other sources. Assessment location 78 is a mine-owned property.

9.3 Year 14 results

Table 9-4 presents the model predictions at each of the assessment locations, the values presented in bold indicate predicted values above the relevant criteria. The assessment locations highlighted in grey are identified as mine-owned assessment locations, and those highlighted in orange are privately-owned assessment locations already in the acquisition zone for other mine operations.

Figure E-19 to **Figure E-27** in **Appendix E** present isopleth diagrams of the predicted modelling results for each of the assessed pollutants in Year 14.

Table 9-4: Modelling predictions for Year 14 of the proposal

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
1	0	0	0	0	0	0.00	9	27	1.77
2	0	0	0	0	0	0.00	9	27	1.78
3	0	0	0	0	0	0.00	9	27	1.79
4	0	0	0	0	0	0.00	9	27	1.79
5	0	0	0	0	0	0.00	9	27	1.79
6	0	0	0	0	0	0.00	9	27	1.79
7	0	0	0	0	0	0.00	9	27	1.80
8	0	0	0	0	0	0.00	10	28	1.81
9	0	0	0	0	0	0.00	10	28	1.81
10	0	0	1	0	0	0.00	10	28	1.81
11**	0	0	0	0	0	0.00	14	36	2.06
12	0	0	1	0	0	0.00	10	29	1.85
13	0	0	1	0	0	0.00	11	29	1.84
14	0	0	1	0	0	0.00	10	29	1.86
15	0	0	1	0	0	0.00	10	29	1.87
16	0	0	1	0	0	0.00	11	30	1.85
17	0	0	1	0	0	0.00	11	30	1.86
18	0	0	1	0	0	0.00	10	29	1.87
19	0	0	1	0	0	0.00	11	31	1.87
20	0	0	1	0	0	0.00	11	29	1.88
21	0	0	1	0	0	0.00	11	30	1.86
22	0	0	1	0	0	0.00	11	29	1.88
23	0	0	1	0	0	0.00	10	29	1.88
24	0	0	1	0	0	0.00	12	31	1.87
25	0	0	1	0	0	0.00	13	34	1.97
26	0	0	1	0	0	0.00	11	30	1.89
27	0	0	1	0	0	0.00	12	32	1.92
28	0	0	1	0	0	0.00	10	29	1.86
29	0	0	1	0	0	0.00	12	32	1.92
30	0	0	1	0	0	0.00	11	30	1.88
31	0	0	1	0	0	0.00	11	31	1.87
32	0	0	1	0	0	0.00	12	31	1.89
33	0	0	1	0	0	0.00	11	30	1.89

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
34	0	0	1	0	0	0.00	13	33	1.97
35	0	0	1	0	0	0.00	11	31	1.88
36	0	0	1	0	0	0.00	11	30	1.89
37	0	0	1	0	0	0.00	12	32	1.92
38	0	0	1	0	0	0.00	11	30	1.89
39	0	0	1	0	0	0.00	11	30	1.89
40	0	0	1	0	0	0.00	11	30	1.90
41	0	0	1	0	0	0.00	10	29	1.86
42	0	0	1	0	0	0.00	12	32	1.88
43	0	0	1	0	0	0.00	11	30	1.90
44	0	0	1	0	0	0.00	11	30	1.90
45	0	0	1	0	0	0.00	11	30	1.89
46	0	0	1	0	0	0.00	11	31	1.90
47	0	0	1	0	0	0.00	11	31	1.90
48	0	0	1	0	0	0.00	12	31	1.90
49	0	0	1	0	0	0.00	12	31	1.90
50	0	0	1	0	0	0.00	11	31	1.90
51	0	0	1	0	0	0.01	15	38	2.12
52	0	0	1	0	0	0.00	11	31	1.90
53	0	0	1	0	0	0.00	12	31	1.90
54	0	0	1	0	0	0.00	10	29	1.87
55	0	0	1	0	0	0.00	12	31	1.91
56	0	0	1	0	0	0.00	12	31	1.91
57	0	0	1	0	0	0.00	12	31	1.91
58	0	0	1	0	0	0.00	12	32	1.91
59	0	0	1	0	0	0.00	12	31	1.91
60	0	0	1	0	0	0.00	12	31	1.91
61	0	0	1	0	0	0.00	11	29	1.87
62	0	0	1	0	0	0.00	12	32	1.91
63	0	0	1	0	0	0.00	12	32	1.91
64	0	0	1	0	0	0.00	12	32	1.91
65	0	0	1	0	0	0.00	12	32	1.91
66	0	0	1	0	0	0.00	12	32	1.91
67	0	0	0	0	0	0.00	10	28	1.81
68	0	0	1	0	0	0.00	12	32	1.92
69	0	0	1	0	0	0.00	12	32	1.92
70	0	0	0	0	0	0.00	10	28	1.81
71	0	0	1	0	0	0.00	12	32	1.92
72	0	0	1	0	0	0.00	12	32	1.92
73	0	0	1	0	0	0.00	12	32	1.92
74	0	0	1	0	0	0.00	11	30	1.88
75	0	0	1	0	0	0.00	12	32	1.93
76	0	0	1	0	0	0.00	11	31	1.91
77	0	0	1	0	0	0.01	**35**	75	3.19

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
78	0	0	1	0	0	0.01	**57**	**117**	**5.15**
79**	0	0	1	0	0	0.01	**34**	72	3.10
80	0	0	0	0	0	0.00	10	29	1.83
81	0	0	1	0	0	0.01	14	35	1.94
82	0	0	1	0	0	0.00	11	31	1.90
83**	0	0	1	0	0	0.00	**33**	69	2.99
84	0	0	0	0	0	0.00	11	30	1.85
86	0	0	1	0	0	0.00	12	33	1.93
87	0	0	1	0	0	0.00	14	35	1.94
89	0	0	0	0	0	0.00	11	30	1.85
90	0	0	1	0	0	0.00	29	63	2.92
91**	0	0	1	0	0	0.01	30	65	2.99
92**	0	0	0	0	0	0.00	11	30	1.87
93	0	0	1	0	0	0.01	30	65	3.10
94**	0	0	1	0	0	0.01	28	61	2.89
95	0	0	1	0	0	0.00	13	34	1.95
96**	0	0	1	0	0	0.01	28	61	2.98
97	0	0	1	0	0	0.00	15	37	1.97
98	0	0	1	0	0	0.00	15	37	1.97
99**	0	0	1	0	0	0.01	28	61	3.07
100	0	0	1	0	0	0.01	16	39	1.99
101	0	0	1	0	0	0.01	16	39	1.99
102	0	0	1	0	0	0.01	26	59	3.03
103**	0	0	1	0	0	0.00	13	33	1.94
104	0	0	1	0	0	0.01	17	40	2.01
105	0	0	1	0	0	0.01	23	52	2.68
106	0	0	1	0	0	0.01	20	46	2.08
107	0	0	1	0	0	0.01	19	43	2.07
108	0	0	2	0	0	0.01	30	65	2.43
109**	0	0	1	0	0	0.01	23	52	2.81
110	0	0	2	0	0	0.01	23	51	2.19
111	0	0	1	0	0	0.00	10	28	1.86
112	0	0	2	0	1	0.01	**43**	90	2.88
113**	0	0	1	0	0	0.00	11	31	2.01
114	0	0	1	0	0	0.01	20	45	2.46
115**	0	0	1	0	0	0.00	18	43	2.46
116	0	0	2	0	1	0.01	17	40	2.22
117	0	0	2	0	0	0.01	17	40	2.36
118	0	0	2	0	0	0.01	17	40	2.31
118	0	0	2	0	0	0.01	17	40	2.31
119	0	0	2	0	1	0.01	16	39	2.21
120	0	0	2	0	0	0.01	15	36	2.21
121	0	0	2	0	0	0.01	15	37	2.24
122	0	0	2	0	0	0.01	14	35	2.17

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
123	0	0	2	0	0	0.01	15	36	2.20
124	0	0	2	0	0	0.01	14	35	2.16
125	0	0	4	1	1	0.02	16	39	2.11
126	1	0	4	1	1	0.02	19	43	2.16
127	0	0	2	0	0	0.01	14	34	2.01
128	0	0	3	1	1	0.01	16	38	2.09
129	0	0	3	0	1	0.01	15	36	2.05
130	0	0	3	0	1	0.01	14	35	2.04
131	1	0	5	1	2	0.03	20	46	2.16
133	0	0	2	0	0	0.01	13	32	1.97
134	0	0	3	0	1	0.01	14	34	2.02
135	1	0	11	3	5	0.07	21	47	2.34
136	1	0	10	3	4	0.07	20	46	2.31
137	0	0	3	0	1	0.01	13	34	2.00
138	1	0	8	2	3	0.05	20	46	2.27
139	0	0	3	0	1	0.01	14	34	2.01
140	1	0	10	3	4	0.07	19	44	2.27
141	0	0	2	0	0	0.00	12	32	1.94
142	0	0	3	0	1	0.01	13	33	1.99
143	0	0	3	0	0	0.01	13	33	1.98
144	1	0	9	2	3	0.04	16	39	2.12
145**	2	0	13	2	3	0.06	22	50	2.37
146	1	0	9	2	3	0.04	16	38	2.09
147	0	0	3	0	1	0.01	13	33	1.95
148	1	0	10	1	2	0.03	14	36	2.03
149	1	0	11	1	2	0.03	14	36	2.04
150	1	0	9	1	2	0.02	14	35	2.00
151**	1	0	6	1	2	0.03	15	37	2.10
152	0	0	3	0	1	0.01	12	32	1.94
153	1	0	9	1	2	0.02	14	34	2.00
154**	1	0	8	1	1	0.02	14	34	1.99
155	0	0	2	0	0	0.00	12	31	1.92
156	0	0	2	0	0	0.00	12	31	1.92
157	0	0	2	0	0	0.00	12	31	1.91
158	0	0	1	0	0	0.01	22	50	3.15
160	0	0	2	0	0	0.01	15	37	2.29
161	0	0	2	0	0	0.01	14	35	2.18
162	0	0	2	0	0	0.01	14	35	2.19
163	0	0	2	0	0	0.01	14	34	2.11
165	0	0	2	0	1	0.01	17	40	2.22
167	0	0	2	0	0	0.00	12	31	1.91
168	0	0	2	0	0	0.00	12	31	1.90
169	0	0	3	0	0	0.00	12	31	1.94
170	0	0	2	0	0	0.00	12	31	1.92

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
172	0	0	3	0	0	0.01	13	32	1.96
173	0	0	3	0	0	0.01	12	32	1.96
174	0	0	2	0	0	0.00	12	31	1.93
175	0	0	2	0	0	0.00	12	31	1.92
176	0	0	1	0	0	0.00	12	31	1.91
177	0	0	1	0	0	0.00	11	31	1.90
178	0	0	1	0	0	0.00	11	30	1.89
179	0	0	1	0	0	0.00	11	30	1.88
180	0	0	2	0	0	0.00	12	31	1.91
181	0	0	2	0	0	0.01	12	31	1.92
182	0	0	2	0	0	0.00	12	31	1.92
183	0	0	2	0	0	0.01	12	31	1.93
184	0	0	3	0	0	0.01	12	31	1.92
185	0	0	3	0	0	0.01	12	31	1.93
186	0	0	3	0	1	0.01	12	31	1.93
187	0	0	3	0	1	0.01	12	31	1.93
188	1	0	5	0	1	0.01	12	32	1.92
189**	1	0	7	1	1	0.01	13	33	1.96
190	1	0	9	1	2	0.02	14	35	2.00
191	0	0	3	0	1	0.01	12	32	1.94
192	0	0	3	0	1	0.01	13	32	1.94
193	0	0	0	0	0	0.00	8	25	1.75
194**	0	0	0	0	0	0.00	9	26	1.78
195**	0	0	0	0	0	0.00	9	27	1.80
196**	0	0	0	0	0	0.00	9	27	1.79
197	0	0	0	0	0	0.00	9	26	1.76
198**	0	0	0	0	0	0.00	8	26	1.75
199	0	0	0	0	0	0.00	8	24	1.72
200	0	0	0	0	0	0.00	8	25	1.73
201	0	0	0	0	0	0.00	8	25	1.73
202	0	0	0	0	0	0.00	8	25	1.73
203	0	0	0	0	0	0.00	8	25	1.73
204	0	0	0	0	0	0.00	8	25	1.73
205	0	0	0	0	0	0.00	8	25	1.73
206	0	0	0	0	0	0.00	8	25	1.73
207	0	0	0	0	0	0.00	8	25	1.73
208	0	0	0	0	0	0.00	8	25	1.74
209**	0	0	3	0	1	0.01	26	55	2.38
210	0	0	1	0	0	0.00	12	32	1.91
211	0	0	1	0	0	0.00	12	32	1.92
215	0	0	1	0	0	0.00	11	31	1.88
217	0	0	1	0	0	0.00	10	28	1.83
218	0	0	1	0	0	0.00	10	28	1.79
219	0	0	0	0	0	0.00	9	27	1.78

Assessment location ID	PM2.5 (µg/m³)		PM10 (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM10 (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
220	0	0	0	0	0	0.00	9	27	1.79
221	0	0	0	0	0	0.00	9	27	1.78
222	0	0	0	0	0	0.00	9	27	1.78
223	0	0	0	0	0	0.00	9	27	1.79
224	0	0	0	0	0	0.00	9	27	1.80
225	0	0	0	0	0	0.00	10	28	1.83
226	0	0	0	0	0	0.00	10	28	1.84
227	0	0	0	0	0	0.00	10	28	1.85
228	0	0	0	0	0	0.00	10	28	1.85
229	0	0	1	0	0	0.00	10	29	1.86
230	0	0	1	0	0	0.00	10	29	1.86
231	0	0	1	0	0	0.00	10	29	1.87
234	0	0	0	0	0	0.00	10	29	1.86
235	0	0	0	0	0	0.00	10	29	1.85
236	0	0	1	0	0	0.00	11	30	1.88
237	0	0	0	0	0	0.00	10	29	1.84
238	0	0	0	0	0	0.00	10	29	1.85
243	0	0	0	0	0	0.00	10	29	1.83
244	0	0	2	0	0	0.01	13	34	2.06
245	0	0	2	0	0	0.01	14	34	2.07
246	0	0	2	0	0	0.01	13	33	2.03
247	0	0	2	0	0	0.01	13	33	2.02
248	0	0	2	0	0	0.00	12	31	1.91
249	0	0	1	0	0	0.00	11	30	1.90
250	0	0	1	0	0	0.00	11	30	1.87
251	0	0	1	0	0	0.00	11	29	1.86
252	0	0	1	0	0	0.00	11	31	1.89
253	0	0	1	0	0	0.00	10	29	1.87
254	0	0	1	0	0	0.00	11	30	1.87
255	0	0	1	0	0	0.00	11	30	1.86
256	0	0	2	0	0	0.01	14	34	2.08
257	0	0	2	0	0	0.01	13	34	2.05
258	0	0	2	0	0	0.01	14	34	2.11
259	0	0	2	0	1	0.01	16	39	2.29
260	0	0	2	0	0	0.01	14	35	2.19
261	0	0	2	0	0	0.01	15	36	2.25
262	1	0	4	1	1	0.02	18	42	2.15
263	0	0	3	0	1	0.01	12	32	1.94
264	0	0	1	0	0	0.01	26	58	3.08
265	0	0	2	0	0	0.01	17	40	2.35
266	0	0	0	0	0	0.00	10	29	1.87
267	0	0	0	0	0	0.00	10	28	1.82
268	0	0	0	0	0	0.00	9	27	1.79
269**	0	0	0	0	0	0.00	13	33	1.98

Assessment location ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Advisory*		Air quality impact criteria						
	25	8	50	-	-	2	30	90	4
270**	0	0	1	0	0	0.00	15	37	2.09
271**	0	0	1	0	0	0.00	46	92	3.09
903	0	0	0	0	0	0.00	10	29	1.83
904	0	0	0	0	0	0.00	9	27	1.77
905	0	0	0	0	0	0.00	8	26	1.75
909	0	0	0	0	0	0.00	10	28	1.80
911	0	0	0	0	0	0.00	9	26	1.76
915	1	0	10	2	3	0.05	16	39	2.14
917	0	0	0	0	0	0.00	10	28	1.81
918	0	0	0	0	0	0.00	10	28	1.81
919	0	0	1	0	0	0.00	11	30	1.89
920	0	0	1	0	0	0.00	12	32	1.91
921	0	0	1	0	0	0.00	10	29	1.86
922	0	0	0	0	0	0.00	10	28	1.83
923	0	0	0	0	0	0.00	8	25	1.75
926	0	0	0	0	0	0.00	8	26	1.75
927a	0	0	0	0	0	0.00	9	27	1.78
927b	0	0	0	0	0	0.00	9	27	1.77
927c	0	0	0	0	0	0.00	9	27	1.78
927d	0	0	0	0	0	0.00	8	25	1.75
927e	0	0	0	0	0	0.00	8	26	1.75
927f	0	0	0	0	0	0.00	8	26	1.76
927g	0	0	0	0	0	0.00	8	25	1.74
927h	0	0	0	0	0	0.00	8	25	1.74
927i	0	0	0	0	0	0.00	8	25	1.74
927j	0	0	0	0	0	0.00	8	25	1.75
928	0	0	0	0	0	0.00	9	27	1.78
929	0	0	0	0	0	0.00	10	28	1.80
932	0	0	2	0	1	0.01	12	32	1.93
936	0	0	0	0	0	0.00	9	27	1.79
937a	0	0	2	0	0	0.01	12	32	1.95
937b	0	0	2	0	0	0.01	12	32	1.94
937c	0	0	2	0	0	0.00	12	31	1.92
937d	0	0	2	0	0	0.01	12	32	1.93
937e	0	0	2	0	0	0.01	12	32	1.93
941**	0	0	1	0	0	0.01	26	58	3.03

*Advisory NEPM reporting standard applicable to the population as a whole

**Other mine owned property

9.3.1 Predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations

Figure E-19 and **Figure E-20** show the predicted maximum 24-hour average and annual average $PM_{2.5}$ concentrations for Year 14 due to emissions from the proposal. The results in **Table 9-4** indicate that all assessment locations are predicted to experience a maximum 24-hour average and annual average concentrations below the advisory reporting standard of 25µg/m³ and 8µg/m³ in Year 14.

9.3.2 Predicted maximum 24-hour and annual average PM_{10} concentrations

Figure E-21 shows the predicted maximum 24-hour average PM_{10} concentrations for Year 14 due to emissions from the proposal. The results in **Table 9-4** indicate that all assessment locations are predicted to experience maximum 24-hour average PM_{10} concentrations below the relevant criterion of 50µg/m^3 in Year 14.

Results for the total (cumulative) impact for maximum 24-hour average PM_{10} concentrations are discussed in **Section 9.5**.

Figure E-22 shows the predicted annual average PM_{10} concentrations for Year 14 due to emissions from the proposal. **Figure E-23** shows the predicted total impact from the proposal and other sources. The results in **Table 9-4** indicate that assessment locations 77, 78, 79, 83, 112 and 271 are predicted to experience annual average PM_{10} concentrations above the relevant criterion of 30µg/m^3 in Year 14. All assessment locations are mine-owned with the exception of assessment location 77. Assessment locations 77 is in the acquisition zone under the current development consent.

It is noted that assessment location 271 is largely unaffected by activity from the proposal. This location would be influenced by other dust sources in the area as indicated by the incremental predictions due to the proposal in **Table 9-4**.

9.3.3 Predicted annual average TSP concentrations

Figure E-24 shows the predicted annual average TSP concentrations for Year 14 due to emissions from the proposal. **Figure E-25** shows the predicted total impact from the proposal and other sources. The results in **Table 9-4** indicate that all assessment locations with the exception of assessment locations 78 and 271 are predicted to experience annual average TSP concentrations below the relevant criterion of 90µg/m^3 in Year 14. Assessment locations 78 and 271 are mine-owned properties.

It is noted that assessment location 271 is largely unaffected by activity from the proposal. This location would be influenced by other dust sources in the area as indicated by the incremental predictions due to the proposal in **Table 9-4**.

9.3.4 Predicted annual average dust deposition levels

Figure E-26 shows the predicted annual average dust deposition levels for Year 14 due to emissions from the proposal. **Figure E-27** shows the predicted total impact from the proposal and other sources. The results in **Table 9-4** indicate that all assessment locations are predicted to experience incremental annual average dust deposition levels below the relevant criterion of 2g/m^2/month in Year 14. Assessment location 78 is predicted to experience total annual average dust deposition levels above the relevant criterion of 4g/m^2/month in Year 14 from the proposal and other sources. Assessment location 78 is a mine-owned property.

9.4 Summary of results

Table 9-5 summarises the assessment locations where impacts are predicted to exceed relevant assessment criteria. The assessment locations highlighted in grey are identified as mine-owned assessment locations, and those highlighted in orange are privately-owned assessment locations already in the acquisition zone for other mine operations.

Cumulative 24-hour PM_{10} impacts are assessed specifically in **Section 9.5**.

As shown, all assessment locations where predicted impacts exceed assessment criteria are mine-owned properties with the exception of assessment location 77, 102 and 246 which are privately-owned. Assessment locations 77 and 102 are in the acquisition zone for other mine operations.

It is noted that assessment locations 145, 209 and 271 are largely unaffected by activity from the proposal. These locations would be influenced by other dust sources in the area.

Table 9-5: Summary of modelled predictions where predicted impacts exceed assessment criteria

Assessment location ID	PM_{10}			TSP	DD	
	Incremental 24-hour average		Total annual average	Total annual average	Incremental annual average	Total annual average
	Criterion 50µg/m³		Criterion 30µg/m³	Criterion 90µg/m³	Criterion 2g/m²/month	Criterion 4g/m²/month
	Year of impact (level of impact - µg/m³)	No. of days above 50µg/m³	Year of impact (level of impact - µg/m³)		Year of impact (level of impact - g/m²/month)	
77			Year 3 (32) Year 9 (36) Year 14 (35)			
78			Year 3 (32) Year 9 (55) Year 14 (57)	Year 9 (110) Year 14 (117)		Year 9 (4.9) Year 14 (5.2)
79*			Year 3 (32) Year 9 (35) Year 14 (34)			
83*			Year 3 (32) Year 9 (34) Year 14 (33)			
90			Year 9 (32)			
91*			Year 9 (32)			
93			Year 9 (33)			
94*			Year 9 (31)			
96*			Year 9 (31)			
99*			Year 9 (32)			
102			Year 3 (31) Year 9 (31)			
109*			Year 3 (61) Year 9 (35)	Year 3 (125)		Year 3 (5.3)
112	Year 3 (67)	6	Year 3 (37) Year 9 (34) Year 14 (43)			
145*			Year 3 (36) Year 9 (41)			
209*			Year 3 (32) Year 9 (35)			
264			Year 3 (31) Year 9 (32)			
271*			Year 3 (44)	Year 9 (92)		

Assessment location ID	PM_{10}			TSP	DD	
	Incremental 24-hour average		Total annual average	Total annual average	Incremental annual average	Total annual average
	Criterion 50µg/m³		Criterion 30µg/m³	Criterion 90µg/m³	Criterion 2g/m²/month	Criterion 4g/m²/month
	Year of impact (level of impact - µg/m³)	No. of days above 50µg/m³	Year of impact (level of impact - µg/m³)		Year of impact (level of impact - g/m²/month)	
			Year 9 (46) Year 14 (46)	Year 14 (92)		
941*			Year 9 (31)			

*Other mine owned property

9.5 Assessment of total (cumulative) 24-hour average PM_{10} concentrations

9.5.1 Introduction

The NSW EPA contemporaneous assessment method was applied to examine the potential maximum (cumulative) 24-hour average PM_{10} impacts for the proposal.

The analysis described in this section focusses on locations at which the data required to conduct this assessment are available and represent the assessment locations surrounding MTO. The locations are five monitoring stations where suitable ambient monitoring data is available. The monitoring data collected at these sites cover the contemporaneous modelling period. The assessment of cumulative impacts uses the monitoring data from the closest monitor.

Figure 9-1 shows the location of each of these monitors in relation to MTO and surrounding assessment locations.

Generally, these monitoring locations are representative of the most impacted receptors in the surrounding assessment locations as they are typically located closer to the mining activity and hence are likely to experience greater impacts. The predicted cumulative 24-hour average PM_{10} levels assessed at the monitor locations can therefore be considered a reasonable, conservative measure of the potential 24-hour average PM_{10} impacts that may arise across the representative assessment locations.

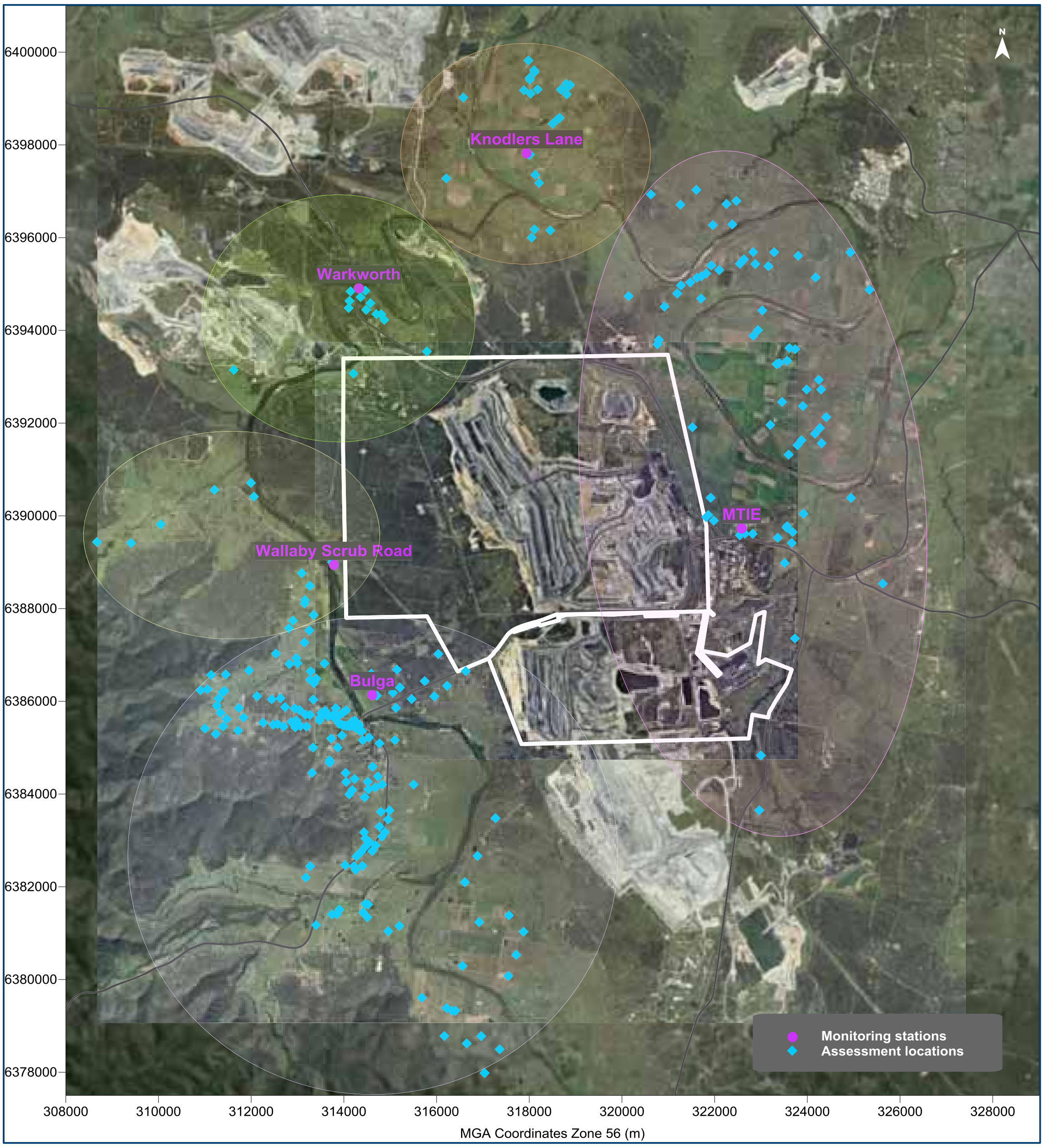

Figure 9-1: Locations available for contemporaneous cumulative impact assessment

9.5.2 Contemporaneous assessment per NSW EPA Approved Methods

An assessment of cumulative 24-hour average PM_{10} impacts was undertaken in accordance with the methods outlined in Section 11.2 of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW DEC**, **2005**). The "Level 2 assessment - Contemporaneous impact and background approach" was applied to assess potential impacts.

As shown in **Section 4**, maximum background levels have in the past reached levels near to the 24-hour average PM_{10} criterion level (depending on the monitoring location and time). As a result, the screening Level 1 NSW EPA approach of adding maximum background levels to maximum predicted proposal only levels would show levels above the criterion.

In such situations, the NSW EPA approach applies a more thorough Level 2 assessment whereby the measured background level on a given day is added contemporaneously with the corresponding proposal only level predicted using the same day's weather data. This method factors into the assessment the spatial and temporal variation in background levels affected by the weather and existing sources of dust in the area on a given day. However, even with a detailed Level 2 approach, any air dispersion modelling has limitations (as described in **Section 8**) in predicting short term impacts which may arise many years into the future, and these limitations need to be understood when interpreting the results.

Ambient (background) dust concentration data for January 2012 to December 2012 from the TEOM stations have been applied in the Level 2 contemporaneous 24-hour average PM_{10} assessment and represent the prevailing measured background levels in the vicinity of Warkworth Mine and surrounding assessment locations.

This period was chosen as it contains meteorological data that if representative for this area, and also as it contains the highest baseline PM_{10} levels measured in Bulga village, but does not contain the anomalous high peaks that occurred during the bushfire period in late 2013 or the relatively low levels that occurred in Bulga village in 2013. The use of this data is likely to result in a generally conservative estimate (ie an overestimate) of the potential cumulative air quality impacts which may be predicted to occur in this area.

As the existing mine was operational during 2012, it would have contributed to the measured levels of dust in the area on some occasions. Due to this it is important to account for these existing activities in the cumulative assessment. Modelling of the actual mining scenario for the 2012 period (in which the weather and background dust data were collected) was conducted to determine the existing contribution to the measured levels of dust. The results were applied in the cumulative assessment to minimise potential double counting of existing mine emissions (as they would occur in both the measured data and in the predicted levels), and thus to make a more reliable prediction of the likely cumulative total dust level.

As the proposal interacts with Warkworth Mine, future Warkworth Mine activities were included as part of the total cumulative assessment of likely future impacts.

Table 9-6 provides a summary of the findings of the contemporaneous assessment at each monitoring location. Detailed tables of the full assessment results are provided in **Appendix F**.

Table 9-6: NSW EPA contemporaneous assessment - maximum number of additional days above 24-hour average criterion depending on background level at monitoring sites

Location	Year 3	Year 9	Year 14
Bulga	0	0	0
Wallaby Scrub Road	0	0	0
Warkworth	1	6	4
Knodlers Lane	0	2	1
MTIE	0	3	0

The results in **Table 9-6** indicate that it is unlikely that cumulative impacts would arise at the assessment locations near the Bulga and Wallaby Scrub Road monitoring locations during the years assessed.

There is potential for cumulative impacts to arise near the Warkworth, Knodlers Lane and MTIE monitoring stations. The potential risk of cumulative impacts at the Knodlers Lane and MTIE monitors is relatively low with only two and three additional days, respectively, of predicted impact above the relevant criterion in Year 9 and only one day for Knodlers Lane in Year 14.

The potential risk of cumulative impacts near the Warkworth monitor is greater with one, six and four additional days predicted to exceed the relevant criterion in Year 3, 9 and 14, respectively. These impacts are as would be expected when analysing the predicted results and isopleth figures in **Appendix E**. The figures show that the prevailing winds would transport material along the mine pit and project dust northwards. As the mine progresses westwards, the impacts to the north of the mine move closer to Warkworth, as represented in the indicative mine plan years assessed.

9.6 Consideration of cumulative $PM_{2.5}$ impacts

There are currently no criteria applicable for $PM_{2.5}$ particulate impact assessment in NSW, however there are NEPM advisory reporting standards that apply to the exposure of the population as a whole, as assessed by monitoring at suitable NEPM "performance monitoring sites"", which are positioned away from "hot spots' such as industry, main roads and other sources of pollution. Compliance with the NEPM standards is assessed by monitoring at such sites, and therefore the NEPM criteria would not generally apply in the near proximity to coal mines, or near to other potentially large sources of particulate emissions.

Despite the absence of suitable criteria, this assessment quantifies the approximate levels of $PM_{2.5}$ that may arise as a result of the proposal.

There are no reliable $PM_{2.5}$ background monitoring data collected at the proposal with which to conduct an accurate technical assessment of impacts and therefore it is necessary to make an approximate assessment to consider 24-hour average $PM_{2.5}$ levels.

The lack of $PM_{2.5}$ data at the proposal is not unusual (such data is rare), but it is an impediment to making an accurate calculation of the likely total $PM_{2.5}$ level in the area. This is especially so in this case as it is known that particulate levels from coal mine emissions contain a relatively small fraction of $PM_{2.5}$ material (approximately 4.7% of TSP from mining– refer to **Section 4.1** and **Section 8.2.2**). This means that in the modelling, where all major mine sources of dust are accounted for, the residual, unaccounted portion of $PM_{2.5}$, for example due to non-mining sources such as wood smoke and other such sources may comprise a significant portion of total $PM_{2.5}$ levels in the environment.

In other words ambient $PM_{2.5}$ levels are likely to be governed by many minor non-mining background sources such as wood heaters and motor vehicles which cannot be reasonably modelled in small populations and rural areas, and there is little $PM_{2.5}$ monitoring data available with which to make a detailed assessment.

The nearest available $PM_{2.5}$ data is collected at the Upper Hunter Air Quality Monitoring Network station at Singleton. This data was examined in the absence of site specific data and is presented in **Figure 9-2**. The graph includes a moving average trend line on a 25 point basis and shows a trend of increasing $PM_{2.5}$ levels in the winter and reduced levels in the summer.

A peak in wintertime $PM_{2.5}$ levels in Singleton is shown. It is unlikely that this arises from mining activity as mining produces a relatively steady level of particulate emissions over the year. It can be reasonably inferred that the increase winter levels of $PM_{2.5}$ may be largely due to urban sources of fine particulate matter such as wood heaters, and that these sources appear to govern the population exposure to $PM_{2.5}$ in this area.

Examination of the available $PM_{2.5}$ measurement data for Singleton shows that during 2012, the annual average $PM_{2.5}$ level is approximately 8µg/m³ and the 70th percentile 24-hour average maximum levels are approximately 9.6µg/m³. Maximum 24-hour average levels are below 25 µg/m³.

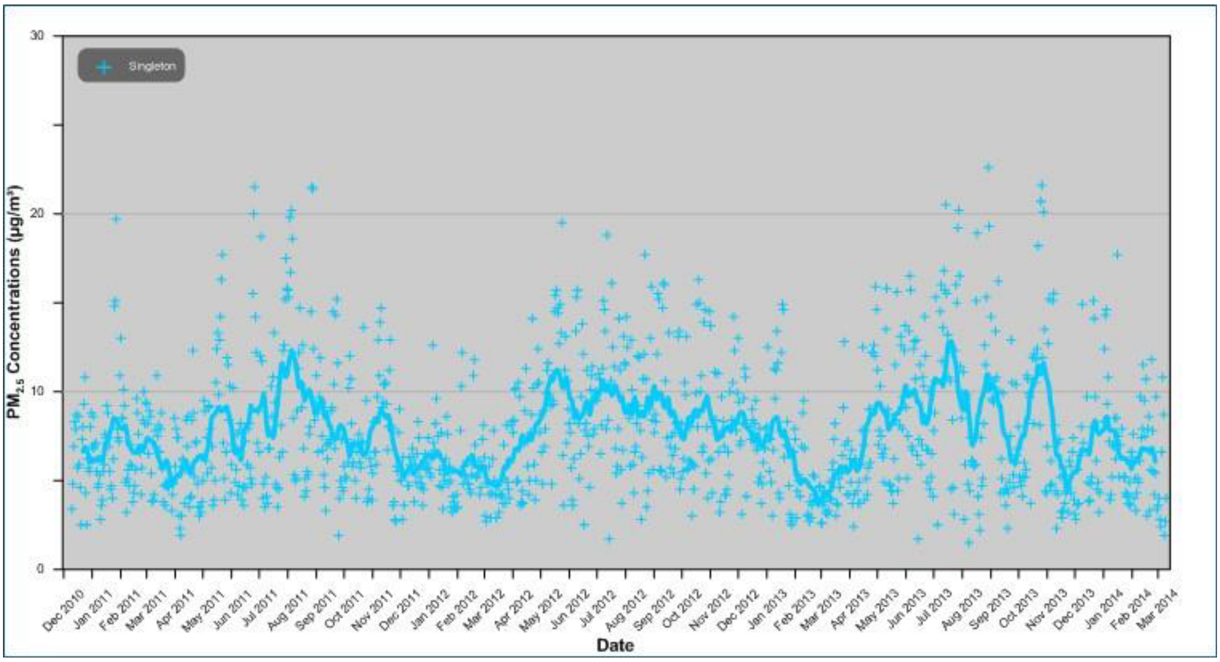

Figure 9-2: Measured $PM_{2.5}$ levels in Singleton

However, as the $PM_{2.5}$ levels in Singleton would be influenced by urban sources of fine particle emissions such as wood heaters, motor vehicles and other combustions sources potentially to a larger extent than the sparsely populated rural receptors surrounding MTO.

This is reflected in the recent CSIRO study (**CSIRO, 2013**) that characterises fine particulate matter in the Hunter Valley region. This study found that wood burning activities in winter make up an average of 62 per cent of the $PM_{2.5}$ in Muswellbrook and 38 per cent of the $PM_{2.5}$ in Singleton.

The monitoring data in Camberwell shows lower levels of $PM_{2.5}$ than are measured in Muswellbrook and Singleton, less of a winter peak, and the location is close to coal mining activity.

On the basis of the available information it would be reasonable to assume that the underlying background levels of $PM_{2.5}$ at the proposal site would be significantly lower than the levels in Singleton, given that wood heaters, people and cars are more widely spaced and, therefore, the likely level has been estimated to be approximately 5µg/m³ on an annual average basis and 9µg/m³ on a 70th percentile 24-hour basis.

Examination of the incremental (mine alone) results for annual and 24-hour $PM_{2.5}$ shown in the tables in **Section 9**, reveals that if these levels were added to the assumed annual average background levels or the 70th percentile 24-hour maximum levels, then no assessment location (predicted to comply with the criteria for other pollutants) would experience $PM_{2.5}$ level above the NEPM advisory reporting standards.

Therefore, the indication is that $PM_{2.5}$ would not appear to be a limiting issue for air quality impacts from the proposal, and that air impacts, including $PM_{2.5}$, would be effectively managed through the existing framework for air quality impact assessment and regulation overseen by NSW EPA and P&I.

The recently released Upper Hunter Air Particles Action Plan (**NSW EPA, 2013**), by the NSW EPA provides additional information about air quality and the actions underway to improve air quality in the Upper Hunter. The action plan has a strong focus on reducing $PM_{2.5}$ levels in the region and outlines 18 actions of which include a dust stop program for coal mining operations, reducing emissions from diesel powered equipment and improving local government wood smoke management in the urban settlements. MTW is actively participating in these relevant actions to assist with the reduction in $PM_{2.5}$ levels from the operation.

10 ASSESSMENT OF DIESEL EMISSIONS

10.1 Preamble

It is generally considered that the quantity of emissions generated from diesel powered equipment used for mining activity is too low to generate any significant off-site concentrations. This is due to consideration of the relatively small individual sources, the generally large distance between the sources and assessment locations, and the generally widely spread distribution of sources across the mine site.

Recent analysis by NSW EPA indicates that a large amount of diesel fuel is used in mining and, consequently, that there may be potential for impacts to arise due to the emissions from diesel powered equipment used during operations.

It is noted that the available data do not indicate any likely issues in this regard. For example, NO_2 is a significant pollutant emitted from the combustion of diesel, yet NO_2 levels at the monitoring stations in the Hunter Valley are low relative to the criteria.

Also, fine particulate (ie $PM_{2.5}$) is a significant pollutant emitted from diesel combustion. However the recent CSIRO study (**CSIRO, 2013**) found that wood burning in winter made up an average of 62 per cent of the $PM_{2.5}$ in Muswellbrook and 38 per cent of the $PM_{2.5}$ in Singleton. Secondary sulphate and industry aged sea salt made the highest contribution during summer months, sulphate levels were found to be comparable to other Australian locations. Vehicle and industry sources comprised of approximately 8 per cent and 17 per cent in Muswellbrook and Singleton, respectively.

Whilst these data may not indicate any issue related to diesel combustion, it is recognised that the locations at which this data was collected are some distance away from coal mines. Thus an assessment of potential impacts from diesel combustion was conducted for the proposal to determine whether any risk may arise. It should be noted that emissions of fine particulate from diesel combustion in mining equipment is generally already included within the assessment of mine dust presented in **Section 8**.

10.2 Approach to assessment

10.2.1 Emission estimation

Emissions from diesel powered equipment were estimated on the basis of manufacturer's data. It is noted that manufacturer's equipment performance specifications were typically categorised on the basis of the US EPA federal tier standards of emissions for diesel equipment (**Dieselnet**, **2012**).

Emissions for certain plant included non-methane-hydrocarbon (NMHC) and NO_x emissions as a single value. For the purpose of this assessment it has been conservatively assumed that the total emission (NHMC and NO_x) comprises NO_2.

The various types of diesel powered mining equipment to be used under the proposal were identified (see **Table 10-1**). Plant hours of operation were based on assumed plant availability and utilisation rates for the specific equipment type, conservatively assuming that all operational plant operates at full power for 20 per cent of the time.

The emission rates used in the modelling are considered conservative and likely to overestimate actual emissions from mining equipment.

Table 10-1: Summary of diesel powered equipment and associated emissions

Equipment type	Number of equipment			CO (g/KWh)	NMHC + NOx / NOx (g/KWh)
	Year 3	Year 9	Year 14		
3600 Excavator	2	-	-	3.5	6.4
Dozer	5	3	-	3.5	3.5
RTD	1	1	-	3.5	6.4
Drill	1	-	-	3.5	6.4
Grader	2	2	2	3.5	4.0
Watercart	1	1	1	1.3	9.2
795 Truck	0	5	3	3.5	6.4
830E Truck	20	10	4	0.8	8.7
789 Truck	6	2	4	11.4	9.2

10.2.2 Dispersion modelling

Dispersion modelling of the diesel powered equipment was conducted for each indicative mine plan year. Modelled sources were described as point sources and incremental impacts due to the proposal were added to the ambient background level to assess potential impacts.

The NO_2 monitoring data presented in **Section 4** shows that the maximum measured 1-hour average NO_2 background level at the Singleton monitor during 2012 was 75.2µg/m^3. In lieu of any data for the site, per the Victorian EPA approach[1], the 70th percentile level of 41.4µg/m^3 obtained from the Singleton data was used as a constant background level contributing to the total cumulative impact predictions. The annual average NO_2 background level at the Singleton monitor during 2012 was 16.9µg/m^3.

It is noted that the background levels measured in Singleton are likely to be higher than the levels for the majority of assessment locations because there are many densely positioned sources of NO_X in Singleton, such as motor vehicles. The measured levels would also include some contribution of emissions arising from the existing operations and thus are considered to be even more conservative and likely to overestimate actual levels.

The conversion of NO_X to NO_2 was estimated using an empirical equation for estimating the oxidation rate of NO in power plant plumes developed by **Janssen et al. (1988)**. This method is outlined in the Approved Methods **(DEC 2005)** and is used to calculate the ratio of NO_2 to NO_X as determined by the atmospheric conditions and distance from the maximum recorded level to the source.

The separation distance from the sources to the maximum predicted 1-hour and annual average ground-level concentrations was taken to be the nominal distance from the centroid of all NOx sources to the nearest likely affected assessment locations. Applying conservative A and α constant values, the ratio of NO_2 to NO_X at receptors due to the diesel powered equipment was calculated to be approximately 15%.

[1]The Victorian Government's State Environment Protection Policy (Air Quality Management), **SEPP (2001)** states at Part B, 3(b) *"Proponents required to include background data where no appropriate hourly background data exists must add the 70th percentile of one year's observed hourly concentrations as a constant value to the predicted maximum concentration from the model simulation. In cases where a 24-hour averaging time is used in the model, the background data must be based on 24-hour averages. "*.

10.3 Modelling predictions

Figure G-1 to **Figure G-6** in **Appendix G** present isopleth diagrams of the predicted modelling results for the assessed 1-hour average and annual average NO_2 concentrations.

Table 10-2 presents the model predictions at each of the assessment locations with background levels included. The assessment locations highlighted in grey are identified as mine-owned assessment locations, and those highlighted in orange are privately-owned assessment locations already in the acquisition zone under the development consent.

Table 10-2: Predicted NO_2 concentrations for each indicative mine plan year

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
1	45	17	43	17	42	17
2	46	17	43	17	42	17
3	46	17	43	17	43	17
4	46	17	43	17	43	17
5	46	17	43	17	43	17
6	46	17	43	17	43	17
7	46	17	43	17	42	17
8	46	17	44	17	43	17
9	46	17	43	17	43	17
10	47	17	44	17	43	17
11*	45	17	43	17	42	17
12	48	17	44	17	43	17
13	47	17	44	17	43	17
14	49	17	45	17	43	17
15	49	17	45	17	43	17
16	50	17	45	17	44	17
17	47	17	44	17	43	17
18	49	17	45	17	43	17
19	47	17	44	17	43	17
20	49	17	45	17	43	17
21	51	17	46	17	44	17
22	48	17	44	17	43	17
23	46	17	44	17	43	17
24	48	17	44	17	43	17
25	46	17	43	17	42	17
26	48	17	44	17	43	17
27	47	17	44	17	43	17
28	46	17	43	17	42	17
29	47	17	44	17	43	17
30	54	17	47	17	45	17
31	53	17	47	17	45	17
32	48	17	44	17	43	17
33	52	17	46	17	44	17
34	46	17	43	17	43	17
35	54	17	47	17	45	17
36	47	17	44	17	43	17
37	48	17	44	17	43	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
38	48	17	44	17	43	17
39	49	17	45	17	43	17
40	49	17	45	17	43	17
41	46	17	43	17	42	17
42	51	17	46	17	45	17
43	48	17	45	17	43	17
44	49	17	45	17	43	17
45	47	17	44	17	43	17
46	49	17	45	17	43	17
47	49	17	45	17	43	17
48	50	17	45	17	43	17
49	50	17	45	17	43	17
50	49	17	45	17	43	17
51	46	17	43	17	42	17
52	48	17	44	17	43	17
53	49	17	45	17	43	17
54	45	17	43	17	42	17
55	50	17	45	17	43	17
56	49	17	45	17	43	17
57	49	17	45	17	43	17
58	51	17	45	17	43	17
59	50	17	45	17	43	17
60	50	17	45	17	43	17
61	45	17	43	17	42	17
62	50	17	45	17	43	17
63	51	17	45	17	43	17
64	51	17	45	17	43	17
65	51	17	45	17	43	17
66	50	17	45	17	43	17
67	45	17	43	17	42	17
68	51	17	45	17	43	17
69	50	17	45	17	43	17
70	45	17	43	17	42	17
71	50	17	45	17	43	17
72	50	17	46	17	43	17
73	50	17	45	17	43	17
74	46	17	43	17	42	17
75	51	17	46	17	43	17
76	48	17	44	17	43	17
77	44	17	43	17	42	17
78	44	17	43	17	42	17
79*	44	17	43	17	42	17
80	45	17	43	17	42	17
81	50	17	45	17	44	17
82	47	17	44	17	42	17
83*	43	17	43	17	42	17
84	45	17	43	17	42	17
86	51	17	46	17	43	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
87	51	17	46	17	44	17
89	46	17	43	17	42	17
90	43	17	43	17	42	17
91*	44	17	43	17	42	17
92*	46	17	43	17	42	17
93	44	17	43	17	42	17
94*	43	17	43	17	42	17
95	53	17	47	17	44	17
96*	44	17	43	17	42	17
97	51	17	45	17	44	17
98	54	17	46	17	44	17
99*	44	17	43	17	42	17
100	50	17	44	17	44	17
101	51	17	45	17	44	17
102	44	17	43	17	42	17
103*	48	17	44	17	42	17
104	53	17	45	17	44	17
105	44	17	43	17	42	17
106	53	17	44	17	44	17
107	56	17	45	17	44	17
108	50	17	45	17	45	17
109*	45	17	43	17	42	17
110	57	17	46	17	45	17
111	45	17	42	17	42	17
112	60	17	49	17	47	17
113*	46	17	43	17	42	17
114	43	17	42	17	42	17
115*	51	17	44	17	42	17
116	43	17	42	17	42	17
117	43	17	42	17	42	17
118	43	17	42	17	42	17
118	43	17	42	17	42	17
119	43	17	42	17	42	17
120	43	17	42	17	42	17
121	43	17	42	17	42	17
122	43	17	42	17	42	17
123	43	17	42	17	42	17
124	43	17	42	17	42	17
125	43	17	43	17	42	17
126	44	17	43	17	43	17
127	44	17	43	17	42	17
128	44	17	43	17	43	17
129	43	17	43	17	43	17
130	43	17	43	17	43	17
131	45	17	44	17	43	17
133	43	17	43	17	42	17
134	43	17	43	17	43	17
135	47	17	45	17	44	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
136	47	17	45	17	44	17
137	43	17	43	17	42	17
138	47	17	45	17	43	17
139	43	17	43	17	42	17
140	47	17	46	17	44	17
141	43	17	42	17	42	17
142	43	17	43	17	43	17
143	43	17	43	17	43	17
144	46	17	44	17	44	17
145*	49	17	47	17	45	17
146	46	17	44	17	44	17
147	45	17	43	17	43	17
148	45	17	44	17	44	17
149	46	17	45	17	44	17
150	45	17	44	17	43	17
151*	48	17	45	17	45	17
152	45	17	43	17	43	17
153	45	17	44	17	44	17
154*	45	17	43	17	43	17
155	44	17	43	17	42	17
156	44	17	43	17	42	17
157	44	17	43	17	42	17
158	43	17	42	17	42	17
160	43	17	42	17	42	17
161	43	17	42	17	42	17
162	43	17	42	17	42	17
163	43	17	42	17	42	17
165	43	17	42	17	42	17
167	43	17	42	17	42	17
168	43	17	42	17	42	17
169	43	17	42	17	42	17
170	43	17	42	17	42	17
172	43	17	43	17	43	17
173	43	17	43	17	43	17
174	43	17	42	17	42	17
175	43	17	42	17	42	17
176	43	17	42	17	42	17
177	43	17	42	17	42	17
178	44	17	42	17	42	17
179	44	17	42	17	42	17
180	45	17	43	17	43	17
181	45	17	43	17	43	17
182	45	17	43	17	43	17
183	45	17	43	17	43	17
184	44	17	43	17	43	17
185	44	17	43	17	43	17
186	44	17	43	17	43	17
187	44	17	43	17	43	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
188	45	17	43	17	43	17
189*	45	17	43	17	43	17
190	45	17	44	17	43	17
191	45	17	43	17	43	17
192	45	17	43	17	43	17
193	43	17	42	17	42	17
194*	43	17	42	17	42	17
195*	45	17	43	17	42	17
196*	46	17	43	17	42	17
197	44	17	42	17	42	17
198*	43	17	42	17	42	17
199	43	17	42	17	42	17
200	43	17	42	17	42	17
201	43	17	42	17	42	17
202	43	17	42	17	42	17
203	43	17	42	17	42	17
204	43	17	42	17	42	17
205	43	17	42	17	42	17
206	43	17	42	17	42	17
207	43	17	42	17	42	17
208	44	17	42	17	42	17
209*	48	17	44	17	43	17
210	51	17	45	17	43	17
211	51	17	46	17	43	17
215	54	17	47	17	45	17
217	47	17	44	17	43	17
218	46	17	43	17	42	17
219	45	17	43	17	42	17
220	46	17	43	17	43	17
221	45	17	43	17	42	17
222	45	17	43	17	42	17
223	46	17	43	17	42	17
224	45	17	43	17	42	17
225	46	17	43	17	42	17
226	46	17	43	17	42	17
227	46	17	43	17	43	17
228	46	17	43	17	42	17
229	46	17	44	17	43	17
230	45	17	43	17	43	17
231	46	17	43	17	43	17
234	45	17	43	17	42	17
235	45	17	43	17	42	17
236	46	17	43	17	42	17
237	45	17	43	17	42	17
238	46	17	43	17	42	17
243	45	17	43	17	42	17
244	43	17	42	17	42	17
245	43	17	42	17	42	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
246	43	17	42	17	42	17
247	43	17	42	17	42	17
248	43	17	42	17	42	17
249	43	17	42	17	42	17
250	44	17	42	17	42	17
251	43	17	42	17	42	17
252	47	17	44	17	42	17
253	47	17	44	17	43	17
254	46	17	43	17	42	17
255	50	17	45	17	44	17
256	42	17	42	17	42	17
257	43	17	42	17	42	17
258	43	17	42	17	42	17
259	43	17	42	17	42	17
260	43	17	42	17	42	17
261	43	17	42	17	42	17
262	44	17	43	17	43	17
263	45	17	43	17	43	17
264	44	17	43	17	42	17
265	43	17	42	17	42	17
266	44	17	42	17	42	17
267	43	17	42	17	42	17
268	43	17	42	17	42	17
269*	46	17	43	17	42	17
270*	45	17	43	17	42	17
271*	44	17	43	17	42	17
903	45	17	43	17	42	17
904	45	17	43	17	42	17
905	44	17	43	17	42	17
909	45	17	43	17	42	17
911	44	17	43	17	42	17
915	46	17	44	17	44	17
917	45	17	43	17	42	17
918	45	17	43	17	42	17
919	47	17	44	17	43	17
920	50	17	45	17	43	17
921	45	17	43	17	42	17
922	44	17	43	17	42	17
923	43	17	42	17	42	17
926	44	17	42	17	42	17
927a	44	17	43	17	42	17
927b	44	17	43	17	42	17
927c	44	17	43	17	42	17
927d	43	17	42	17	42	17
927e	43	17	42	17	42	17
927f	43	17	42	17	42	17
927g	43	17	42	17	42	17
927h	43	17	42	17	42	17

Assessment locations ID	Year 3		Year 9		Year 14	
	1-hour average	Annual average	1-hour average	Annual average	1-hour average	Annual average
927i	43	17	42	17	42	17
927j	43	17	42	17	42	17
928	45	17	43	17	42	17
929	45	17	43	17	42	17
932	46	17	45	17	44	17
936	45	17	43	17	42	17
937a	44	17	43	17	42	17
937b	44	17	42	17	42	17
937c	44	17	42	17	42	17
937d	44	17	43	17	42	17
937e	44	17	43	17	42	17
941*	44	17	43	17	42	17

*Other mine owned property

10.4 Results

10.4.1 Analysis of NO_2 modelling

The modelling predictions in **Table 10-2** indicate that in Year 3, 9 and 14 all assessment locations are predicted to experience maximum 1-hour average and annual average NO_2 concentrations below the relevant criterion of 246µg/m^3 and 63µg/m^3, respectively.

10.4.2 Other diesel powered plant impacts

The ambient air quality goals for CO are set at higher concentration levels than the NO_2 goals. Based on the NO_2 monitoring data which are low compared to the goals, and consideration of the typical mix of ambient pollutant levels and associated emissions of CO, the indication is that predictions of CO would be well below the air quality goals and do not require further consideration.

11 ASSESSMENT OF BLAST FUME EMISSIONS

11.1 Preamble

Air quality impacts of blast operations at MTO are managed under MTW's Blast Management Plan (BMP) MTW-10-ENVMP-SITE-060. The purpose of the BMP is to ensure that blasting operations comply with all relevant requirements particularly noise, overpressure, vibration, blast fume and dust effects.

The BMP applies a blasting permissions flowchart to guide operators on the suitability of various factors including the current weather conditions for blasting. The BMP takes into consideration meteorological factors such as wind speed and direction which can affect the scale of potential blast impacts at assessment locations.

A predictive blast system is also used, to schedule blast events to the least-risk time of the day where feasible. This approach minimises the risk of any off-site impact occurring, and is based on hourly forecast weather conditions that may affect the dispersion of blast emissions.

11.2 Approach to assessment

11.2.1 Emission estimation

Blast fume emissions (NO_2) were estimated on the basis of emission levels presented in a CSIRO study into Hunter Valley blasts (**Attala et al., 2008**). Blast fume emissions can vary greatly depending on a number of factors but largely depend on the tendency of a particular blast to generate NO_2 emissions. The assessment is based on the measured level of emissions presented in the CSIRO study.

11.2.2 Dispersion modelling

Dispersion modelling of the potential blast fume emissions was conducted for the Year 3 indicative mine plan year. The model setup was generally in accordance with the setup discussed in **Section 6**. Blast emission sources were modelled in the centre of the active pit location. It is noted that the source location would vary; however, for the purposes of this assessment it is considered that the centre of the pit would provide a suitable indication of the potential impacts.

The model was set up to generate a blast during each hour of the day when blasting is permitted, and considering weather conditions and the existing blast permissions. In other words the model was programmed to halt a blast based on the weather condition if that is what the blasting permissions would require.

As a comparison, modelling of blasts during each hour of the day without consideration of the blasting permissions was also conducted to determine the suitability of these permissions.

11.3 Modelling predictions

Figure H-1 to **Figure H-9** in **Appendix H** present isopleth diagrams of the predicted modelling results for the assessed maximum 1-hour average NO_2 concentrations during each potential blast hour of each year. It should be noted that the isopleth diagrams show the maximum hourly extent of all potential blasts in all daytime hours in a full year per the blast permissions, and do not represent a single blast event.

The isopleth diagrams indicate that based on the potential blast hours in each day, blasts occurring at 4:00pm and 5:00pm have the potential to result in adverse blast fume impacts. This indicates that the meteorological conditions during these periods may at times be unfavourable for blasting and the most case should be taken if conducting blasting at these times.

The decision to blast under such conditions is based on skilled and experienced operator judgement of the actual prevailing weather conditions, forecast weather conditions and the expected nature of potential plume travel towards the nearest assessment locations. It is not reasonably possible to incorporate the human decision making element of the blast permissions into a computer model, thus it is considered likely that the potential late evening impacts that are predicted in the modelling would not arise in practice, due to the benefit of the actual human intervention that occurs.

An examination of the blast impact isopleth diagrams shown in **Figure H-1** to **Figure H-9** in **Appendix H** was conducted to analyse any potential issues of compliance with the NO_2 criterion of 246µg/m^3, 1-hour average. The red isopleths show the impact that could hypothetically occur if blasting occurred without any regard to the blast permissions (on every hour of the day) and the light blue isopleths show the potential impact if the blast permissions that apply are adhered to.

The results indicate that whilst the blast permissions take into account the location of the blast in reference to the surrounding assessment locations, the prevailing meteorological conditions in which blasts are not permitted occur infrequently and the modelling results show little difference.

11.4 Conclusions

Overall, it is noticeable that during the middle daytime hours no impacts due to blasting fume emissions are predicted to occur. During these times, the blast permissions have a relatively small effect in mitigating impacts (largely as there would not be any appreciable impact to mitigate).

However, in the early evening, when there is potential for impacts to arise off-site, the results show that application of the blasting permissions would avert such potential impacts for most assessment locations.

It is noted that in this regard MTW have implemented a predictive management system to aid with management of blasting operations. Such a system uses actual conditions for each blast to predict the potential impact which may occur. The prediction is made on the basis of forecast weather data, allowing operators to schedule a blast to the time of least impact over the course of the upcoming day. In effect the system updates the blasting permissions for each individual blast on the basis of predicted impact. The system thus deals with the spatially and time varying weather and terrain influences and is generally more reliable than relying on a fixed set of wind speed and wind direction restrictions.

Overall, it is anticipated that with due care, potential blast impacts would be averted.

12 PARTICULATE MATTER HEALTH EFFECTS

12.1 Introduction

The following section is a summarised excerpt of private correspondence from Environmental Risk Sciences Pty Ltd to Todoroski Air Sciences.

Detailed reviews of the available studies that relate to health effects associated with exposure to particulates are available from various sources (**NEPC 2010, USEPA 2009**, **Anderson et al. 2004, WHO 2003, OEHHA 2002**). Particulate matter is comprised of a diverse range of substances, with varying morphological, chemical, physical and thermodynamic properties, across a large size range. Particulates can be derived from natural sources such as crustal dust, pollen, sea salts and moulds, and anthropogenic (human) activities including combustion and industrial processes. Secondary particulate matter is formed via atmospheric reactions of primary gaseous emissions. The most significant contributors to secondary particulates include nitrogen oxides, ammonia, sulfur oxides, and certain organic gases (emitted from vehicles, combustion, agriculture, industry and biogenic sources).

Particulate matter comprises particles which can remain suspended in the air for extended periods, and is typically classified by particle size.

12.2 Particulate size

The size of particulates is important as it determines how far from an emission source the particulates may be present in air (with larger particulates settling out first and smaller particles remaining airborne for greater distances) but also the potential for adverse effects to occur as a result of exposure.

The common measures of particulate matter that are considered in the assessment of air quality and health risks are previously outlined in **Section 4.1** with more detail in regard to health as follows:

- TSP refers to all particulate with an equivalent aerodynamic particle size below approximately 50µm diameter. Larger particles (termed "inspirable", comprise particles around 10µm and larger) that may cause nuisance and would deposit out of the air (measured as deposited dust) closer to the source. Such particles, if inhaled are mostly trapped in the upper respiratory system[2] and do not reach the lungs. Finer particles (smaller than 10µm, termed "respirable") tend to be of more concern as these particles can penetrate into the lungs. As only a fraction of TSP material is harmful to human health, it is a measure of nuisance impact, not health impact.

- PM_{10}, particulate matter below 10µm in diameter, $PM_{2.5}$, particulate matter below 2.5µm in diameter and PM_1, particulate matter below 1µm in diameter. These particles are small and have the potential to penetrate beyond the nose and upper respiratory system, with the smaller particles able to penetrate into the lower respiratory tract[3] and lungs which may result in adverse health effects (**OEHHA, 2002**).

[2] The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

[3] The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

Monitoring for PM_{10} is the most commonly applied metric in local and regional air quality monitoring program. Smaller particulates such as $PM_{2.5}$ and PM_1 are generally of most significance with respect to evaluating health effects as a higher proportion of these particles penetrate into the lungs; however, monitoring for such particulate matter is technically challenging and thus is not widely established. Thus PM_{10} monitoring serves as a defacto method of measuring $PM_{2.5}$ (**WHO, 2005**).

Apart from small aerodynamic diameter factors such as the hygroscopicity, electrostatic charge, and characteristics of the human respiratory system including airway structure and geometry, as well as depth, rate and mode of breathing (eg nasal vs. oral/nasal) affect the extent of particulate penetration and deposition into the lung.

A significant amount of research has been conducted on the health effects of particulates with causal effects relationships identified for exposure to $PM_{2.5}$. A more limited body of evidence suggests an association between exposure to larger particles, PM_{10} and adverse effects (**USEPA, 2009 and WHO, 2003**).

12.3 Particulates composition

Evaluation of size alone in regard to particle health impacts is difficult as particle size may not be independent of chemical composition. Certain particulate size fractions tend to contain certain chemical components, such as crustal materials in the coarse particle fraction (PM_{10} or larger) or metals in fine particulates (<$PM_{2.5}$). In addition, different sources of particulates may emit other pollutants in addition to particulate matter. For example, combustion sources, the dominant particulate source in urban areas, emit predominantly fine particulates as well as gaseous pollutants such as ozone, nitrogen dioxide, carbon monoxide and sulfur dioxide, all of which have independent health effects.

There is strong evidence (**WHO, 2003**) to conclude that fine particles (<2.5µm, $PM_{2.5}$) are more hazardous than coarse particles, primarily on the basis of studies conducted in urban air environments where there is a higher proportion of fine particulates present from fuel combustion sources, rather than from crustal origins. Studies indicate that particles generated from fossil fuel combustion may be a significant contributor to adverse health outcomes. Amongst the characteristics found to be contributing to these outcomes are high organic carbon content, metal content, presence of Poly-cyclic Aromatic Hydrocarbons (PAHs), other organic components, endotoxin and both small (<2.5µm) and extremely small size (<100nm) particulate (**USEPA 2009, WHO 2006a**, **WHO 2003**).

This does not mean that the coarse fraction of PM_{10} is not harmful, however, it appears to be a less critical source (**WHO, 2003 and USEPA, 2009**).

The observed health effects are derived from studies conducted in urban areas, whereas the actual health impacts from particulate matter in a specific location would be affected by the specific characteristics of the mix of particulate matter at the location.

Reviews of the currently available information have not been able to identify any single physical or chemical property of particles that is responsible for the array of adverse health outcomes reported in epidemiological studies (**USEPA, 2009 and WHO, 2003**). Hence, WHO (**WHO, 2006b**) and NEPC (**NEPC, 2010**) concluded that the evidence at present cannot support an indicator for a standard that is more specific than size fraction alone.

As a consequence, the potential for adverse health effects is assumed to apply equally for all sources and composition of particulates at this time.

12.4 Health effects

Adverse health effects associated with exposure to particulate matter have been primarily derived from population-based epidemiological studies. It is difficult to obtain reliable measures of $PM_{2.5}$, hence much of data considered in the studies is based on ambient PM_{10} data measured in urban areas.

Short term exposure (days to weeks) and long term exposure (years) to PM_{10} has been linked to adverse health effects.

Mortality effects relate to the increase in the number of deaths due to existing (underlying) respiratory or cardiovascular diseases that have been associated with exposure to PM_{10} or $PM_{2.5}$ in population-based epidemiological studies.

Morbidity effects relate to a wide range of health indicators used to define illness or the severity of illness associated with exposure to PM_{10} or $PM_{2.5}$, primarily related to the respiratory and cardiovascular system (**USEPA, 2009 and Morawska et al., 2004**) and include:

- Aggravation of existing respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits, school absences, work loss days, and restricted activity days);
- Changes in cardiovascular risk factors such as blood pressure;
- Changes in lung function and increased respiratory symptoms (including asthma);
- Changes to lung tissues and structure; and
- Altered respiratory defence mechanisms.

These effects are commonly used as measures of population exposure to particulate matter in community epidemiological studies. While there is general agreement on the mortality effects associated with exposure to particulate matter, it is noted that there is less agreement on the wide range of morbidity indicators.

12.5 Summary of health effects

The following table presents a summary of the adverse effects associated with exposure to particulate matter in generally large cities and the susceptible populations identified (relevant to the health endpoint).

Table 12-1: Summary of potential adverse health effects from exposure to particulate matter in cities

Health-effect	Susceptible group	Comments
Short term		
Mortality	Elderly, infants, persons with chronic cardiopulmonary disease, influenza or asthma	Causal relationship has been identified for exposure to PM_{10} and $PM_{2.5}$.
Hospitalisation rates (respiratory and cardiovascular effects)	Elderly, infants, persons with chronic cardiopulmonary disease, pneumonia, influenza or asthma	Reflects substantive health impacts in terms of illness, discomfort, treatment costs, work or school time lost.
Increased respiratory symptoms	Most consistently observed in people with asthma, and children	For most, effects are transient with minimal overall health consequences. May result in some short term absence from work or school due to illness.
Decreased lung function	Observed in both children and adults	For most, effects seem to be small and transient.
Long term		
Increased mortality rates, reduced survival times, chronic cardiopulmonary disease, reduced lung function, lung cancer	Observed in population-wide epidemiological studies, including adults, children and infants. All chronically exposed are potentially affected	Long-term repeated exposure appears to increase the risk of cardiopulmonary disease and mortality. May also result in lower lung function.

12.6 Considerations relevant to mining

Table 12-1 relates to studies of human exposure to particulate matter in generally large cities, where a larger portion of the particulates are in the fine fraction that would penetrate into the lung, and also where a greater portion of the particulate matter is from combustion sources, and thus carries with it other individually toxic substances that are damaging to human health.

It is important to understand that the majority of particulate emissions from mining are dust which originates from the soil. Due to the extreme forces required at the micro level to break down a particle of dust into smaller particles in the fine fraction, mining techniques used at coal mines generally cannot breakdown rock, coal or soil material into these very fine fractions. As a result emissions from mines are predominantly in the coarse size fraction which would not penetrate as deeply into the lung, or carry additional toxic combustion substances. On average it has been measured that approximately 5 per cent of the total dust (TSP) from mining is in the $PM_{2.5}$ size fraction, and approximately 12 per cent of PM_{10} from mining is in the $PM_{2.5}$ fraction (**SPCC, 1986**).

In contrast, in the urban areas in which the majority of the health studies have been conducted, approximately 50 per cent of the PM_{10} is comprised of particles in the $PM_{2.5}$ size range, and most of these are from combustion.

It needs to be understood that rural populations are simply too small for conclusive epidemiological studies to be conducted in those areas, and insufficient alternative data is available for rural areas to identify specific issues that health experts can agree on. Therefore, as a matter of precaution, the findings for urban areas (as shown in **Table 12-1**) are extrapolated to cover rural areas in order to have a basis for managing exposure to particulate matter for rural populations.

This is not to say that particulate emissions from mining are harmless. Mining emissions include a component of particles in the PM_{10} and $PM_{2.5}$ range and this would include fine combustion particles from diesel equipment.

In the context of health impacts in rural areas, it needs to be noted that in many rural areas domestic wood smoke is a key issue of health impact. Wood smoke warrants close attention in any evaluation of health impact as it can be a significant, highly localised source of toxic pollution in the winter period for rural communities and individuals.

The recent studies by CSIRO (**CSIRO, 2013**) into the composition of particulate matter in the Hunter Valley found that a key source of fine particulate is wood smoke. As has occurred in many rural towns, NSW EPA has launched an initiative to target particulates in the Hunter Valley (**NSW EPA, 2013**), and a key action relates to management of wood smoke in the urban areas.

In this regard it is also important to interpret emission inventory data, such as NPI data and data from NSW EPA's air emissions inventory for the Greater Metropolitan Region (GMR) in NSW in the correct context. For example, if one compares mine dust emissions with those from wood heaters based on only the inventory data, one would see that the two produce roughly the same amount of $PM_{2.5}$ emissions. However, it would be wrong to conclude that mines and wood heaters have similar health impacts on the residential population. Unlike coal mines, wood heaters are located inside living rooms and their chimneys are closer to residents than coal mines, which means the air that the population breathes will be affected by wood heater emissions to a much greater degree.

It also needs to be noted that health should be considered in terms of risk of adverse impacts to individuals residing in a specific location, but also in regard to the impacts on the whole community. In the Hunter Valley, the community includes mine workers, and to maintain overall population health it is reasonable to also minimise mine staff exposure to pollutants that may be harmful, or to situations that may be dangerous.

13 GREENHOUSE GAS ASSESSMENT

13.1 Introduction

Dynamic interactions between the atmosphere and surface of the earth create the unique climate that enables life on earth. Solar radiation from the sun provides the heat energy necessary for this interaction to take place, with the atmosphere acting to regulate the complex equilibrium. A large part of this regulation occurs from the "greenhouse effect" with the absorption and reflection of the solar radiation dependent on the composition of specific greenhouse gases in the atmosphere.

Over the last century, the composition and concentration of greenhouse gases in the atmosphere has increased due to increased anthropogenic activity. Climatic observations indicate that the average pattern of global weather is changing as a result. The measured increase in global average surface temperatures indicate an unfavourable and unknown outcome if the rate of release of greenhouse gas emissions remain at the current rate.

This assessment aims to estimate the predicted emissions of greenhouse gases (GHG) to the atmosphere due to the proposal and to provide a comparison of the direct emissions from the proposal at the state and national level.

13.2 Greenhouse gas inventory

The National Greenhouse Accounts (NGA) Factors document published by the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICSRTE) defines three scopes (Scope 1, 2 and 3) for different emission categories based on whether the emissions generated are from "direct" or "indirect" sources.

Scope 1 emissions encompass the direct sources from the proposal defined as:

"*...from sources within the boundary of an organisation as a result of that organisation's activities*" (**DIICSRTE, 2013a**).

Scope 2 and 3 emissions occur due to the indirect sources from the proposal as:

"*...emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation*" (**DIICSRTE, 2013a**).

For the purpose of this assessment, emissions generated in all three scopes defined above provide a suitable approximation of the total GHG emissions generated from the proposal.

Scope 3 emissions can often result in a significant component of the total emissions inventory; however, these emissions are often not directly controlled by the proposal. These emissions are understood to be considered in the Scope 1 emissions from other various organisations related to the proposal. The primary contribution of the Scope 3 emissions from the proposal occurs from the transportation of the product coal and from the end use of the product coal.

Scope 3 emissions also have the potential to arise from a greater number of sources associated with the operation of the proposal. As these are often difficult to quantify due to the diversity of sources and relatively minor individual contributions, they have not been considered in this assessment.

13.2.1 Emission sources

Scope 1 and 2 GHG emission sources identified from the operation of the proposal are the on-site combustion of diesel fuel, petrol fuel, petroleum based greases and oils, explosives, emissions of methane from the exposed coal seams, gaseous fuels and on-site consumption of electricity.

Scope 3 emissions have been identified as resulting from the purchase of diesel, petrol, petroleum based greases and oils, electricity for use on-site, the transport of product to its final destination and the final use of the product.

Estimated quantities of materials that have the potential to emit GHG emissions associated with Scope 1 and 2 emissions for the proposal have been summarised in **Table 13-1** below. These estimates are based on a conservative upper limit of the assumed maximum production throughout the life of the proposal. The assessment provides a reasonable worst case approximation of the potential GHG emissions for the purpose of this assessment.

Table 13-1: Summary of quantities of materials estimated for the proposal

Period	ROM coal (tonnes)	Diesel (kL)	Petrol (kL)	Grease/oils/lubes (kL)	Electricity (kWh)	Explosives (t)	LPG (kL)	Acetylene (m^3)
Annual	10,000,000	64,850	69	480	99,832	37,580	0.11	710.35
Total	50,000,000	324,248	347	2,399	499,158	187,902	1.0	3,552

Scope 3 emissions for the transport and final use of the coal may have the potential to vary in the future depending on the market situation at the time. These assumptions include emission factors for the transport modes of rail and shipping and the associated average weighted distance travelled for the export coal.

13.2.2 Emission factors

To quantify the amount of carbon dioxide equivalent (CO_2-e) material generated from the proposal, emission factors obtained from the NGA Factors (**DIICSRTE, 2013a**) and other sources as required and are summarised in **Table 13-2**.

Table 13-2: Summary of emission factors

Type	Energy content factor	Emission factor			Units	Scope	Source
		CO_2	CH_4	N_2O			
Diesel	38.6	69.2	0.2	0.5	kg CO_2-e/GJ	1	Table 4 (**DIICSRTE, 2013a**)
		5.3				3	Table 40 **DIICSRTE, 2013a**)
Petrol	34.2	66.7	0.6	2.3	kg CO_2-e/GJ	1	Table 4 (**DIICSRTE, 2013a**)
		5.3				3	Table 40 (**DIICSRTE, 2013a**)
Grease/oils/lubes	38.8	27.9			kg CO_2-e/GJ	1	Table 3 (**DIICSRTE, 2013a**)
		5.3				3	Table 40 (**DIICSRTE, 2013a**)
Electricity		0.87			kg CO_2-e/kWh	2	Table 5 (**DIICSRTE, 2013a**)

Type	Energy content factor	Emission factor			Units	Scope	Source
		CO_2	CH_4	N_2O			
		0.19				3	Table 41 (**DIICSRTE, 2013a**)
Explosives[(1)]		0.18			t CO_2-e/tonne	1	Table 4 (**DCC, 2008**)
LPG	25.7	1.547			kg CO_2-e/GJ	1	Proponent
Acetylene	0.0393	0.002			t CO_2-e/m^3	1	Proponent
Fugitive emissions		0.045			kg CO_2-e/t ROM	1	Table 7 (**DIICSRTE, 2013a**)
Rail		16.66			t CO_2-e/Mt-km	3	Proponent
Ship – Handy		5.422			t CO_2-e/Mt-km	3	Proponent
Ship – Panamax		3.459			t CO_2-e/Mt-km	3	Proponent
Ship – Bulk Carrier		2.090			t CO_2-e/Mt-km	3	Proponent
Thermal coal[(2)]	29	88.2	0.03	0.2	kg CO_2-e/GJ	3	Table 1 (**DIICSRTE, 2013a**)

[(1)]Assumes all explosives considered as Heavy ANFO
[(2)]Assumes type of coal is anthracite

Product coal is transported to the Port of Newcastle by rail and then transferred to coal loaders before being shipped to its final destination. The approximate rail distance is taken to be 166km (return distance). The approximate shipping distance of 13,000km (return distance) is based predominately on destinations in the Asian market.

The emissions generated from the end use of coal produced by the proposal have assumed that 5 per cent of the product coal is consumed at the Redbank power station and the remaining quantity is assumed to be used in power generation and steel manufacturing. As it is difficult to estimate emissions from power stations in other countries, this assessment has assumed the emissions generated would be equivalent to those generated from a power station in NSW. For the product coal used in steel manufacture we have taken a mass balance approach and assumed that all the carbon used will be converted to CO_2, where in reality some of the carbon would be captured in the steel. This approach is very conservative; however, in the absence of specific data, it has been adopted for this assessment.

13.3 Summary of greenhouse gas emissions

Table 13-3 summarises the estimated annual CO_2-e emissions due to the operation of the proposal.

Table 13-3: Summary of CO_2-e emissions for the proposal (t CO_2-e)

		Annual	Total
Fugitive emissions	Scope 1	203,163	1,015,823
Diesel	Scope 1	174,973	874,866
	Scope 3	13,267	66,335
Petrol	Scope 1	165	827
	Scope 3	13	63
Grease/oil/lubes	Scope 1	519	2,597
	Scope 3	99	493
Electricity	Scope 2	86,854	434,268
	Scope 3	18,968	94,840
Explosives	Scope 1	6,764	33,822
LPG	Scope 1	4.3	21.3
Acetylene	Scope 1	0.06	0.28
Transport via rail	Scope 3	18,391	91,955
Transport via ship	Scope 3	248,288	1,241,441
Final use of product – power supply	Scope 3	9,424,427	47,122,136

		Annual	Total
Final use of product – steel	Scope 3	12,191,667	60,958,333

13.4 Contribution of greenhouse gas emissions

Table 13-4 summarises the emissions associated with the proposal based on Scopes 1, 2 and 3.

Table 13-4: Summary of CO2-e emissions per scope (t CO_2-e)

Period	Scope 1	Scope 2	Scope 3
Annual	385,591	86,854	21,915,119
Total	**1,927,957**	**434,268**	**109,575,596**

The estimated annual greenhouse emissions for Australia for the period October 2012 to September 2013 was 567.5 Mt CO_2-e (**DoE, 2014**). In comparison, the conservative estimated annual average greenhouse emission over the 21-year life of the proposal is 0.472Mt CO_2-e (Scope 1 and 2). Therefore, the annual contribution of greenhouse emissions from the proposal in comparison to the Australian greenhouse emissions for the period October 2012 to September 2013 is conservatively estimated to be approximately 0.1 per cent.

At a state level, the estimated greenhouse emissions for NSW in the 2010-11 period was 159 Mt CO_2-e (**DIICSRTE, 2013b**). The annual contribution of greenhouse emissions from the proposal in comparison to the NSW greenhouse emissions for the 2010-11 period is conservatively estimated to be approximately 0.3 per cent.

The estimated greenhouse gas emissions generated in all three scopes are based on approximated quantities of materials and where applicable generic emission factors. Therefore, the estimated emissions for the proposal are considered conservative.

13.5 Greenhouse gas management

The proposal will continue to utilise various mitigation measures to minimise the overall generation of greenhouse gas emissions. The proposal's climate change programme has objectives in four key areas delivered through ongoing integration into existing business processes:

- Supporting research and promotion of technologies that reduce carbon dioxide emission from the use of coal;
- The improved use of energy at operations, projects and supply chain;
- Designing future projects with energy efficiency and climate change risks considered; and
- Raising awareness amongst stakeholders that climate change is an issues that requires us all to change how we currently operate.

Research programme funding is provided for the COAL21 Fund, the Australian Coal Association Research Programme (ACARP) and the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) to support and develop the research of low emissions coal technologies.

The bulk consumption of diesel is monitored and reported monthly with the on-site fuel management system monitoring the quantity of fuel dispensed from tanks and service trucks through metering. Vehicles and plant equipment are fitted with identification tags to assist in tracking diesel consumption; the regular maintenance of diesel equipment ensures operational efficiency.

The total site electricity consumption is monitored and reported monthly with significant infrastructure and equipment such as the CPPs, draglines and electric rope shovels fitted with various meters to monitor electricity consumption.

MTW have developed and implemented energy efficiency performance metrics for fuel and electricity consumption which are tracked monthly against internal targets.

Waste is managed across the site in accordance with an appropriate waste management procedure. Waste management contributes to energy efficiency through measures such as planning when purchasing items to avoid or minimise waste with preference is given to products that are recyclable and reusable over ones that are not; consideration of minimum of packaging or packaging which is reusable or recyclable; and segregating waste to facilitate maximum reuse or recycling.

14 CONCLUSION

The study has identifies the potential air quality impacts that may arise from the proposal. The assessment utilises air dispersion modelling and focuses on potential dust impacts from the proposal in isolation (incrementally) and cumulatively with other nearby mines and background levels of dust. The assessment also investigates the potential air quality impacts associated with diesel fuel combustion, blast fume emissions and calculates potential greenhouse gas emissions.

The dispersion modelling predictions show that 18 assessment locations may experience levels above the relevant criterion for certain dust metrics due to the proposal.

Of these 18 potentially affected assessment locations, 15 are mine owned properties. The other three are identified as assessment locations 77, 102 and 264. Location 102 is the Warkworth community hall, and the remaining two assessment locations are privately owned residences in Warkworth. All three of these properties would lie within the area encompassed by the acquisition zone of neighbouring mines, but it should be noted that assessment location 264 is newly identified and does not appear in the explicit list of affected properties. In any case, all three of these potentially affected, non-mine owned properties would be afforded acquisition rights should the proposal proceed.

The assessment of cumulative 24-hour average PM_{10} concentrations found that impacts may potentially occur near the Warkworth, Knodlers Lane and MTIE monitoring locations. Of these locations, the potential risk of cumulative impacts is greatest near the Warkworth monitor as would be expected given the prevailing wind conditions in the area are likely to transport material from the operation towards this location as it progresses in a westerly direction.

An indicative cumulative 24-hour average $PM_{2.5}$ assessment reveals that no assessment location (predicted to comply with the criteria for other pollutants) would experience $PM_{2.5}$ level above the NEPM advisory reporting standards.

The assessment of diesel emissions shows that in the assessed years, all assessment locations are predicted to experience NO_2 concentrations below the relevant criterion.

The investigation into potential blast impacts found that the area of potential risk would shift towards the west over time with the progression of the proposal. With the current blast management practices, it is anticipated that any potential blast impacts can be adverted.

The greenhouse gas assessment conservatively calculates the annual Scope 1 and Scope 2 emission generated from the proposal to be 0.472Mt CO_2-e. Relative to the annual greenhouse gas emissions from Australian and NSW, it is estimated the proposal would contribute approximately 0.1 per cent and 0.3 per cent respectively.

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Appendix A

Assessment locations

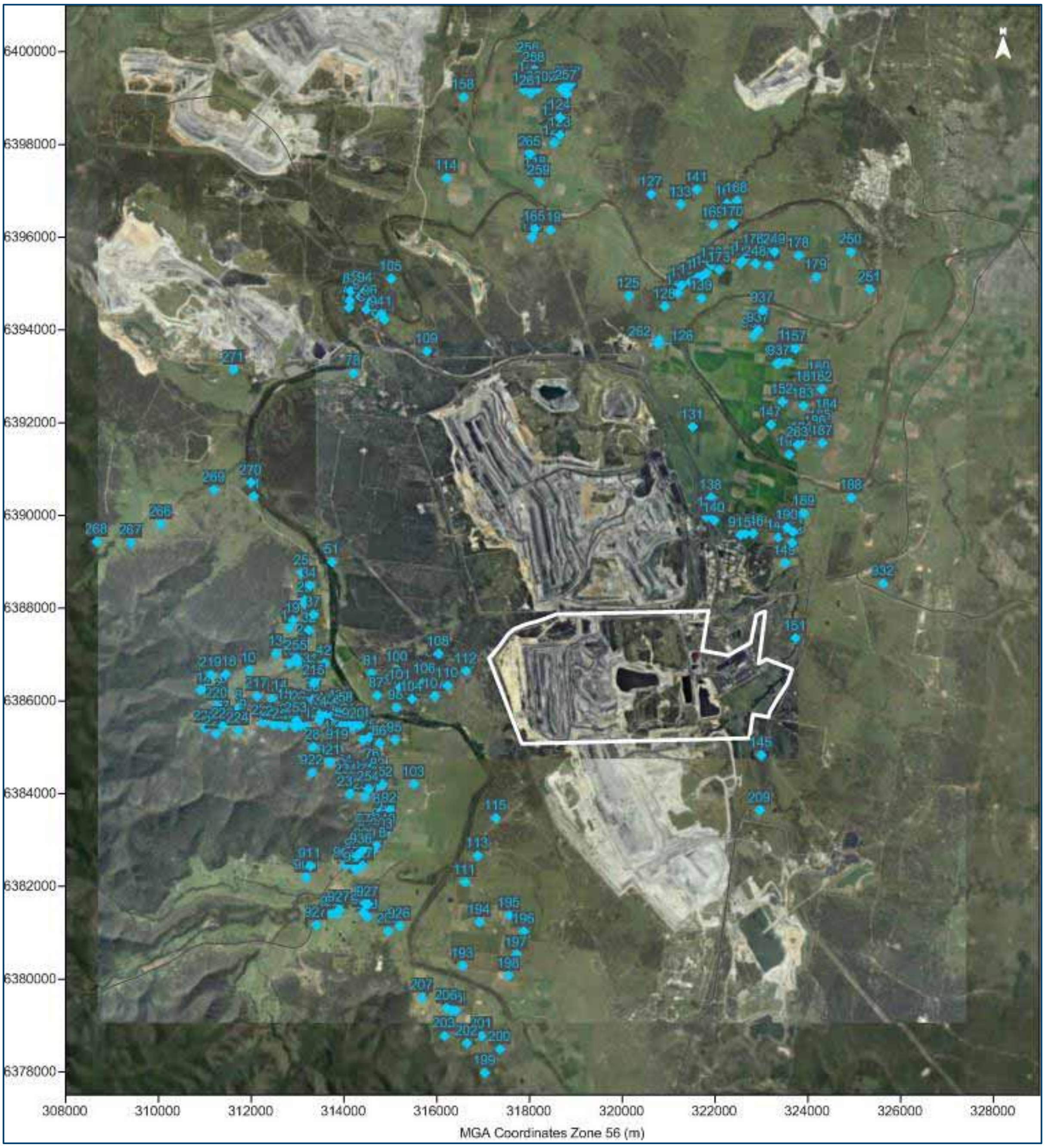

Figure A-1: Location of assessment locations assessed in this study

Table A-1: List of assessment locations assessed in this study

ID	X	Y	NAME
1	310903	6386238	JUDITH LESLIE
2	311055	6386261	SHAYNE AARON CURRIE
3	311295	6386059	PAUL TEMPLE VINES JESSOP
4	311336	6385751	GRAEME O'BRIEN & SUSANN FLORENCE O'BRIEN
5	311384	6386200	TREVOR HALTON MCTAGGART
6	311422	6386223	DOUGLAS KEITH PARTRIDGE
7	311470	6385618	DARRAL KEITH MARGERY & ANNETTE GAYE MARGERY
8	311735	6385855	LAURENCE FLETCHER & MARGARET ANN FLETCHER
9	311832	6385649	DONALD BRUCE ROSER
10	311950	6386665	PAKA INVESTMENTS PTY LIMITED
11**	312058	6390414	WAMBO MINING CORPORATION
12	312442	6386044	RONALD ALEXANDER CORINO
13	312532	6387028	ILARIO FRANCISCO CIRCOSTA & MARIA ANGELA CIRCOSTA
14	312632	6386066	KARIN MARGARET HUNT
15	312729	6385875	WILLIAM LINDSAY GORDON SLANEY
16	312822	6386804	LEONA ANN WILLIAMS
17	312814	6387573	GEORGE DAVID LIANOS
18	312935	6385847	BARRY JOHN ANDERSON & MELISSA GAI ANDERSON
19	312900	6387741	DENIS CYRIL MAIZEY
20	313041	6385812	GREGORY WILLIAM BANKS & MARION ELIZABETH BANKS
21	312998	6386821	GREGORY WILLIAM BANKS
22	313169	6385713	ELIZABETH MACKENZIE
23	313193	6385453	PETER JASON KOLATCHEW & HEIDI KOLATCHEW
24	313145	6387267	RONALD GARRY BAILEY
25	313091	6388764	WARKWORTH MINING LIMITED
26	313266	6385706	BARBARA GAE HARRISON & TREVOR ERIC HARRISON
27	313151	6388111	WARKWORTH MINING LIMITED
28	313335	6385003	HUBERT GEORGE UPWARD
29	313160	6388183	ILARIO FRANCISCO CIRCOSTA
30	313270	6386465	DAMIEN MICHAEL HANSON
31	313281	6386646	GREGORY MALCOLM CABAN
32	313252	6387528	PAUL MARK DUNN
33	313338	6386039	IAN NORRIS BARTHOLOMEW
34	313265	6388491	ALLAN CLYDE LEPISTO
35	313406	6386485	LAWRENCE MALCOLM CABAN
36	313473	6385589	RAYMOND CARL POWELL & CHRISTINE THERESE SHANNON
37	313345	6387861	GREGORY PAUL CROWE
38	313489	6385650	CHRISTOPHER LEONARD PRICE & LESLEY PRICE
39	313511	6385747	FERDINANDO FAMELI & JOELLE FAMELI
40	313595	6385794	MARGARET PLAYER & JOHN MACLACHLAN PLAYER
41	313690	6384726	HUBERT GEORGE UPWARD
42	313580	6386816	MARK ANTHONY LANCASTER
43	313658	6385668	DAVID JOHN BENSON
44	313658	6385708	BARRY FOGWELL
45	313725	6385198	ADAM CHARLES CAMERON
46	313798	6385640	DAVID JAMES GOLDSTEIN & VANESSA AMY GOLDSTEIN
47	313793	6385729	PHILIP ADAMTHWAITE
48	313823	6385853	BRETT JAMES GALLAGHER
49	313872	6385678	DEON PIERRE JANSE VAN RENSBURG
50	313898	6385517	SCOTT JAMES PRINGLE & LEANNE PRINGLE

ID	X	Y	NAME
51	313744	6389001	WARKWORTH MINING LIMITED
52	313956	6385265	STEWART JAMES MITCHELL & MARIE CLARE MITCHELL
53	313965	6385488	ROBERT MCLAUGHLIN
54	314037	6384456	CHRISTOPHER STANLEY NEVILLE & ELIZABETH ANN NEVILLE
55	313981	6385757	ROBERT JOHN EVANS
56	314005	6385480	LEONARD WALTER MCLACHLAN
57	314055	6385470	PAUL WILLIAM HARRIS
58	314046	6385804	DAVID ANDREW GREGORY
59	314088	6385479	WARKWORTH MINING LIMITED
60	314128	6385459	DAVID SAUNDERS
61	314231	6384325	DARRELL STANLEY KAIZER
62	314225	6385443	PATRICK JOHN MAGIN
63	314229	6385540	PETER JAMES COOKE
64	314242	6385504	DUSKO DRAGICEVIC
65	314239	6385584	GORDON KEITH GRAINGER
66	314258	6385447	MICHAEL VIVIAN BENDALL
67	314434	6383176	MICHAEL SHANE DAWSON & SUZANA DAWSON
68	314306	6385515	WARKWORTH MINING LIMITED
69	314329	6385371	WARKWORTH MINING LIMITED
70	314462	6383042	PETER FRANCIS RITCHIE AND FIONA JENNIFER RITCHIE
71	314354	6385377	ROBERT IAN HEDLEY
72	314392	6385359	FRANCIS HENRY TURNBULL
73	314407	6385160	PHILLIP JOSEPH REID
74	314514	6384263	RONALD GUY GODYN & ANNE-MARIE GODYN
75	314546	6385220	LINDSAY ROBERT SMITH
76	314618	6384591	THE STATE OF NEW SOUTH WALES
77	314103	6394482	WILLIAM JOSEPH KELLY
78	314203	6393069	WARKWORTH MINING LIMITED
79**	314121	6394634	WAMBO MINING CORPORATION LIMITED
80	314769	6383296	DIMITRIOUS VIKAS & JOY MARY VIKAS
81	314590	6386597	JOHN CHARLES MULALLY & PETER EDWIN MCMAUGH & GARRETT JOHN BURKE
82	314734	6384379	DONALD JAMES WALTERS
83**	314144	6394841	XSTRATA COAL PTY LIMITED
84	314796	6383618	MARY VERONICA THOMPSON
86	314767	6385091	THE STATE OF NEW SOUTH WALES
87	314711	6386122	MILLER POHANG COAL COMPANY PTY LTD
89	314951	6383454	BRYAN DUDLEY MEDHURST
90	314344	6394886	COAL & ALLIED OPERATIONS PTY LIMITED
91**	314359	6394718	WAMBO COAL PTY LTD
92**	314985	6383647	SAXONVALE COAL PTY LIMITED
93	314481	6394444	COAL & ALLIED OPERATIONS PTY LIMITED
94**	314463	6394855	WAMBO COAL PTY LTD
95	315097	6385163	MILLER POHANG COAL COMPANY
96**	314571	6394587	WAMBO MINING CORPORATION PTY LIMITED
97	315058	6386183	WARKWORTH MINING LIMITED
98	315125	6385857	MILLER POHANG COAL COMPANY
99**	314699	6394352	WAMBO COAL PTY LTD
100	315144	6386684	MILLER POHANG COAL COMPANY PTY LTD
101	315208	6386297	MILLER POHANG COAL COMPANY
102	314800	6394348	BRIAN EDWARD KENNEDY & JOHN GRIFFITHS

ID	X	Y	NAME
103**	315505	6384205	SAXONVALE COAL PTY. LIMITED
104	315463	6386048	MILLER POHANG COAL COMPANY
105	315017	6395104	COAL & ALLIED OPERATIONS PTY LIMITED
106	315742	6386435	MILLER POHANG COAL COMPANY
107	315949	6386105	MILLER POHANG COAL COMPANY PTY LIMITED
108	316037	6387020	MILLER POHANG COAL COMPANY PTY LIMITED
109**	315789	6393545	XSTRATA COAL (NSW) PTY LIMITED
110	316226	6386333	MILLER POHANG COAL COMPANY PTY LIMITED
111	316609	6382098	WALLACE RUSSELL
112	316629	6386649	MILLER POHANG COAL COMPANY PTY LIMITED
113**	316882	6382664	SAXONVALE COAL PTY LIMITED
114	316208	6397277	COAL & ALLIED OPERATIONS PTY LIMITED
115**	317271	6383479	SAXONVALE COAL PTY. LIMITED
116	318052	6396001	COAL & ALLIED OPERATIONS PTY LIMITED
117	317982	6397794	PHILLIP & COLLEEN ALGIE
118	318128	6397356	ROBERT ALGIE
118	318128	6397356	ROBERT ALGIE
119	318452	6396156	COAL & ALLIED OPERATIONS PTY LIMITED
120	318504	6398457	R & J WENHAM
121	318530	6398039	JULIE & GREGORY ERNST
122	318608	6398554	STEPHEN EDWARDS
123	318658	6398205	N & G NELSON
124	318655	6398582	STEPHEN EDWARDS
125	320142	6394738	COAL & ALLIED OPERATIONS PTY LIMITED
126	320764	6393699	PETER GLEN STUART
127	320624	6396932	NOEL & ELAINE RILEY
128	320916	6394511	PETER & DAPHNE WELSH
129	321192	6394796	COAL & ALLIED OPERATIONS PTY LIMITED
130	321271	6394970	FRANK & JOANNE VENTRA
131	321519	6391910	WARKWORTH MINING LIMITED
133	321261	6396710	COAL & ALLIED OPERATIONS PTY LIMITED
134	321472	6395034	LUCIANO CHARLES GATT
135	321816	6389971	WARKWORTH MINING LIMITED
136	321862	6390017	WARKWORTH MINING LIMITED
137	321617	6395135	COAL & ALLIED OPERATIONS PTY LIMITED
138	321914	6390390	WARKWORTH MINING LIMITED
139	321707	6394686	KEVIN DENNIS
140	321981	6389895	WARKWORTH MINING LIMITED
141	321604	6397030	WARREN AND LESLEY BARRY
142	321715	6395167	COAL & ALLIED OPERATIONS PTY LIMITED
143	321817	6395230	COAL & ALLIED OPERATIONS PTY LIMITED
144	322654	6389614	CAROL ANNE DYSON
145**	322998	6384833	SAXONVALE COAL PTY. LIMITED
146	322820	6389611	PAUL HENRY RUSSELL
147	323200	6391960	WARKWORTH MINING LIMITED
148	323360	6389527	DOROTHY CLARE RUSSELL
149	323510	6388982	IAN BULMER HEDLEY
150	323560	6389775	KEITH DAVID ISAAC AND SHARON ANN ISAAC
151**	323731	6387355	BULGA COAL MANAGEMENT PTY LIMITED
152	323454	6392457	GRAHAM EDWIN BERRY

ID	X	Y	NAME
153	323662	6389415	THOMAS WILLIAM KERMODE & KATHLEEN MAY KERMODE
154**	323680	6389650	BULGA COAL MANAGEMENT PTY LIMITED
155	323565	6393343	KEITH GEORGE BERRY
156	323610	6393617	ROBERT O'HARA
157	323739	6393594	ROBERT O'HARA
158	316576	6399021	COAL & ALLIED OPERATIONS PTY LIMITED
160	317883	6399178	ELIZABETH BOWMAN
161	318010	6399448	WYOMING HOLSTEINS PTY LTD
162	318011	6399407	WYOMING HOLSTEINS PTY LTD
163	318114	6399572	WYOMING HOLSTEINS PTY LTD
165	318110	6396180	COAL & ALLIED
167	322254	6396725	NATHAN JAMES LAING
168	322468	6396793	STUART FRANCIS NICHOL WRIGHT AND PAMELA LYNN WRIGHT
169	321959	6396271	HAROLD DOUGLAS HOBDEN
170	322379	6396285	JOHN MARCHEFF
172	321925	6395400	JOHN STUART GOUGH AND LYNETTE JEAN GOUGH
173	322099	6395301	JOHN STUART GOUGH AND LYNETTE JEAN GOUGH
174	322545	6395438	COLIN RAYMOND NEAL AND MARGARET ANNE NEAL
175	322633	6395534	BRADLEY JOHN HALTER
176	322830	6395688	MICHAEL RAYMOND MAPP AND SHIRLEY MAREE MAPP
177	323156	6395384	DELANEY
178	323801	6395607	CRAIG IAN FLISSINGER AND CATHERINE ANNE FLISSINGER
179	324177	6395141	TICKALARA PTY. LIMITED
180	324246	6392934	MOORE
181	323983	6392725	DAVID CHARLES VASSALLO AND SHEREE ANN VASSALLO
182	324296	6392725	ROBERT FRANCIS HOLSTEIN AND ANDREA TERRY HOLSTEIN
183	323903	6392368	HALL
184	324407	6392127	CAMPBELL STUART BALL AND GAIL AGNES BALL
185	324272	6391894	LEONARD DALE FRANKS
186	324164	6391772	LEONARD DALE FRANKS
187	324308	6391565	HEUSTON PTY LTD
188	324940	6390387	WALDOCK
189**	323916	6390047	BULGA COAL MANAGEMENT PTY LIMITED
190	323552	6389746	KEITH DAVID ISAAC AND SHARON ANN ISAAC
191	323873	6391630	ROBERT JOHN VIDLER AND CORAL MAY VIDLER
192	323595	6391320	O'HARA R & J
193	316558	6380293	ROBERT KENNEDY
194**	316918	6381236	SAXONVALE COAL PTY LIMITED
195**	317561	6381382	SAXONVALE COAL PTY LIMITED
196**	317877	6381030	SAXONVALE COAL PTY LIMITED
197	317716	6380532	ROBERT KENNEDY
198**	317549	6380075	SAXONVALE COAL PTY LIMITED
199	317036	6377983	ADRIAN GARTON
200	317360	6378494	KARREN ANNE MCCRAW
201	316963	6378778	RICHARD JAMES OWENS
202	316649	6378621	RICHARD JAMES OWENS
203	316167	6378781	GRAPEMEN HOLDINGS PTY LIMITED
204	316407	6379326	ESSLEMONT FAMILY HOLDINGS PTY LIMITED
205	316333	6379327	VICTORIA ANN FOSTER
206	316214	6379385	THEO POULOS

ID	X	Y	NAME
207	315682	6379608	JOHN STEPHEN TULLOCH
208	314955	6381041	CYBELE GENEVIEVE ORTON
209**	322962	6383649	SAXONVALE COAL PTY LIMITED
210	314178	6385559	MERIA VIOLET FORD
211	314331	6385481	MIKE DEAN SILK
215	313354	6386390	
217	312125	6386110	
218	311450	6386578	
219	311134	6386568	
220	311258	6385905	
221	311001	6385414	
222	311233	6385294	
223	311393	6385458	
224	311716	6385367	
225	312256	6385540	
226	312474	6385495	
227	312569	6385509	
228	312698	6385457	
229	312866	6385557	
230	312952	6385439	
231	313060	6385467	
234	314048	6384261	
235	314181	6384088	
236	314679	6384143	
237	314116	6383992	
238	314448	6383932	
243	314883	6383176	
244	318808	6399092	
245	318679	6399194	
246	318795	6399314	
247	318879	6399292	
248	322876	6395431	
249	323284	6395685	
250	324927	6395679	
251	325339	6394874	
252	314827	6384207	
253	312973	6385584	
254	314529	6384103	
255	312973	6386930	ILARIO FRANCISCO CIRCOSTA & MARIA ANGELA CIRCOSTA
256	317979	6399821	BRUCE ERIC MOXEY
257	318793	6399221	ROBERT JOHN ALGIE
258	318104	6399611	WYOMING HOLSTEINS PTY LTD
259	318211	6397178	ROBERT JOHN ALGIE
260	318180	6399198	WYOMING HOLSTEINS PTY LTD
261	318030	6399106	WYOMING HOLSTEINS PTY LTD
262	320794	6393794	PETER GLEN STUART
263	323786	6391522	JOHN KLASEN
264	314870	6394227	GEORGE ROBERT MILLER
265	318014	6397793	PHILLIP JOHN ALGIE
266	310048	6389815	RONALD WAYNE FENWICK

ID	X	Y	NAME
267	309407	6389413	KENNETH MAX BROSI & CORAL MAUDE BROSI
268	308672	6389436	KENNETH MAX BROSI
269**	311206	6390559	WAMBO MINING CORPORATION PTY LIMITED
270**	311995	6390710	WAMBO MINING CORPORATION PTY LIMITED
271**	311622	6393146	WAMBO MINING CORPORATION PTY LIMITED
903	314821	6383080	ADAM JOHN BAKER
904	314024	6382465	ALLAN MARK BRASINGTON, JUDITH ANNE BRASINGTON
905	313176	6382198	CAMERON MICHAEL TURNER, MELISSA JAYNE HARRIS
909	314611	6382770	EMANUEL VICTOR VASSALLO
911	313271	6382442	GARY DALE HARRIS
915	322542	6389581	JASON CYRIL RUMBEL, REBECCA RUTH RUMBEL
917	314549	6382967	JOHN ROBERT LAMB
918	314686	6382893	JOSEPH VASSALLO, DORIS VASSALLO
919	313866	6385003	KENNETH NEIL CAMERON
920	314208	6385455	LINDSAY GORDON HARRIS, JILLIAN MAY FERGUSON
921	313692	6384676	MELANIE CABAN, KEIRAN LIONEL CABAN
922	313313	6384456	MELANIE EVELYN UPWARD
923	314505	6381343	MICHELLE MARIA BRENNAN
926	315197	6381155	PAUL WILLIAM MACKAY, SUZANNE ELIZABETH MACKAY
927a	314213	6382445	PHILLIP JOHN GUNTER, LEONA MARY GUNTER
927b	314251	6382364	
927c	314400	6382451	
927d	314414	6381446	
927e	314462	6381631	
927f	314521	6381618	
927g	313398	6381173	
927h	313742	6381405	
927i	313851	6381411	
927j	313902	6381509	
928	314270	6382655	SARAH ELIZABETH PURSER, STIRLING OWEN KEAYES
929	314462	6382864	SIMON JAMES BEAVIS
932	325626	6388538	STEPHEN DENNIS TIPPING
936	314376	6382753	THOMAS CHARLES JACKSON, SUSAN GAI JACKSON
937a	322832	6393883	TREVOR KEITH BERRY, GRAHAM EDWIN BERRY
937b	322935	6394004	
937c	323028	6394431	
937d	323333	6393272	
937e	323391	6393295	
941**	314808	6394346	XSTRATA COAL PTY LIMITED

**Other mine owned property

Appendix B

Monitoring Data

Table B-1: TEOM Monitoring data

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
1/01/2012	ND	ND	20	21	16	15	1/01/2013	22	21	26	19	25	28
2/01/2012	ND	ND	18	27	21	18	2/01/2013	19	34	31	34	ND	22
3/01/2012	ND	12	17	21	20	20	3/01/2013	30	32	39	53	33	37
4/01/2012	ND	14	17	19	22	14	4/01/2013	ND	17	21	ND	ND	20
5/01/2012	26	22	36	38	25	21	5/01/2013	21	15	18	21	26	21
6/01/2012	33	ND	ND	39	ND	ND	6/01/2013	ND	16	21	15	ND	29
7/01/2012	18	11	16	16	13	15	7/01/2013	18	13	16	21	28	21
8/01/2012	19	13	19	22	20	15	8/01/2013	14	10	11	13	ND	14
9/01/2012	34	ND	30	26	31	24	9/01/2013	ND	32	42	35	ND	40
10/01/2012	18	ND	17	22	16	ND	10/01/2013	41	42	52	49	ND	39
11/01/2012	15	ND	20	25	13	ND	11/01/2013	33	23	27	32	40	33
12/01/2012	19	ND	42	45	23	ND	12/01/2013	ND	29	36	30	34	33
13/01/2012	17	ND	26	32	18	ND	13/01/2013	ND	36	6	43	ND	ND
14/01/2012	23	ND	29	28	22	18	14/01/2013	30	15	30	30	35	ND
15/01/2012	18	ND	24	31	19	20	15/01/2013	9	6	10	5	10	ND
16/01/2012	15	ND	13	22	13	12	16/01/2013	18	12	14	18	22	12
17/01/2012	15	7	11	32	15	14	17/01/2013	27	24	31	33	32	29
18/01/2012	19	11	17	26	20	17	18/01/2013	ND	38	ND	ND	ND	31
19/01/2012	14	8	13	18	13	15	19/01/2013	ND	46	54	ND	41	39
20/01/2012	15	ND	16	ND	13	15	20/01/2013	27	26	31	25	26	34
21/01/2012	27	ND	23	43	20	20	21/01/2013	10	12	13	18	13	12
22/01/2012	15	14	24	23	13	17	22/01/2013	20	13	15	19	23	22
23/01/2012	12	ND	15	18	11	19	23/01/2013	16	16	2	30	17	ND
24/01/2012	17	ND	ND	12	16	14	24/01/2013	13	16	18	14	15	ND
25/01/2012	14	ND	ND	1	11	14	25/01/2013	17	15	18	16	20	19
26/01/2012	9	ND	ND	12	9	13	26/01/2013	13	7	8	6	14	13
27/01/2012	10	ND	ND	10	10	12	27/01/2013	16	10	11	12	ND	15
28/01/2012	15	ND	ND	15	16	15	28/01/2013	7	7	9	7	10	11
29/01/2012	11	ND	ND	6	11	12	29/01/2013	4	4	4	1	6	7
30/01/2012	14	ND	ND	10	14	12	30/01/2013	6	6	7	10	8	10
31/01/2012	17	ND	ND	17	15	16	31/01/2013	18	17	10	ND	21	22
1/02/2012	ND	ND	13	11	13	13	1/02/2013	ND	18	23	6	ND	24
2/02/2012	5	4	7	8	6	7	2/02/2013	12	17	18	19	ND	19
3/02/2012	4	4	5	2	5	5	3/02/2013	4	7	7	3	6	6
4/02/2012	7	ND	9	5	8	8	4/02/2013	9	12	15	17	10	11
5/02/2012	9	ND	15	15	11	14	5/02/2013	13	17	16	17	14	17
6/02/2012	17	ND	18	15	17	17	6/02/2013	13	13	15	16	ND	15
7/02/2012	18	ND	26	ND	17	22	7/02/2013	13	10	12	12	ND	14
8/02/2012	8	ND	15	18	17	12	8/02/2013	13	12	15	18	16	19
9/02/2012	17	ND	19	21	ND	17	9/02/2013	21	20	25	23	27	26
10/02/2012	13	ND	18	17	13	16	10/02/2013	41	22	29	21	ND	30
11/02/2012	12	ND	17	18	14	ND	11/02/2013	ND	21	25	23	ND	24
12/02/2012	9	ND	15	16	10	12	12/02/2013	7	11	13	20	10	10
13/02/2012	14	ND	11	15	16	11	13/02/2013	6	10	11	8	9	13
14/02/2012	13	ND	18	13	14	13	14/02/2013	8	8	9	8	12	15
15/02/2012	10	ND	12	8	12	13	15/02/2013	11	11	13	14	12	13
16/02/2012	9	ND	11	11	10	12	16/02/2013	8	8	8	12	11	20
17/02/2012	13	ND	6	13	14	14	17/02/2013	8	7	10	11	9	12
18/02/2012	18	ND	18	22	17	18	18/02/2013	10	9	10	10	12	14
19/02/2012	18	ND	28	22	22	24	19/02/2013	9	12	13	21	12	15
20/02/2012	22	ND	24	21	20	17	20/02/2013	12	12	12	14	ND	18
21/02/2012	13	ND	13	14	14	14	21/02/2013	ND	12	15	16	14	21
22/02/2012	8	ND	9	12	8	9	22/02/2013	11	12	13	13	14	18

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
23/02/2012	13	ND	19	15	ND	17	23/02/2013	13	14	15	14	16	21
24/02/2012	17	ND	12	ND	17	13	24/02/2013	5	7	8	7	9	10
25/02/2012	13	ND	12	15	15	17	25/02/2013	12	9	10	ND	18	15
26/02/2012	15	ND	11	9	13	14	26/02/2013	14	10	12	ND	16	18
27/02/2012	11	ND	13	15	11	14	27/02/2013	17	12	14	13	20	20
28/02/2012	14	ND	17	18	ND	14	28/02/2013	15	12	14	7	17	19
29/02/2012	16	ND	24	ND	17	19	1/03/2013	ND	ND	15	13	12	16
1/03/2012	13	ND	28	21	15	19	2/03/2013	ND	3	4	ND	4	4
2/03/2012	15	ND	22	21	16	19	3/03/2013	ND	4	6	ND	6	6
3/03/2012	3	ND	4	5	5	7	4/03/2013	ND	10	13	10	15	16
4/03/2012	10	ND	10	7	13	10	5/03/2013	14	12	15	15	20	21
5/03/2012	16	ND	ND	18	15	15	6/03/2013	14	ND	13	11	17	16
6/03/2012	8	ND	12	14	11	11	7/03/2013	11	9	12	12	14	18
7/03/2012	11	ND	18	20	16	17	8/03/2013	15	10	ND	18	14	12
8/03/2012	10	ND	13	15	10	10	9/03/2013	12	10	ND	14	13	15
9/03/2012	3	ND	8	17	6	6	10/03/2013	10	10	10	14	12	14
10/03/2012	9	13	15	21	11	14	11/03/2013	13	11	12	24	14	15
11/03/2012	10	14	19	19	13	17	12/03/2013	13	12	13	14	14	16
12/03/2012	23	17	22	22	21	18	13/03/2013	12	11	13	15	15	17
13/03/2012	14	17	15	21	16	16	14/03/2013	14	12	16	19	19	15
14/03/2012	12	11	ND	17	14	ND	15/03/2013	20	19	22	34	22	25
15/03/2012	11	15	13	24	14	17	16/03/2013	16	18	19	ND	15	16
16/03/2012	ND	13	20	21	16	17	17/03/2013	19	19	24	24	21	21
17/03/2012	16	12	15	ND	ND	13	18/03/2013	17	21	24	28	15	17
18/03/2012	8	12	14	12	9	11	19/03/2013	13	16	20	27	16	17
19/03/2012	11	13	15	12	14	14	20/03/2013	10	14	18	21	13	14
20/03/2012	ND	9	10	11	10	12	21/03/2013	9	9	10	24	13	13
21/03/2012	8	11	14	20	13	15	22/03/2013	14	18	24	21	15	20
22/03/2012	8	10	12	16	12	14	23/03/2013	21	40	39	46	25	27
23/03/2012	8	15	17	16	7	17	24/03/2013	13	17	15	14	15	12
24/03/2012	17	27	26	30	20	21	25/03/2013	9	26	24	ND	12	16
25/03/2012	10	18	20	21	14	16	26/03/2013	21	35	39	50	24	ND
26/03/2012	9	15	16	21	13	17	27/03/2013	ND	30	38	35	ND	30
27/03/2012	12	12	14	13	15	16	28/03/2013	ND	ND	21	ND	20	21
28/03/2012	11	13	14	17	16	16	29/03/2013	19	38	28	30	22	20
29/03/2012	9	10	11	11	12	15	30/03/2013	10	10	14	16	12	14
30/03/2012	11	16	20	17	11	16	31/03/2013	12	15	17	24	14	16
31/03/2012	10	21	21	21	12	16	1/04/2013	10	21	23	32	9	15
1/04/2012	10	ND	14	19	14	15	2/04/2013	10	15	17	25	9	14
1/04/2012	13	22	22	32	16	17	3/04/2013	9	15	16	16	10	15
2/04/2012	12	14	16	23	13	14	4/04/2013	8	17	19	19	8	13
3/04/2012	ND	20	21	32	15	17	5/04/2013	6	11	13	10	7	10
4/04/2012	ND	20	20	25	23	24	6/04/2013	9	8	11	13	9	12
5/04/2012	12	12	12	34	18	18	7/04/2013	6	10	12	20	6	10
6/04/2012	13	11	11	16	13	15	7/04/2013	8	10	12	22	10	11
7/04/2012	26	28	30	33	27	24	8/04/2013	9	10	11	17	12	12
8/04/2012	24	27	31	29	26	27	9/04/2013	6	12	12	22	8	14
9/04/2012	10	16	17	20	11	13	10/04/2013	5	7	5	12	8	10
10/04/2012	9	16	21	21	10	12	11/04/2013	9	10	11	21	10	15
11/04/2012	8	16	15	23	9	10	12/04/2013	10	12	13	25	10	15
12/04/2012	ND	9	12	15	9	11	13/04/2013	14	20	20	22	12	21
13/04/2012	12	13	12	21	14	13	14/04/2013	10	17	19	27	13	20
14/04/2012	10	15	19	18	12	13	15/04/2013	16	27	35	42	19	25
15/04/2012	17	22	26	27	17	21	16/04/2013	6	12	14	15	9	13

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
16/04/2012	12	14	17	19	13	24	17/04/2013	6	14	16	15	9	ND
17/04/2012	8	16	16	21	10	9	18/04/2013	ND	14	16	ND	11	12
18/04/2012	6	6	7	8	6	11	19/04/2013	7	15	19	23	7	12
19/04/2012	ND	6	6	13	9	ND	20/04/2013	4	16	19	5	6	7
20/04/2012	7	ND	16	19	11	14	21/04/2013	4	10	12	10	7	11
21/04/2012	9	13	19	23	13	20	22/04/2013	8	19	25	32	9	17
22/04/2012	13	20	23	28	16	20	23/04/2013	17	16	22	31	9	12
23/04/2012	10	18	23	23	14	15	24/04/2013	13	ND	10	29	ND	13
24/04/2012	6	14	17	22	8	14	25/04/2013	17	25	28	42	16	20
25/04/2012	7	13	14	20	11	9	26/04/2013	10	26	31	43	12	18
26/04/2012	12	17	21	ND	13	16	27/04/2013	19	30	36	38	20	24
27/04/2012	16	17	20	22	18	15	28/04/2013	38	34	36	51	32	28
28/04/2012	16	21	24	27	19	16	29/04/2013	79	38	47	67	72	51
29/04/2012	10	18	20	26	13	17	30/04/2013	25	24	28	32	28	30
30/04/2012	14	17	9	24	17	16	1/05/2013	21	28	32	37	26	26
1/05/2012	15	15	17	26	14	15	2/05/2013	ND	ND	19	25	14	18
2/05/2012	13	15	18	21	14	16	3/05/2013	14	20	23	29	13	17
3/05/2012	9	10	15	10	10	12	4/05/2013	20	22	34	33	24	25
4/05/2012	ND	15	14	18	13	14	5/05/2013	19	34	34	35	23	24
5/05/2012	8	13	14	29	6	11	6/05/2013	ND	14	17	25	11	16
6/05/2012	10	20	18	25	ND	11	7/05/2013	11	ND	ND	27	15	22
7/05/2012	10	20	8	35	11	14	8/05/2013	ND	15	10	21	ND	15
8/05/2012	10	19	24	32	11	11	9/05/2013	26	18	18	30	19	23
9/05/2012	12	22	30	ND	12	15	10/05/2013	38	25	25	42	40	35
10/05/2012	12	ND	29	47	ND	16	11/05/2013	25	29	31	46	29	35
11/05/2012	15	31	31	46	17	19	12/05/2013	23	13	13	23	14	12
12/05/2012	12	28	28	55	12	17	13/05/2013	ND	ND	32	48	19	23
13/05/2012	10	25	34	47	13	18	14/05/2013	5	10	12	16	8	8
14/05/2012	8	16	24	35	9	12	15/05/2013	6	16	21	22	10	10
15/05/2012	ND	21	30	34	ND	13	16/05/2013	10	17	23	36	14	12
16/05/2012	14	24	28	38	17	18	17/05/2013	6	10	16	28	10	12
17/05/2012	16	17	22	30	14	16	18/05/2013	6	16	19	23	9	10
18/05/2012	13	22	24	33	13	19	19/05/2013	7	12	13	26	10	9
19/05/2012	15	25	29	43	17	16	20/05/2013	13	21	32	29	16	13
20/05/2012	14	28	32	35	15	16	21/05/2013	12	27	29	36	14	18
21/05/2012	14	18	ND	31	16	16	22/05/2013	ND	32	39	41	14	20
22/05/2012	12	27	29	39	18	17	23/05/2013	3	6	7	13	5	5
23/05/2012	15	27	35	47	15	15	24/05/2013	6	8	11	ND	9	8
24/05/2012	14	29	38	54	19	20	25/05/2013	3	8	9	10	5	7
25/05/2012	7	10	11	14	8	10	26/05/2013	6	9	11	25	8	10
26/05/2012	9	13	15	13	12	10	27/05/2013	11	18	23	34	14	16
27/05/2012	7	13	14	27	6	7	28/05/2013	6	10	11	14	7	13
28/05/2012	12	24	26	ND	12	16	29/05/2013	9	13	14	27	11	12
29/05/2012	7	ND	14	12	ND	10	30/05/2013	10	ND	19	ND	11	16
30/05/2012	8	11	12	13	8	12	31/05/2013	9	15	16	17	10	13
31/05/2012	9	13	14	14	11	16	1/06/2013	10	18	21	19	ND	13
1/06/2012	7	7	9	19	8	12	2/06/2013	3	5	7	7	2	6
2/06/2012	6	7	8	11	6	11	3/06/2013	5	8	12	24	3	9
3/06/2012	4	5	5	6	4	5	4/06/2013	8	12	18	31	3	11
4/06/2012	4	6	5	3	5	5	5/06/2013	9	12	14	26	10	11
5/06/2012	6	8	8	10	8	7	6/06/2013	11	18	27	41	12	14
6/06/2012	9	8	10	9	10	9	7/06/2013	6	15	20	22	12	11
7/06/2012	6	7	9	18	ND	8	8/06/2013	9	11	13	27	10	15
8/06/2012	6	9	10	11	8	10	9/06/2013	10	11	11	21	11	13

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
9/06/2012	9	10	10	15	10	10	10/06/2013	7	9	11	18	10	13
10/06/2012	9	14	15	22	10	12	11/06/2013	4	6	7	24	6	7
11/06/2012	5	7	9	5	5	7	12/06/2013	8	9	10	21	9	10
12/06/2012	7	8	9	11	7	7	13/06/2013	3	6	7	10	6	6
13/06/2012	ND	9	9	10	ND	8	14/06/2013	3	6	7	10	6	5
14/06/2012	12	10	10	19	16	ND	15/06/2013	4	7	9	14	7	6
15/06/2012	8	15	19	16	11	13	16/06/2013	5	10	10	13	8	6
16/06/2012	8	13	14	24	9	10	17/06/2013	6	12	11	20	10	8
17/06/2012	6	8	9	8	8	6	18/06/2013	5	9	11	24	7	8
18/06/2012	7	14	13	ND	8	8	19/06/2013	6	13	ND	19	7	9
19/06/2012	5	9	13	ND	6	8	20/06/2013	6	13	ND	21	8	11
20/06/2012	6	13	17	10	8	10	21/06/2013	7	18	20	35	12	14
21/06/2012	8	17	ND	19	11	10	22/06/2013	7	10	14	17	9	10
22/06/2012	10	14	19	16	15	10	23/06/2013	5	10	13	16	5	7
23/06/2012	6	9	11	9	6	6	24/06/2013	2	12	11	18	5	6
24/06/2012	8	10	16	11	9	9	25/06/2013	4	6	ND	26	8	9
25/06/2012	10	10	20	22	11	9	26/06/2013	11	13	17	18	12	13
26/06/2012	6	17	21	18	7	12	27/06/2013	8	10	13	6	7	8
27/06/2012	8	8	10	10	8	9	28/06/2013	4	7	8	12	6	ND
28/06/2012	ND	10	9	17	6	9	29/06/2013	4	ND	7	6	5	ND
29/06/2012	12	14	20	19	15	ND	30/06/2013	8	10	11	7	4	ND
30/06/2012	6	11	10	14	7	8	1/07/2013	2	13	11	20	5	ND
1/07/2012	8	17	20	29	10	9	2/07/2013	4	9	10	21	9	ND
2/07/2012	5	12	11	20	8	6	3/07/2013	5	8	9	15	8	6
3/07/2012	7	9	14	16	9	8	4/07/2013	9	14	16	ND	11	11
4/07/2012	9	17	23	21	9	10	5/07/2013	6	14	14	20	10	10
5/07/2012	7	16	23	24	8	11	6/07/2013	6	14	16	20	13	9
6/07/2012	6	9	12	11	7	7	7/07/2013	6	12	16	22	9	10
7/07/2012	6	15	19	10	8	13	8/07/2013	8	15	17	26	12	12
8/07/2012	13	16	20	26	16	12	9/07/2013	10	19	24	24	11	15
9/07/2012	12	10	12	20	14	12	10/07/2013	5	13	16	17	ND	11
10/07/2012	7	12	15	36	7	13	11/07/2013	7	13	16	21	10	14
11/07/2012	5	6	7	12	6	8	12/07/2013	7	13	17	23	9	11
12/07/2012	8	12	15	31	8	12	13/07/2013	16	10	13	18	13	18
13/07/2012	4	9	9	11	7	7	14/07/2013	14	12	14	24	15	15
14/07/2012	4	6	6	9	7	6	15/07/2013	11	19	22	ND	14	15
15/07/2012	6	7	7	8	10	5	16/07/2013	5	ND	16	23	8	12
16/07/2012	8	11	15	11	11	9	17/07/2013	7	11	14	4	9	ND
17/07/2012	6	13	16	29	5	10	18/07/2013	7	11	14	24	9	ND
18/07/2012	ND	14	18	22	7	11	19/07/2013	7	12	15	19	10	12
19/07/2012	ND	12	17	25	8	11	20/07/2013	2	9	9	23	6	11
20/07/2012	7	18	21	26	10	11	21/07/2013	4	12	11	27	8	8
21/07/2012	8	16	28	25	11	13	22/07/2013	5	14	15	35	8	9
22/07/2012	7	13	19	17	9	10	23/07/2013	5	10	12	12	7	10
23/07/2012	6	9	13	10	8	10	24/07/2013	9	14	22	30	9	11
24/07/2012	4	8	9	13	6	5	25/07/2013	16	19	23	35	19	17
25/07/2012	6	10	16	18	8	2	26/07/2013	10	18	25	36	14	16
26/07/2012	ND	19	26	27	12	7	27/07/2013	15	17	26	33	16	16
27/07/2012	5	12	14	25	7	9	28/07/2013	15	13	18	32	18	16
28/07/2012	5	10	12	18	9	6	29/07/2013	11	16	21	33	15	19
29/07/2012	10	12	18	17	12	8	30/07/2013	ND	18	26	39	14	15
30/07/2012	5	6	15	36	6	11	31/07/2013	ND	12	14	17	10	11
31/07/2012	7	8	30	ND	10	14	1/08/2013	ND	11	12	21	8	10
1/08/2012	6	15	17	15	12	9	2/08/2013	2	16	28	28	ND	13

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
2/08/2012	6	10	14	18	8	8	3/08/2013	4	13	15	26	11	12
3/08/2012	8	16	23	36	11	12	4/08/2013	4	13	16	26	12	10
4/08/2012	8	18	23	31	11	13	5/08/2013	7	22	29	34	17	19
5/08/2012	13	22	32	37	15	13	6/08/2013	7	29	34	32	14	18
6/08/2012	12	18	25	ND	24	16	7/08/2013	5	22	30	41	16	17
7/08/2012	11	17	28	28	12	13	8/08/2013	ND	5	6	10	5	6
8/08/2012	12	23	34	33	15	11	9/08/2013	3	10	ND	21	8	10
9/08/2012	10	19	30	37	16	13	10/08/2013	6	18	21	20	13	10
10/08/2012	10	14	23	44	15	12	11/08/2013	4	18	23	27	11	12
11/08/2012	7	12	20	33	12	11	12/08/2013	7	23	31	ND	11	15
12/08/2012	10	15	24	18	17	12	13/08/2013	ND	23	22	27	11	13
13/08/2012	13	17	24	28	27	20	14/08/2013	6	34	35	37	11	ND
14/08/2012	14	22	32	36	26	16	15/08/2013	5	16	22	34	8	11
15/08/2012	15	30	41	48	26	15	16/08/2013	ND	ND	36	ND	18	18
16/08/2012	15	20	31	57	21	15	17/08/2013	21	39	47	55	27	27
17/08/2012	33	33	50	68	35	32	18/08/2013	6	20	23	39	12	12
18/08/2012	12	17	30	34	27	14	19/08/2013	7	41	36	61	14	16
19/08/2012	9	11	15	24	20	8	20/08/2013	2	10	16	47	7	11
20/08/2012	16	19	29	37	23	18	21/08/2013	4	18	19	29	15	10
21/08/2012	14	23	30	23	22	15	22/08/2013	3	26	19	29	12	10
22/08/2012	17	28	41	59	28	24	23/08/2013	7	29	24	32	15	11
23/08/2012	17	20	30	38	26	22	24/08/2013	10	12	17	27	15	12
24/08/2012	6	9	9	19	36	8	25/08/2013	7	23	21	30	11	13
25/08/2012	8	14	18	24	25	12	26/08/2013	12	22	29	41	17	15
26/08/2012	10	12	18	23	11	8	27/08/2013	17	ND	34	44	19	21
27/08/2012	12	15	20	27	28	12	28/08/2013	19	11	28	ND	ND	20
28/08/2012	12	14	20	19	20	12	29/08/2013	35	33	37	21	ND	37
29/08/2012	20	27	34	34	29	26	30/08/2013	28	37	46	51	34	34
30/08/2012	14	25	37	65	23	19	31/08/2013	ND	25	36	69	20	23
31/08/2012	11	17	31	47	26	19	1/09/2013	21	21	29	61	25	23
1/09/2012	9	12	18	34	10	10	2/09/2013	17	18	20	15	20	20
2/09/2012	12	19	25	30	19	13	3/09/2013	10	13	15	21	15	17
3/09/2012	17	18	26	62	25	16	4/09/2013	18	14	18	24	20	18
4/09/2012	18	25	35	47	23	21	5/09/2013	17	30	ND	33	28	22
5/09/2012	28	42	ND	59	37	33	6/09/2013	22	ND	49	ND	ND	32
6/09/2012	28	39	50	53	45	38	7/09/2013	18	36	40	55	25	27
7/09/2012	18	ND	55	56	31	26	8/09/2013	24	27	37	40	28	35
8/09/2012	15	30	23	24	31	17	9/09/2013	22	29	35	38	28	31
9/09/2012	13	15	22	23	20	15	10/09/2013	ND	53	61	77	36	43
10/09/2012	16	ND	35	41	19	20	11/09/2013	4	22	29	57	16	ND
11/09/2012	25	40	41	ND	30	ND	12/09/2013	10	27	30	59	12	16
12/09/2012	25	35	19	42	28	30	13/09/2013	11	19	22	35	21	17
13/09/2012	20	ND	52	76	ND	30	14/09/2013	9	17	21	31	18	18
14/09/2012	12	12	19	25	19	15	15/09/2013	ND	11	11	25	13	17
15/09/2012	14	20	23	51	19	22	16/09/2013	9	9	12	9	ND	15
16/09/2012	17	21	23	26	17	20	17/09/2013	ND	5	6	5	ND	6
17/09/2012	ND	24	31	35	31	31	18/09/2013	ND	19	12	17	ND	8
18/09/2012	9	ND	21	21	13	16	19/09/2013	2	18	17	21	ND	15
19/09/2012	11	10	14	ND	16	11	20/09/2013	4	25	26	44	ND	17
20/09/2012	20	22	26	ND	24	20	21/09/2013	4	14	17	16	ND	13
21/09/2012	11	24	28	45	16	23	22/09/2013	8	17	19	27	ND	16
22/09/2012	15	19	26	38	17	17	23/09/2013	6	33	29	52	ND	22
23/09/2012	12	24	26	29	18	13	24/09/2013	16	47	53	94	ND	28
24/09/2012	ND	25	32	52	16	18	25/09/2013	11	24	27	54	ND	22

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
25/09/2012	ND	25	27	ND	ND	20	26/09/2013	11	54	55	102	ND	26
26/09/2012	24	16	22	ND	29	27	27/09/2013	18	22	27	37	ND	20
27/09/2012	22	29	41	34	25	27	28/09/2013	10	33	29	56	ND	21
28/09/2012	39	56	70	51	44	37	29/09/2013	14	27	35	37	ND	27
29/09/2012	14	19	28	37	14	16	30/09/2013	16	27	27	39	ND	24
30/09/2012	8	17	25	24	10	13	1/10/2013	44	51	66	103	ND	45
1/10/2012	13	16	21	31	16	17	2/10/2013	2	21	13	31	ND	10
2/10/2012	18	11	14	ND	16	ND	3/10/2013	4	20	16	32	ND	19
3/10/2012	28	ND	33	28	24	15	4/10/2013	8	20	21	25	ND	14
4/10/2012	19	43	53	63	22	25	5/10/2013	6	25	20	31	ND	11
5/10/2012	21	47	53	73	20	29	7/10/2013	9	46	41	39	ND	18
6/10/2012	41	27	33	26	41	36	8/10/2013	13	31	33	56	ND	26
8/10/2012	16	ND	21	34	ND	18	9/10/2013	12	17	20	19	ND	17
9/10/2012	18	18	22	32	20	ND	10/10/2013	10	26	28	25	ND	16
10/10/2012	17	19	21	28	18	17	11/10/2013	26	48	56	52	ND	34
11/10/2012	20	23	28	26	20	18	12/10/2013	35	38	42	52	ND	37
12/10/2012	10	ND	23	21	13	14	13/10/2013	17	31	34	36	ND	26
13/10/2012	7	12	16	20	10	7	14/10/2013	62	53	71	78	ND	57
14/10/2012	15	13	17	24	13	12	15/10/2013	4	13	14	21	ND	13
15/10/2012	11	13	17	20	12	12	16/10/2013	11	25	33	45	ND	15
16/10/2012	14	21	26	25	15	15	17/10/2013	12	ND	56	ND	ND	ND
17/10/2012	28	48	64	ND	33	27	18/10/2013	60	57	72	84	ND	49
18/10/2012	ND	44	49	ND	46	36	19/10/2013	35	31	36	40	ND	33
19/10/2012	26	19	26	31	31	ND	20/10/2013	30	27	30	35	ND	34
20/10/2012	27	33	41	38	28	31	21/10/2013	29	25	27	16	ND	29
21/10/2012	30	41	48	49	33	34	22/10/2013	ND	46	46	45	ND	38
22/10/2012	34	34	46	35	30	26	23/10/2013	ND	59	75	80	ND	58
23/10/2012	24	41	45	30	26	38	24/10/2013	42	42	43	63	ND	35
24/10/2012	16	21	23	25	18	18	25/10/2013	26	28	26	67	31	31
25/10/2012	32	29	9	41	30	26	26/10/2013	36	37	48	57	33	37
26/10/2012	26	50	56	42	27	30	27/10/2013	38	51	57	70	46	50
27/10/2012	27	49	62	72	33	38	28/10/2013	24	24	27	22	24	25
28/10/2012	22	14	20	54	22	19	29/10/2013	44	36	41	49	47	36
29/10/2012	23	18	22	24	24	26	30/10/2013	ND	43	ND	58	ND	37
30/10/2012	16	13	18	34	17	15	31/10/2013	17	13	15	15	17	14
31/10/2012	19	23	26	29	21	23	1/11/2013	16	14	15	17	20	18
1/11/2012	27	29	34	38	28	25	2/11/2013	24	16	17	16	24	22
2/11/2012	28	55	76	77	29	35	3/11/2013	ND	33	31	50	23	33
3/11/2012	23	27	31	51	29	26	4/11/2013	64	58	62	81	60	50
4/11/2012	16	13	15	18	20	19	5/11/2013	31	22	23	23	27	26
5/11/2012	23	20	27	28	ND	24	6/11/2013	22	21	19	21	21	19
6/11/2012	ND	19	25	ND	ND	ND	7/11/2013	28	20	19	29	28	19
7/11/2012	30	34	41	41	ND	40	8/11/2013	ND	35	38	38	35	38
8/11/2012	39	34	42	40	ND	35	9/11/2013	ND	62	36	80	49	ND
9/11/2012	16	18	24	11	17	16	10/11/2013	ND	44	47	47	31	30
10/11/2012	12	12	14	ND	14	14	11/11/2013	15	17	17	19	16	20
11/11/2012	13	15	17	14	20	16	12/11/2013	ND	4	5	4	4	4
12/11/2012	14	12	12	ND	17	16	13/11/2013	4	7	8	7	7	ND
13/11/2012	22	17	ND	ND	20	ND	14/11/2013	5	9	15	18	8	ND
14/11/2012	ND	31	44	33	33	29	15/11/2013	12	26	25	ND	19	16
15/11/2012	24	19	23	27	29	28	16/11/2013	ND	ND	18	ND	18	14
16/11/2012	24	21	26	1	27	28	17/11/2013	6	10	9	5	7	7
17/11/2012	17	17	21	22	20	22	18/11/2013	2	13	13	7	5	5
18/11/2012	13	11	14	10	17	15	19/11/2013	3	6	6	6	6	6

Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth	Date	Bulga	Knodlers Lane	Maison Dieu	MTIE	Wallaby Scrub Road	Warkworth
19/11/2012	17	13	14	10	20	23	20/11/2013	6	9	11	13	9	8
20/11/2012	10	20	23	21	13	16	21/11/2013	10	10	9	12	16	13
21/11/2012	15	ND	20	18	20	20	22/11/2013	12	12	12	16	16	17
22/11/2012	23	25	29	25	ND	23	23/11/2013	5	11	12	12	ND	ND
23/11/2012	27	33	31	34	32	33	24/11/2013	ND	ND	ND	ND	7	ND
24/11/2012	23	22	23	27	29	24	25/11/2013	9	11	9	16	13	ND
25/11/2012	24	ND	20	15	29	32	26/11/2013	10	20	16	17	13	ND
26/11/2012	21	27	23	33	29	ND	27/11/2013	16	21	7	18	20	13
27/11/2012	56	36	47	5	34	ND	28/11/2013	26	22	20	23	26	17
28/11/2012	18	22	24	28	ND	21	29/11/2013	ND	23	26	30	20	21
29/11/2012	12	12	13	10	15	16	30/11/2013	15	24	24	30	21	18
30/11/2012	23	16	17	14	26	24	1/12/2013	10	13	13	14	15	13
1/12/2012	ND	ND	25	25	ND	23	2/12/2013	9	10	10	12	13	12
2/12/2012	37	27	30	32	41	31	3/12/2013	9	9	9	14	15	12
3/12/2012	24	16	18	15	24	20	4/12/2013	14	10	ND	12	17	12
4/12/2012	12	10	11	11	12	15	5/12/2013	20	25	28	21	24	21
5/12/2012	9	15	21	27	9	16	6/12/2013	10	ND	13	36	13	20
6/12/2012	17	25	16	47	18	23	7/12/2013	8	11	14	13	13	9
7/12/2012	29	25	33	ND	30	29	8/12/2013	24	20	23	30	22	19
8/12/2012	25	25	26	28	29	27	9/12/2013	24	23	29	24	27	22
9/12/2012	25	32	36	28	30	29	10/12/2013	ND	ND	44	47	31	34
10/12/2012	21	24	27	25	ND	32	11/12/2013	ND	28	38	38	21	22
11/12/2012	9	14	15	21	10	ND	12/12/2013	20	27	34	35	24	23
12/12/2012	11	19	17	14	12	12	13/12/2013	23	23	26	32	29	25
13/12/2012	11	9	8	13	13	18	14/12/2013	ND	23	29	28	29	32
14/12/2012	16	12	12	21	20	16	15/12/2013	ND	19	23	32	19	22
15/12/2012	25	18	ND	22	28	27	16/12/2013	18	13	17	21	22	20
16/12/2012	28	23	ND	25	ND	26	17/12/2013	13	12	12	21	18	20
17/12/2012	19	25	ND	23	25	27	18/12/2013	ND	13	14	18	19	16
18/12/2012	ND	ND	27	25	ND	28	19/12/2013	12	15	13	30	16	ND
19/12/2012	33	25	ND	30	34	41	20/12/2013	ND	15	14	32	21	ND
20/12/2012	22	16	9	17	ND	27	21/12/2013	ND	37	36	37	32	ND
21/12/2012	26	29	40	32	32	ND	22/12/2013	ND	45	55	74	45	38
22/12/2012	28	24	28	27	33	26	23/12/2013	ND	28	36	36	30	29
23/12/2012	24	17	19	22	30	25	24/12/2013	ND	53	53	60	34	38
24/12/2012	19	15	19	30	23	22	25/12/2013	12	13	22	22	17	21
25/12/2012	ND	22	30	26	ND	20	26/12/2013	ND	13	15	12	14	14
26/12/2012	6	ND	ND	5	ND	ND	27/12/2013	ND	7	7	6	8	8
27/12/2012	14	12	14	11	15	17	28/12/2013	7	9	10	13	14	12
28/12/2012	19	16	18	28	17	17	29/12/2013	ND	13	13	14	19	17
29/12/2012	17	19	23	22	17	20	30/12/2013	ND	29	30	31	28	37
30/12/2012	27	19	23	20	17	25	31/12/2013	28	26	30	30	34	33
31/12/2012	20	14	18	18	17	20							

Table B-1: HVAS PM_{10} Monitoring data

Date	Loders Creek	MTIE	MTO	WML	Knodlers Lane	Long Point
3/01/2012	-	-	31	-	27	13
9/01/2012	-	29	-	-	16	16
12/01/2012	-	-	22	-	-	-
15/01/2012	-	31	16	-	10	4
17/01/2012	-	25	-	-	-	-
19/01/2012	-	43	-	-	-	-
21/01/2012	-	33	17	-	23	7
24/01/2012	-	12	-	-	-	-
27/01/2012	-	10	22	-	10	10
30/01/2012	-	23	-	-	-	-
2/02/2012	-	8	4	-	3	2
8/02/2012	-	19	10	-	16	-
14/02/2012	-	13	13	-	12	-
20/02/2012	-	17	11	-	18	-
26/02/2012	-	17	11	-	15	-
3/03/2012	-	10	8	-	13	-
9/03/2012	-	24	10	-	18	-
15/03/2012	-	27	22	-	18	-
21/03/2012	-	22	13	-	12	-
27/03/2012	-	16	21	-	13	-
2/04/2012	-	33	18	-	18	-
8/04/2012	-	38	32	-	34	-
14/04/2012	-	24	12	-	23	-
20/04/2012	-	21	15	-	22	-
26/04/2012	-	30	13	-	24	-
2/05/2012	-	25	13	-	20	-
8/05/2012	-	-	13	-	22	-
14/05/2012	-	-	14	-	16	-
20/05/2012	-	-	14	-	28	-
26/05/2012	-	-	7	-	12	-
1/06/2012	-	-	8	-	7	-
5/06/2012	-	12	-	-	-	-
7/06/2012	-	22	4	-	3	-
13/06/2012	-	15	2	-	2	-
14/06/2012	-	17	-	-	-	-
16/06/2012	-	22	-	-	-	-
19/06/2012	-	-	2	-	9	-
20/06/2012	-	18	-	-	-	-
25/06/2012	-	17	8	-	11	-
26/06/2012	-	11	-	-	-	-
27/06/2012	-	16	-	-	-	-
1/07/2012	-	-	7	-	17	-
4/07/2012	-	34	-	-	-	-
7/07/2012	-	19	4	-	13	-
13/07/2012	-	8	3	-	6	-
19/07/2012	-	30	5	-	13	-
25/07/2012	-	28	17	-	14	-
31/07/2012	-	47	8	-	28	-
6/08/2012	-	63	14	-	19	-
12/08/2012	-	18	9	-	21	-
18/08/2012	-	29	12	19	22	-
24/08/2012	-	22	7	6	17	-
30/08/2012	-	66	14	12	36	-
5/09/2012	-	63	51	32	59	-
11/09/2012	-	70	36	26	38	-
17/09/2012	-	44	48	17	27	-
23/09/2012	-	42	14	16	32	-

Date	Loders Creek	MTIE	MTO	WML	Knodlers Lane	Long Point
29/09/2012	-	35	11	8	17	-
5/10/2012	-	98	54	24	56	-
11/10/2012	-	19	10	11	20	-
17/10/2012	-	46	46	43	51	-
23/10/2012	-	25	26	14	28	-
29/10/2012	-	29	19	16	18	-
4/11/2012	-	35	42	10	28	-
10/11/2012	-	16	22	13	16	-
16/11/2012	-	26	17	15	19	-
22/11/2012	-	37	31	27	42	-
28/11/2012	-	10	16	15	14	-
4/12/2012	-	36	13	10	20	-
10/12/2012	-	15	7	6	20	-
16/12/2012	-	27	35	24	39	-
22/12/2012	-	22	32	21	22	-
28/12/2012	-	26	20	18	24	-
3/01/2013	-	27	33	21	22	-
9/01/2013	-	58	67	47	55	-
15/01/2013	-	15	29	15	13	-
21/01/2013	-	25	36	23	16	-
27/01/2013	-	7	10	7	7	-
2/02/2013	-	10	6	4	6	-
8/02/2013	-	26	26	22	31	-
14/02/2013	-	14	12	8	10	-
20/02/2013	-	17	12	10	12	-
26/02/2013	-	12	17	12	13	-
4/03/2013	6	-	19	15	12	-
10/03/2013	13	-	17	9	11	-
16/03/2013	25	-	22	22	28	-
22/03/2013	40	-	31	19	49	-
28/03/2013	30	-	25	20	54	-
3/04/2013	13	-	5	6	22	-
9/04/2013	9	-	6	3	13	-
15/04/2013	39	-	20	18	29	-
21/04/2013	11	-	-	5	15	-
27/04/2013	38	-	-	16	38	-
1/05/2013	-	-	16	-	-	-
2/05/2013	-	-	12	-	-	-
3/05/2013	33	-	16	12	27	-
9/05/2013	17	-	48	22	30	-
15/05/2013	19	-	10	7	22	-
21/05/2013	35	-	6	9	40	-
27/05/2013	26	-	11	9	17	-
2/06/2013	5	-	2	1	4	-
8/06/2013	15	-	6	4	9	-
14/06/2013	9	-		1	4	-
20/06/2013	16	-	4	3	12	-
26/06/2013	12	-	4	5	10	-
2/07/2013	18	-	5	6	7	-
8/07/2013	21	-	8	7	12	-
14/07/2013	18	-	11	9	11	-
20/07/2013	12	-	3	2	6	-
26/07/2013	25	-	11	9	18	-
1/08/2013	18	-	6	6	10	-
7/08/2013	21	-	6	8	25	-
13/08/2013	19	-	6	7	24	-
19/08/2013	36	-	8	10	40	-
25/08/2013	37	-	13	3	26	-

Date	Loders Creek	MTIE	MTO	WML	Knodlers Lane	Long Point
31/08/2013	74	-	19	16	31	-
6/09/2013	49	-	26	25	40	-
12/09/2013	47	-	22	8	27	-
18/09/2013	25	-	6	5	18	-
24/09/2013	73	-	19	20	47	-
30/09/2013	26	-	21	21	34	-
6/10/2013	57	-	12	14	51	-
12/10/2013	36	-	23	23	40	27
18/10/2013	32	-	37	29	-	29
21/10/2013	-	-	-	-	84	-
24/10/2013	73	-	33	36	42	37
30/10/2013	16	-	19	14	18	14
5/11/2013	23	-	25	20	31	19
11/11/2013	5	-	3	3	1	7
17/11/2013	5	-	3	5	15	8
23/11/2013	11	-	11	11	16	13
29/11/2013	27	-	20	16	28	19
5/12/2013	18	-	12	12	27	14
11/12/2013	28	-	24	22	35	28
17/12/2013	12	-	28	17	14	12
23/12/2013	51	-	39	38	72	45
29/12/2013	33	-	35	29	36	27

Table B-1: HVAS TSP Monitoring data

Date	Loders Creek	MTO	WML	Warkworth	Long Point
3/01/2012	-	132	96	65	-
9/01/2012	-	63	47	50	-
15/01/2012	-	74	40	54	-
21/01/2012	-	41	30	63	-
27/01/2012	-	77	41	48	-
2/02/2012	-	10	8	8	-
8/02/2012	-	-	31	35	-
14/02/2012	-	33	24	43	-
15/02/2012	-	40	-	-	-
20/02/2012	-	30	26	27	-
26/02/2012	-	43	35	47	-
3/03/2012	-	20	26	27	-
9/03/2012	-	28	55	50	-
15/03/2012	-	49	40	41	-
21/03/2012	-	35	34	50	-
27/03/2012	-	58	47	48	-
2/04/2012	-	60	-	37	-
4/04/2012	-	-	69	-	-
8/04/2012	-	72	29	56	-
14/04/2012	-	-	43	33	-
16/04/2012	-	17	-	-	-
20/04/2012	-	45	38	36	-
26/04/2012	-	-	55	67	-
27/04/2012	-	63	-	-	-
2/05/2012	-	40	53	50	-
8/05/2012	-	35	45	39	-
14/05/2012	-	25	28	30	-
20/05/2012	-	47	46	50	-
26/05/2012	-	31	39	31	-
1/06/2012	-	36	23	46	-
7/06/2012	-	10	12	17	-

Date	Loders Creek	MTO	WML	Warkworth	Long Point
13/06/2012	-	10	-	13	-
19/06/2012	-	15	23	17	-
21/06/2012	-	-	33	-	-
25/06/2012	-	34	39	24	-
1/07/2012	-	29	29	33	-
7/07/2012	-	19	11	51	-
13/07/2012	-	11	12	8	-
19/07/2012	-	16	17	16	-
25/07/2012	-	65	-	32	-
26/07/2012	-	-	34	-	-
31/07/2012	-	28	19	37	-
6/08/2012	-	44	51	50	-
12/08/2012	-	19	22	23	-
18/08/2012	-	52	64	60	-
24/08/2012	-	28	26	27	-
30/08/2012	-	39	34	60	-
5/09/2012	-	120	68	112	-
11/09/2012	-	103	92	103	-
17/09/2012	-	140	84	143	-
23/09/2012	-	52	55	51	-
29/09/2012	-	45	35	41	-
5/10/2012	-	151	74	83	-
11/10/2012	-	40	42	41	-
17/10/2012	-	161	160	103	-
23/10/2012	-	114	-	62	-
24/10/2012	-	-	61	-	-
29/10/2012	-	97	-	55	-
30/10/2012	-	-	105	-	-
4/11/2012	-	155	71	96	-
10/11/2012	-	106	66	49	-
16/11/2012	-	67	54	86	-
22/11/2012	-	85	54	96	-
28/11/2012	-	65	41	47	-
4/12/2012	-	56	41	52	-
10/12/2012	-	30	19	18	-
16/12/2012	-	124	83	92	-
22/12/2012	-	152	99	87	-
28/12/2012	-	55	51	76	-
3/01/2013	-	102	60	50	-
9/01/2013	-	207	119	121	-
15/01/2013	-	104	73	66	-
21/01/2013	-	138	71	77	-
27/01/2013	-	54	21	29	-
2/02/2013	-	19	12	14	-
8/02/2013	-	96	77	70	-
14/02/2013	-	69	26	39	-
20/02/2013	-	49	38	73	-
26/02/2013	-	75	-	54	-
4/03/2013	-	63	44	53	-
5/03/2013	-	-	33	-	-
10/03/2013	31	63	46	41	-
11/03/2013	18	-	-	-	-
16/03/2013	69	66	57	64	-
22/03/2013	111	99	62	87	-
28/03/2013	78	61	49	59	-
3/04/2013	31	13	12	22	-
9/04/2013	43	34	21	41	-
15/04/2013	104	56	50	77	-

Date	Loders Creek	MTO	WML	Warkworth	Long Point
21/04/2013	45	-	24	35	-
27/04/2013	107	-	54	84	-
1/05/2013	-	41	-	-	-
2/05/2013	-	31	-	-	-
3/05/2013	114	57	49	55	-
9/05/2013	50	93	50	49	-
15/05/2013	55	43	34	38	-
21/05/2013	111	23	64	78	-
27/05/2013	84	22	18	52	-
2/06/2013	24	7	9	12	-
8/06/2013	55	45	25	46	-
14/06/2013	24	10	15	8	-
20/06/2013	65	22	10	24	-
26/06/2013	41	11	22	27	-
2/07/2013	63	23	21	27	-
8/07/2013	66	35	43	35	-
14/07/2013	40	51	44	38	-
20/07/2013	33	13	9	31	-
26/07/2013	93	37	36	50	-
1/08/2013	65	26	26	31	-
7/08/2013	58	30	32	53	-
13/08/2013	52	22	21	65	-
19/08/2013	78	30	27	64	-
25/08/2013	125	60	40	61	-
31/08/2013	175	74	50	70	-
6/09/2013	114	97	101	105	-
12/09/2013	117	68	29	62	-
18/09/2013	44	31	21	27	-
24/09/2013	151	51	48	88	-
30/09/2013	106	72	44	86	-
6/10/2013	121	47	52	81	-
12/10/2013	112	76	58	93	69
18/10/2013	67	108	69	93	87
24/10/2013	150	51	50	69	93
30/10/2013	43	82	46	49	55
5/11/2013	63	88	62	65	70
11/11/2013	31	19	13	17	42
17/11/2013	20	16	11	14	23
23/11/2013	23	34	26	33	24
29/11/2013	49	-	41	40	48
2/12/2013	-	78	-	-	-
5/12/2013	49	30	25	50	45
11/12/2013	67	72	55	60	95
17/12/2013	28	99	58	51	40
23/12/2013	121	101	91	141	121
29/12/2013	68	31	63	106	55

Appendix C

Emission Calculation

MTO Continuation 2014 - Emission Calculation

The mining schedule and mine plan designs provided by the proponent have been combined with emissions factor equations that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions, and composition of the material being handled.

Emission factors and associated controls have been sourced from the US EPA AP42 Emission Factors (**US EPA, 1985 and Updates**), the State Pollution Control Commission document "*Air Pollution from Coal Mining and Related Developments*" (**SPCC, 1983**), the National Pollutant Inventory document "Emission Estimation Technique Manual for Mining, Version 3.1" (**NPI, 2012**) and the NSW EPA document, "*NSW Coal Mining Benchmarking Study: International Best Practise Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*", prepared by Katestone Environmental (**Katestone, 2010**).

The emission factor equations used for each dust generating activity are outlined in **Table C-1** below. Detailed emission inventories for each modelled year are presented in **Table C-2** to **Table C-6**.

Table C-1: Emission factor equations

Activity	Emission factor equation	Variables	Control	Source
Drilling (overburden/coal)	$EF = 0.59\ kg/hole$	-	70% - water sprays	US EPA, 1985 NPI, 2012
Blasting (overburden/coal)	$EF = 0.00022\ \times A^{1.5}\ kg/blast$	A = area to be blasted (m^2)	-	US EPA, 1985
Loading / emplacing overburden	$EF = k\ \times 0.0016\ \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$	Ktsp = 0.74 U = wind speed (m/s) M = moisture content (%)	-	NPI, 2012
Dragline	$EF =\ 0.0046\ \times d^{1.1}/M^{1.3}\ kg/m^3$	d = drop height (m) M = moisture content (%)	-	US EPA, 1985
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times\ k\ \times\ (s/12)^{0.7} \times\ (1.1023\ \times M/3)^{0.45}\ kg/VKT$	S = silt content (%) M = average vehicle gross mass (tonnes)	80% - watering of trafficked areas	US EPA, 1985
Dozers on overburden	$EF = 2.6\ \times\ \frac{s^{1.2}}{M^{1.3}}\ kg/hour$	S = silt content (%) M = moisture content (%)	-	US EPA, 1985
Dozers on coal	$EF = 35.6\ \times\ \frac{s^{1.2}}{M^{1.4}}\ kg/hour$	S = silt content (%) M = moisture content (%)	-	US EPA, 1985
Loading / emplacing coal	$EF = \frac{0.58}{M^{1.2}}\ kg/tonne$	M = moisture content (%)	85% - enclosed dump hopper and water sprays	US EPA, 1985
Loading product coal to stockpile	$EF = k\ \times 0.0016\ \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right)\ kg/tonne$	Ktsp = 0.74 U = wind speed (m/s) M = moisture content (%)	25% - variable height stacker	US EPA, 1985
Wind erosion on exposed areas / stockpiles	$EF = 0.4\ kg/ha\ /hour$	-	50% - water sprays, interim rehabilitation	SPCC, 1983
Grading roads	$EF = 0.0034\ \times\ s^{2.5}\ kg/VKT$	S = speed of grader (km/hr)	-	US EPA, 1985

Table C-2: Emission inventory – Year 3

ACTIVITY	TSP emission (kg/y) - Uncontrolled	TSP emission (kg/y) - Controlled	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Mt Thorley																		
OB - Dozers stripping topsoil	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Drilling	12,757	3,827	21,623	holes/year	0.59	kg/hole											70	% Control
OB - Blasting	98,214	98,214	86	blasts/year	1143	kg/blast	30,000	Area of blast in square metres										
OB - Dragline	227,330	227,330	7,154,857	bcm/year	0.032	kg/m^3	7	drop height in m	2	moisture content in %								
OB - Loading OB to haul truck	71,694	71,694	42,296,002	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	2	moisture content in %								
OB - Hauling to emplacement area	3,088,748	617,750	42,296,002	tonnes/year	0.073	kg/t	240	tonnes/load	6.0	km/return trip	2.9	kg/VKT	1.8	% silt content	275	Ave GMV (tonnes)	80	% Control
OB - Hauling to emplacement area - from Warkworth	749,015	149,803	23,669,300	tonnes/year	0.032	kg/t	240	tonnes/load	2.6	km/return trip	2.9	kg/VKT	1.8	% silt content	275	Ave GMV (tonnes)	80	% Control
OB - Emplacing at area	111,814	111,814	65,965,302	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	2	moisture content in %								
OB - Dozers in pit	222,959	222,959	13,323	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Dozers on dump and rehab	89,626	89,626	5,355	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
CL - Drilling	929	279	9,294	holes/year	0.10	kg/hole											70	% Control
CL - Blasting	3,979	3,979	18	blasts/year	220	kg/blast	10,000	Area of blast in square metres										
CL - Dozers ripping/pushing/clean-up	48,714	48,714	1,416	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CL - Loading ROM coal to haul truck	202,661	202,661	3,609,604	tonnes/year	0.056	kg/t	7	moisture content in %										
CL - Hauling ROM to hopper - Mt Thorley CHPP	670,612	134,122	3,609,604	tonnes/year	0.186	kg/t	190	tonnes/load	13.0	km/return trip	2.7	kg/VKT	1.8	% silt content	234	Ave GMV (tonnes)	80	% Control
CL - Hauling Warkworth ROM to hopper - Mt Thorley CHPF	407,704	81,541	3,479,068	tonnes/year	0.117	kg/t	190	tonnes/load	8.2	km/return trip	2.7	kg/VKT	1.8	% silt content	234	Ave GMV (tonnes)	80	% Control
CHPP - Unloading ROM to hopper - Mt Thorley CHPP	202,661	30,399	3,609,604	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Unloading Warkworth ROM to hopper - Mt Thorley	195,332	29,300	3,479,068	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Rehandle ROM at hopper - Mt Thorley CHPP	79,599	11,940	1,417,734	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Dozer pushing ROM coal - Mt Thorley CHPP	42,997	42,997	1,250	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CHPP - Dozer pushing Product coal - Mt Thorley CHPP	13,593	13,593	1,250	hours/year	10.9	kg/h	5	silt content in %	11	moisture content in %								
CHPP - Loading Product coal to stockpile - Mt Thorley CHP	773	580	4,962,070	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	11	moisture content in %							25	% Control
CHPP - Loading Product coal to train - Mt Thorley CHPP	773	232	4,962,070	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	11	moisture content in %							70	% Control
CHPP - Loading rejects - Mt Thorley CHPP	335	335	1,881,767	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	10	moisture content in %								
CHPP - Hauling rejects - Mt Thorley CHPP	64,542	12,908	1,881,767	tonnes/year	0.034	kg/t	190	tonnes/load	2.4	km/return trip	2.7	kg/VKT	1.8	% silt content	234	Ave GMV (tonnes)	80	% Control
CHPP - Hauling rejects from Warkworth - Mt Thorley CHPF	110,967	22,193	2,283,733	tonnes/year	0.049	kg/t	190	tonnes/load	3.4	km/return trip	2.7	kg/VKT	1.8	% silt content	234	Ave GMV (tonnes)	80	% Control
CHPP - Unloading rejects - Mt Thorley CHPP	742	742	4,165,500	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.3 ir	10	moisture content in %								
CHPP - Conveying to train load out from Mt Thorley CHPP	1,060	318	0.3	ha	3,504	kg/ha/year											70	% Control
WE - Overburden emplacement areas - Mt Thorley	1,411,955	705,978	403.0	ha	3,504	kg/ha/year											50	% Control
WE - Open pit - Mt Thorley	520,144	520,144	148.4	ha	3,504	kg/ha/year												
WE - ROM stockpiles - Mt Thorley	61,495	30,748	17.6	ha	3,504	kg/ha/year											50	% Control
WE - Product stockpiles - Mt Thorley	49,486	24,743	14.1	ha	3,504	kg/ha/year											50	% Control
Grading roads	22,157	22,157	36,000	km	0.62	kg/VKT	8	speed of graders in km/h										
Total TSP emissions (kg/yr)	**8,785,368**	**3,533,619**																

Table C-3: Emission inventory – Year 9

ACTIVITY	TSP emission (kg/y) - Uncontrolled	TSP emission (kg/y) - Controlled	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Mt Thorley																		
OB - Dozers stripping topsoil	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Drilling	-	-	-	holes/year	0.59	kg/hole											70	% Control
OB - Blasting	-	-	-	blasts/year	1143	kg/blast	30,000	Area of blast in square metres										
OB - Dragline	-	-	-	bcm/year	0.032	kg/m³	7	drop height in m	2	moisture content in %								
OB - Loading OB to haul truck	-	-	-	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.:	2	moisture content in %								
OB - Hauling to emplacement area	-	-	-	tonnes/year	0.000	kg/t	240	tonnes/load	-	km/return trip	2.9	kg/VKT	1.8	% silt conter	275	Ave GMV (tonnes	80	% Control
OB - Hauling to emplacement area - from Warkworth	3,076,074.2	615,215	48,602,834	tonnes/year	0.063	kg/t	240	tonnes/load	5.2	km/return trip	2.9	kg/VKT	1.8	% silt conter	275	Ave GMV (tonnes	80	% Control
OB - Emplacing at area	82,384.0	82,384	48,602,834	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.:	2	moisture content in %								
OB - Dozers in pit	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Dozers on dump and rehab	99,642.2	99,642	5,954	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
CL - Drilling	-	-	-	holes/year	0.10	kg/hole											70	% Control
CL - Blasting	-	-	-	blasts/year	220	kg/blast	10,000	Area of blast in square metres										
CL - Dozers ripping/pushing/clean-up	-	-	-	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CL - Loading ROM coal to haul truck	-	-	-	tonnes/year	0.056	kg/t	7	moisture content in %										
CL - Hauling ROM to hopper - Mt Thorley CHPP	-	-	-	tonnes/year	0.000	kg/t	190	tonnes/load	-	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CL - Hauling Warkworth ROM to hopper - Mt Thorley CHPP	809,892.5	161,979	6,159,861	tonnes/year	0.131	kg/t	190	tonnes/load	9.2	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Unloading ROM to hopper - Mt Thorley CHPP	-	-	-	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Unloading Warkworth ROM to hopper - Mt Thorley	345,844.8	51,877	6,159,861	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Rehandle ROM at hopper - Mt Thorley CHPP	69,169.0	10,375	1,231,972	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Dozer pushing ROM coal - Mt Thorley CHPP	42,997.2	42,997	1,250	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CHPP - Dozer pushing Product coal - Mt Thorley CHPP	13,592.9	13,593	1,250	hours/year	10.9	kg/h	5	silt content in %	11	moisture content in %								
CHPP - Loading Product coal to stockpile - Mt Thorley CHP	672.0	504	4,311,903	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.:	11	moisture content in %							25	% Control
CHPP - Loading Product coal to train - Mt Thorley CHPP	672.0	202	4,311,903	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.:	11	moisture content in %							70	% Control
CHPP - Loading rejects - Mt Thorley CHPP	238.0	238	1,336,690	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.:	10	moisture content in %								
CHPP - Hauling rejects - Mt Thorley CHPP	45,847.0	9,169	1,336,690	tonnes/year	0.034	kg/t	190	tonnes/load	2.4	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Hauling rejects from Warkworth - Mt Thorley CHPP	100,656.3	20,131	2,515,442	tonnes/year	0.040	kg/t	190	tonnes/load	2.8	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Unloading rejects - Mt Thorley CHPP	686.0	686	3,852,132	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.:	10	moisture content in %								
CHPP - Conveying to train load out from Mt Thorley CHPP	1,059.6	318	0.3	ha	3,504	kg/ha/year											70	% Control
WE - Overburden emplacement areas - Mt Thorley	985,601.6	492,801	281.3	ha	3,504	kg/ha/year											50	% Control
WE - Open pit - Mt Thorley	-	-	-	ha	3,504	kg/ha/year												
WE - ROM stockpiles - Mt Thorley	41,802.7	20,901	11.9	ha	3,504	kg/ha/year											50	% Control
WE - Product stockpiles - Mt Thorley	49,486.3	24,743	14.1	ha	3,504	kg/ha/year											50	% Control
Grading roads	22,156.8	22,157	36,000	km	0.62	kg/VKT	8	speed of graders in km/h										
Abbey Green North																		
Drilling overburden	5,900	5,900																
Blasting overburden	31,300	31,300																
Dozers on overburden dumps	54,500	54,500																
Dozers on overburden assisting excavators	55,400	55,400																
Loading overburden to trucks	50,500	50,500																
Hauling overburden to waste dump	720,000	720,000																
Unloading overburden to waste dump	50,500	50,500																
Dozers working on coal	5,690	5,690																
Loading coal to trucks	169,000	169,000																
Hauling coal to the MTCPP	78,900	78,900																
Unloading coal to hopper	25,000	25,000																
Re-handle coal at the ROM hopper	2,500	2,500																
Loading coal to stockpiles	1,130	1,130																
Loading coal to trains	791	791																
WE - Waste emplacement 1	258,000	258,000																
WE - Waste emplacement 2	63,900	63,900																
WE - Pit	278,000	278,000																
WE - ROM stockpile	2,580	2,580																
WE - Product stockpile	875	875																
Grading roads	1,120	1,120																
Total TSP emissions (kg/yr)	**7,644,061**	**3,525,498**																

Table C-3: Emission inventory – Year 14

ACTIVITY	TSP emission (kg/y) - Uncontrolled	TSP emission (kg/y) - Controlled	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Variable 6	Units
Mt Thorley																		
OB - Dozers stripping topsoil	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Drilling	-	-	-	holes/year	0.59	kg/hole											70	% Control
OB - Blasting	-	-	-	blasts/year	1143	kg/blast	30,000	Area of blast in square metres										
OB - Dragline	-	-	-	bcm/year	0.032	kg/m^3	7	drop height in m	2	moisture content in %								
OB - Loading OB to haul truck	-	-	-	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.3 i	2	moisture content in %								
OB - Hauling to emplacement area	-	-	-	tonnes/year	0.000	kg/t	240	tonnes/load	-	km/return trip	2.9	kg/VKT	1.8	% silt conter	275	Ave GMV (tonnes	80	% Control
OB - Hauling to emplacement area - from Warkworth	-	-	-	tonnes/year	0.000	kg/t	240	tonnes/load	-	km/return trip	2.9	kg/VKT	1.8	% silt conter	275	Ave GMV (tonnes	80	% Control
OB - Emplacing at area	-	-	-	tonnes/year	0.00170	kg/t	1.432	average of (wind speed/2.2)^1.3 i	2	moisture content in %								
OB - Dozers in pit	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
OB - Dozers on dump and rehab	-	-	-	hours/year	16.7	kg/h	10	silt content in %	2	moisture content in %								
CL - Drilling	-	-	-	holes/year	0.10	kg/hole											70	% Control
CL - Blasting	-	-	-	blasts/year	220	kg/blast	10,000	Area of blast in square metres										
CL - Dozers ripping/pushing/clean-up	-	-	-	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CL - Loading ROM coal to haul truck	-	-	-	tonnes/year	0.056	kg/t	7	moisture content in %										
CL - Hauling ROM to hopper - Mt Thorley CHPP	-	-	-	tonnes/year	0.000	kg/t	190	tonnes/load	-	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CL - Hauling Warkworth ROM to hopper - Mt Thorley CHPP	941,504.3	188,301	7,486,365	tonnes/year	0.126	kg/t	190	tonnes/load	8.8	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Unloading ROM to hopper - Mt Thorley CHPP	-	-	-	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Unloading Warkworth ROM to hopper - Mt Thorley CHPP	420,321.3	63,048	7,486,365	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Rehandle ROM at hopper - Mt Thorley CHPP	84,064.3	12,610	1,497,273	tonnes/year	0.056	kg/t	7	moisture content in %									85	% Control
CHPP - Dozer pushing ROM coal - Mt Thorley CHPP	42,997.2	42,997	1,250	hours/year	34.4	kg/h	8	silt content in %	7	moisture content in %								
CHPP - Dozer pushing Product coal - Mt Thorley CHPP	13,592.9	13,593	1,250	hours/year	10.9	kg/h	5	silt content in %	11	moisture content in %								
CHPP - Loading Product coal to stockpile - Mt Thorley CHPP	816.7	612	5,240,456	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.3 i	11	moisture content in %							25	% Control
CHPP - Loading Product coal to train - Mt Thorley CHPP	816.7	245	5,240,456	tonnes/year	0.00016	kg/t	1.432	average of (wind speed/2.2)^1.3 i	11	moisture content in %							70	% Control
CHPP - Loading rejects - Mt Thorley CHPP	331.5	331	1,861,472	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.3 i	10	moisture content in %								
CHPP - Hauling rejects - Mt Thorley CHPP	319,232.0	63,846	1,861,472	tonnes/year	0.171	kg/t	190	tonnes/load	12.0	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Hauling rejects from Warkworth - Mt Thorley CHPP	232,907.8	46,582	2,214,306	tonnes/year	0.105	kg/t	190	tonnes/load	7.4	km/return trip	2.7	kg/VKT	1.8	% silt conter	234	Ave GMV (tonnes	80	% Control
CHPP - Unloading rejects - Mt Thorley CHPP	725.8	726	4,075,778	tonnes/year	0.00018	kg/t	1.432	average of (wind speed/2.2)^1.3 i	10	moisture content in %								
CHPP - Conveying to train load out from Mt Thorley CHPP	1,059.6	318	0.3	ha	3,504	kg/ha/year											70	% Control
WE - Overburden emplacement areas - Mt Thorley	-	-	-	ha	3,504	kg/ha/year											50	% Control
WE - Open pit - Mt Thorley	-	-	-	ha	3,504	kg/ha/year												
WE - ROM stockpiles - Mt Thorley	41,802.7	20,901	11.9	ha	3,504	kg/ha/year											50	% Control
WE - Product stockpiles - Mt Thorley	49,486.3	24,743	14.1	ha	3,504	kg/ha/year											50	% Control
Grading roads	22,156.8	22,157	36,000	km	0.62	kg/VKT	8	speed of graders in km/h										
Total TSP emissions (kg/yr)	**2,171,816**	**501,011**																

Appendix D

CALMET/CALPUFF Input Variables

Table D-1: CALMET input variables

Parameter	Value
Terrain radius of influence (TERRAD)	10km
Vertical extrapolation of surface wind observations (IEXTRP)	-4
Layer dependent weighting factor of surface vs. upper air wind observations (BIAS [NZ])	-1,-0.5,-0.25,0,0,0,0,0
Weighting parameter for Step 1 wind field vs. Observations	R1 = 2.5km, R2 = 2.5km
Maximum radius of influence for meteorological stations in Layer 1 and layers aloft	RMAX1=1.0km, RMAX2=1.0km

Table D-2: CALPUFF input variables

Parameter	Used option	Value
Aqueous phase transformation modelled?	No	0
Boundary conditions modelled?	No	0
CGRUP (Species groups)	PM2.5, PM10 and TSP	-
Chemical transformation	Not modelled	0
Dry deposition modelled?	Yes	1
Gravitational settling (plume tilt) modelled?	No	0
Horizontal size of puff (m) beyond which time-dependent dispersion equations (Heffter) are used to determine sigma-y and sigma-z	Default	550
Individual source conditions saved?	No	0
Maximum length of a slug (met. grid units)	Default	1
Maximum mixing height	Default	3000
Maximum number of sampling steps for one puff/slug during one time step	-	60
Maximum number of slugs/puffs release from one source during one time step	-	60
Maximum sigma z allowed to avoid numerical problem in calculating virtual time or distance	Default	5.00E+06
Maximum travel distance of a puff/slug during one sampling step	Default	1
Method used to compute dispersion coefficients?	Internally calculated sigma v, sigma w using micrometeorological variables	2
Method used for lagrangian timescale for Sigma-y	Draxler default 617.284	0
Method used to compute turbulence sigma-v & sigma-w using micrometeorological variables	Standard CALPUFF subroutines	1
Minimum mixing height	Default	50
Minimum sigma y for a new puff/slug	Default	1
Minimum sigma z for a new puff/slug	Default	1
Minimum turbulence velocities sigma-v and sigma-w for each stability class over land and over water	Default	-
Near-field puffs modelled as elongated slugs?	No	0
Plume path coefficients for each stability class	Default	-
Potential temperature gradient for stable classes E, F	Default	-
Puff splitting allowed?	No	0
Range of land use categories for which urban dispersion is assumed	Default	-
Slug - to - puff transition criterion factor	Default	10
Stability class used to determine plume growth rates for puffs above the boundary layer	Default	5
Sub grid-scale complex terrain	Not Modelled	0
Switch for using Heffter equation for sigma-z	Default(Not use Heffter)	0
Terrain adjustment method	Default(Partial plume path adjustment)	3
Vegetation state in unirrigated areas	Default(Active and unstressed)	1
Vertical dispersion constant for stable conditions	Default	0.01
Vertical distribution used in the near field	Default (Gaussian)	1
Wet removal modelled?	No	0
Wind speed classes	Default	-
Wind speed profile power-law exponents for stabilities	Default	-

Appendix E

Isopleth Diagrams – Dust emissions

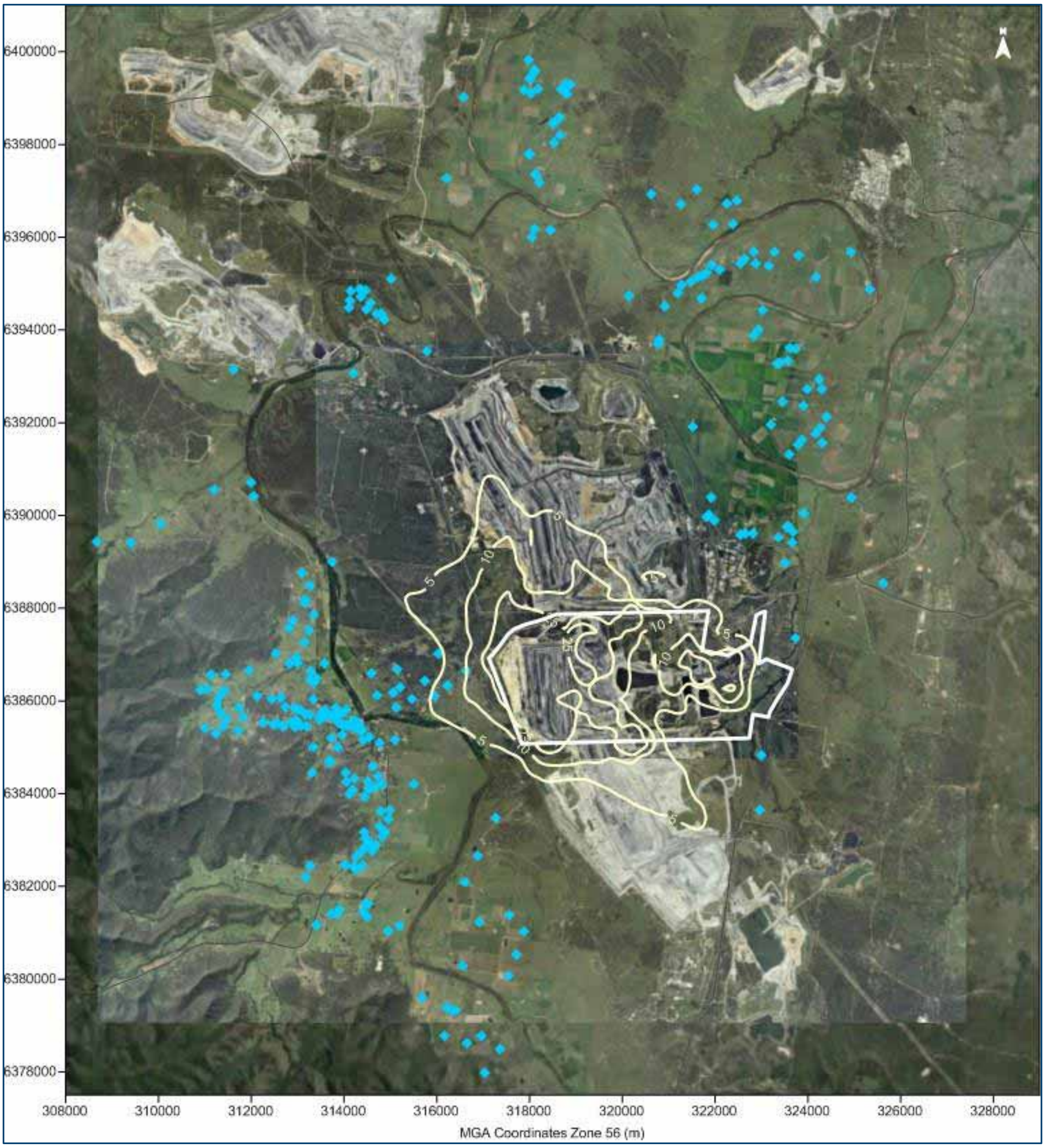

Figure E-1: Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 3 (µg/m³)

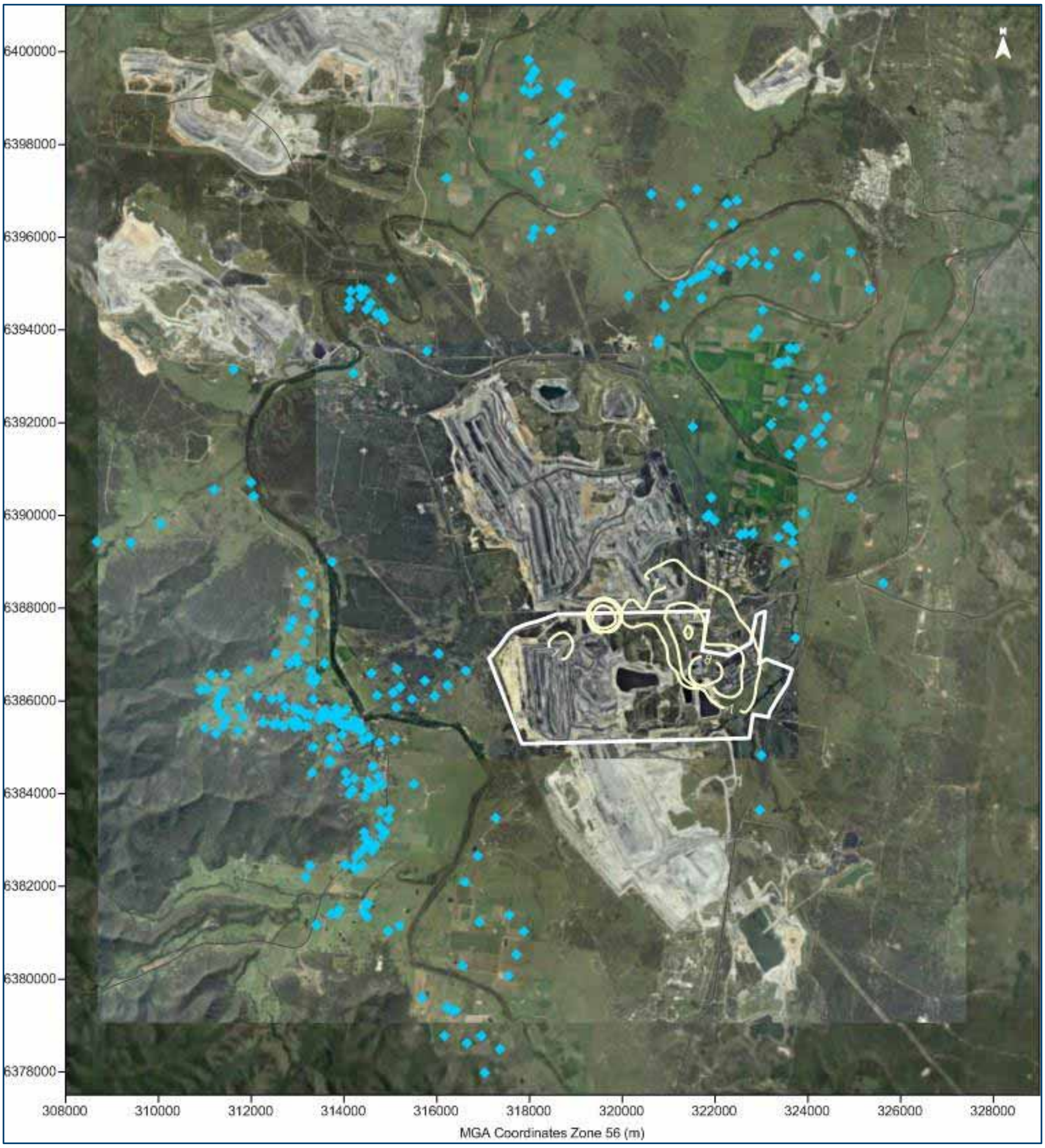

Figure E-2: Predicted annual average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 3 (µg/m³)

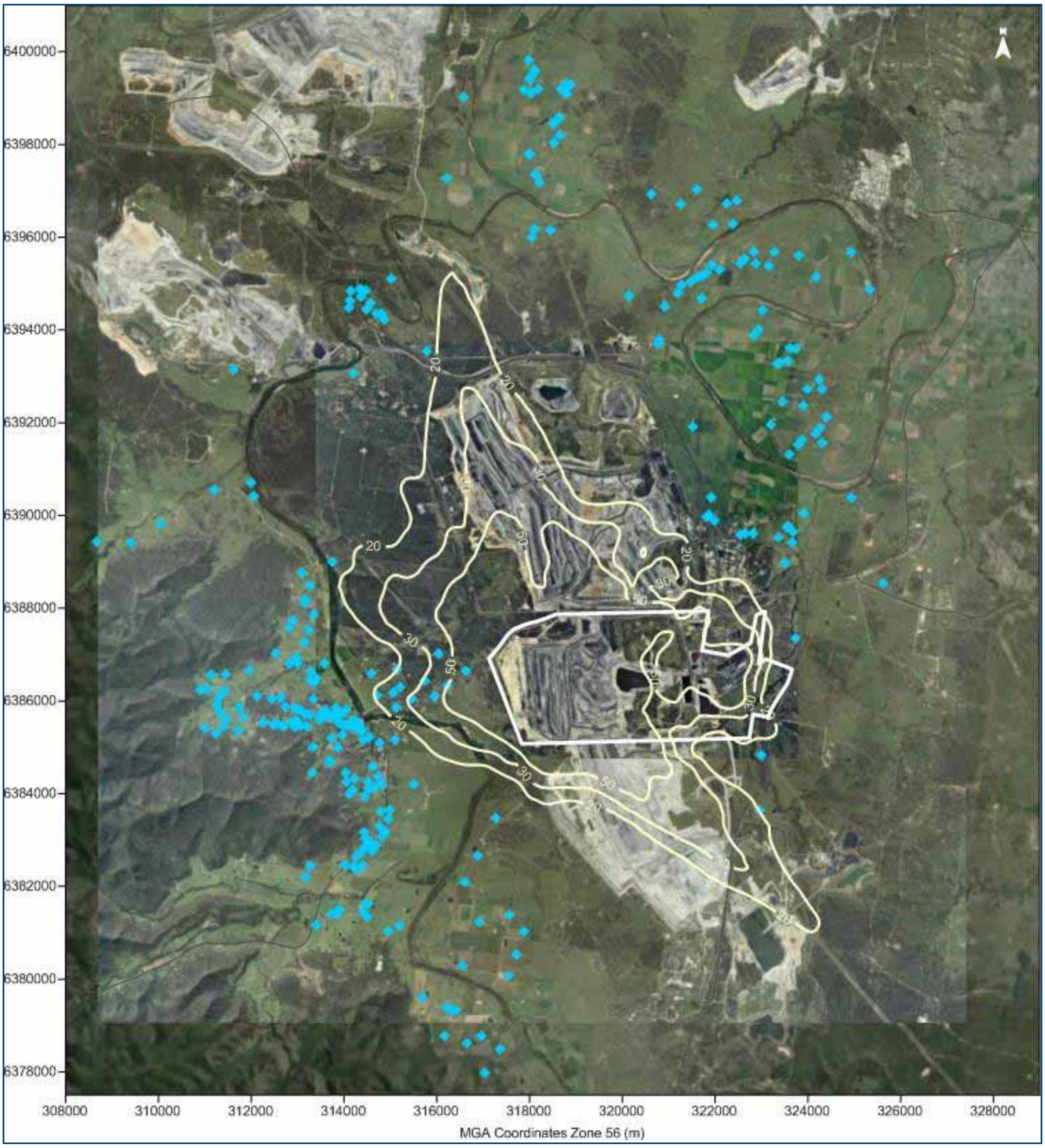

Figure E-3: Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the proposal in Year 3 (µg/m³)

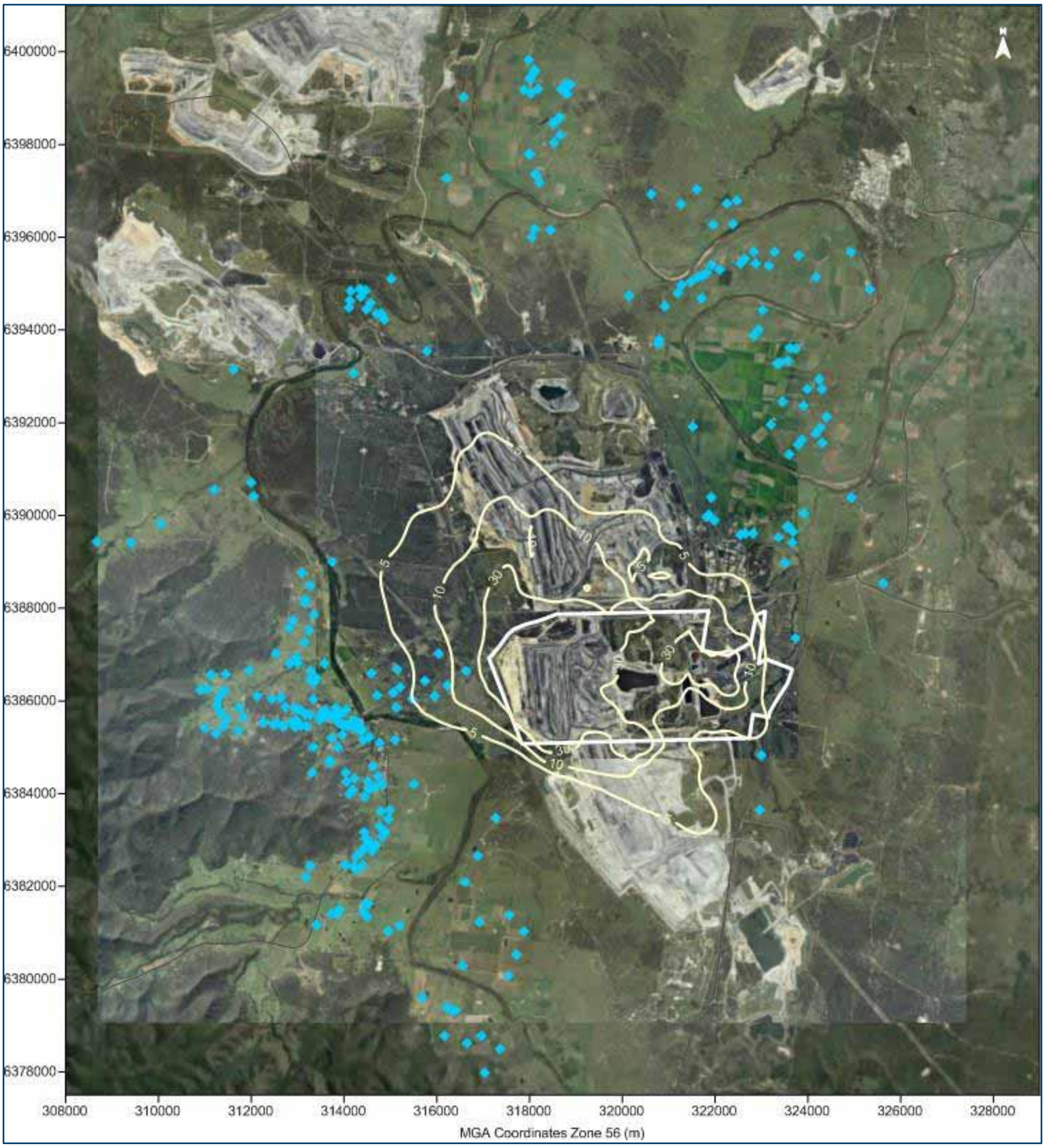

Figure E-4: Predicted annual average PM_{10} concentrations due to emissions from the proposal in Year 3 ($\mu g/m^3$)

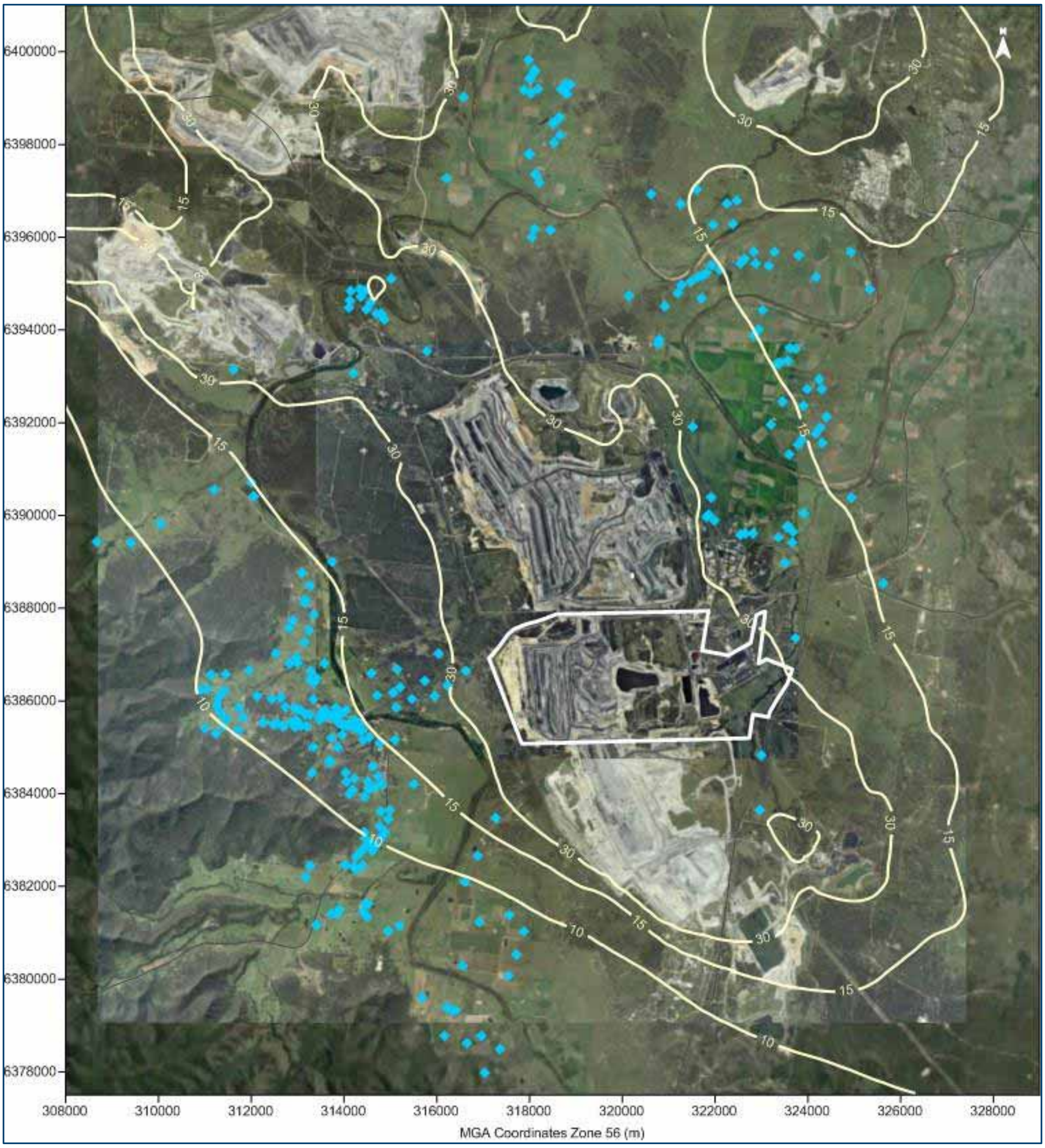

Figure E-5: Predicted annual average PM_{10} concentrations due to emissions from the proposal and other sources in Year 3 (µg/m³)

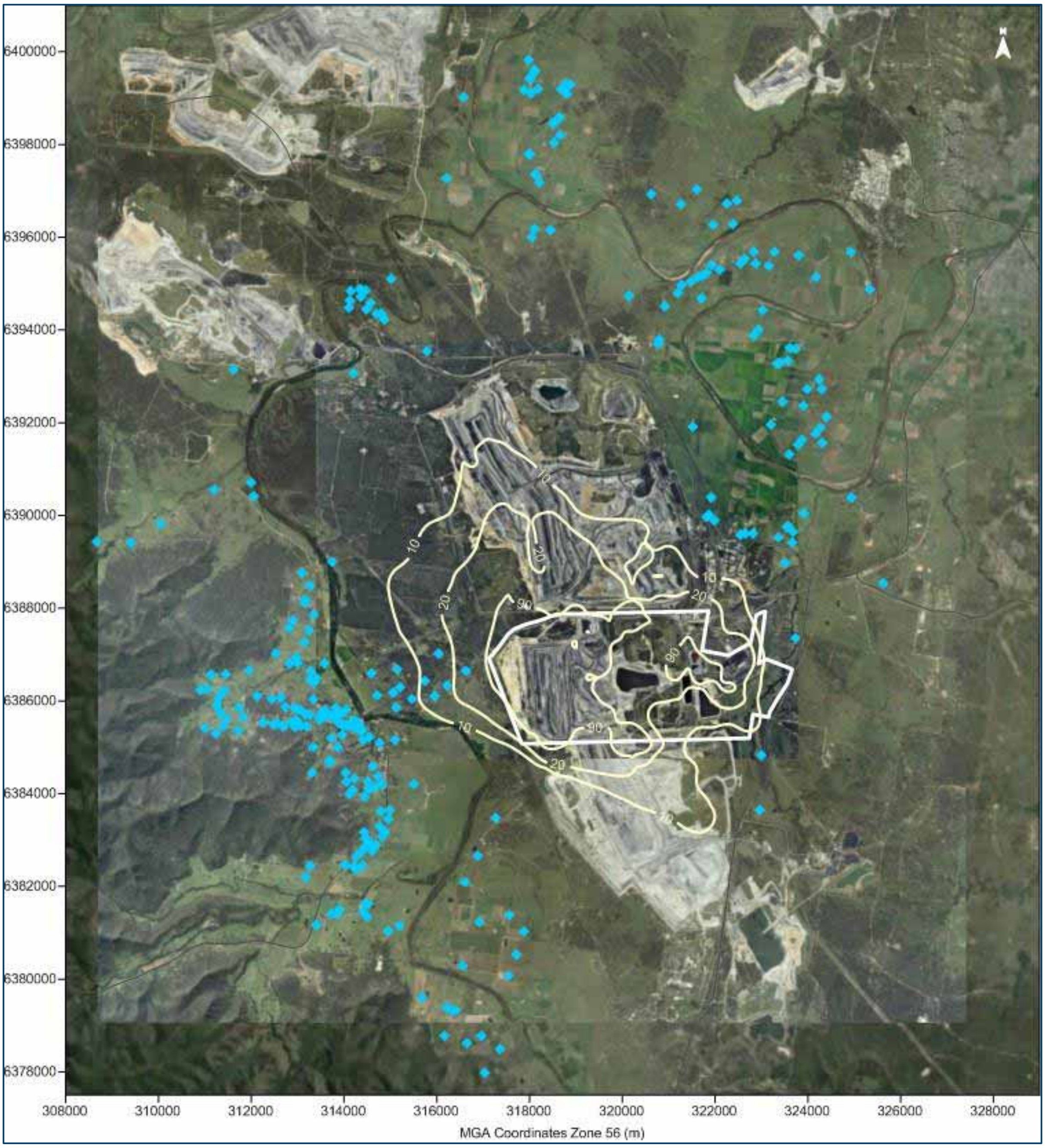

Figure E-6: Predicted annual average TSP concentrations due to emissions from the proposal in Year 3 (µg/m³)

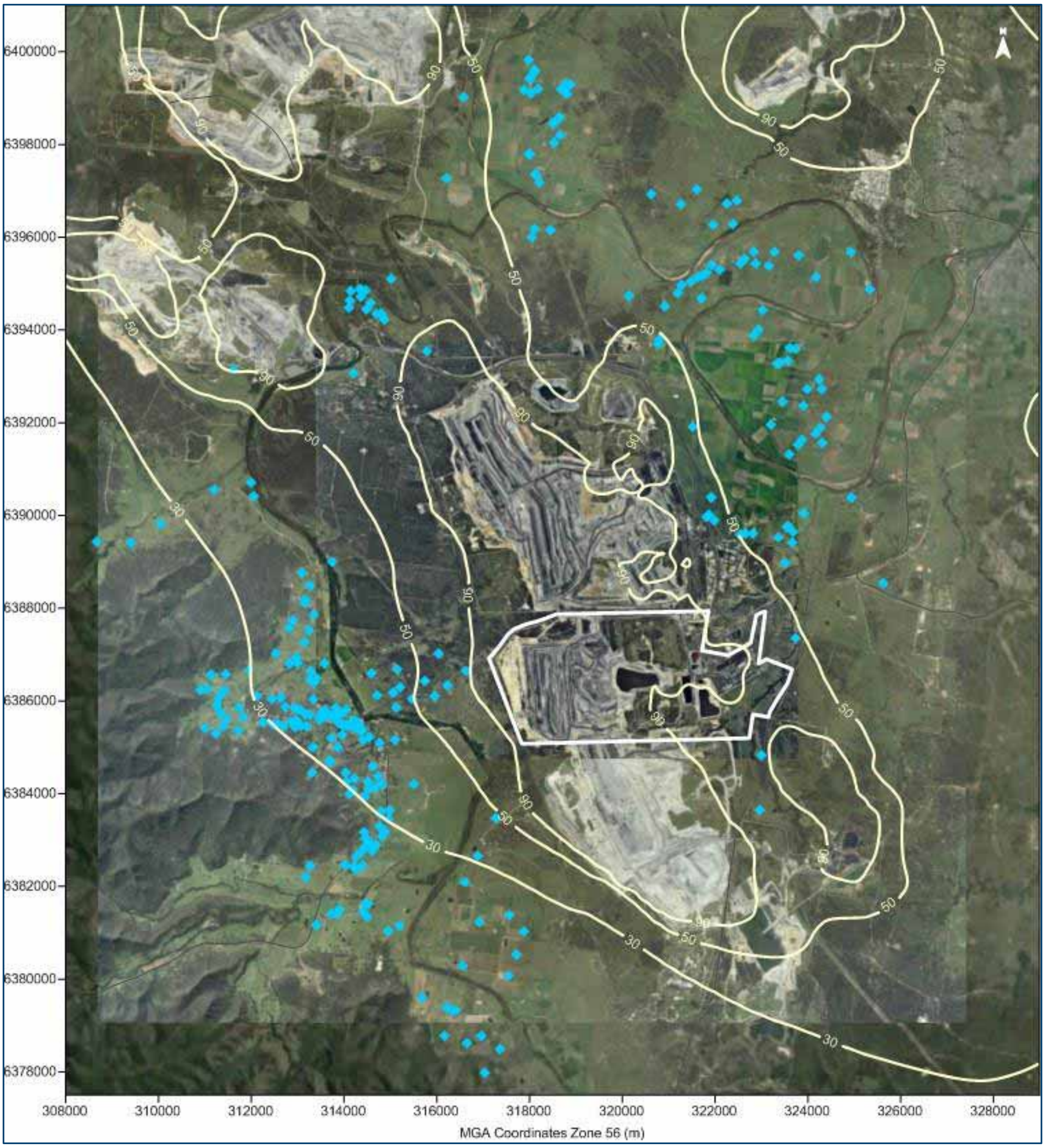

Figure E-7: Predicted annual average TSP concentrations due to emissions from the proposal and other sources in Year 3 (µg/m³)

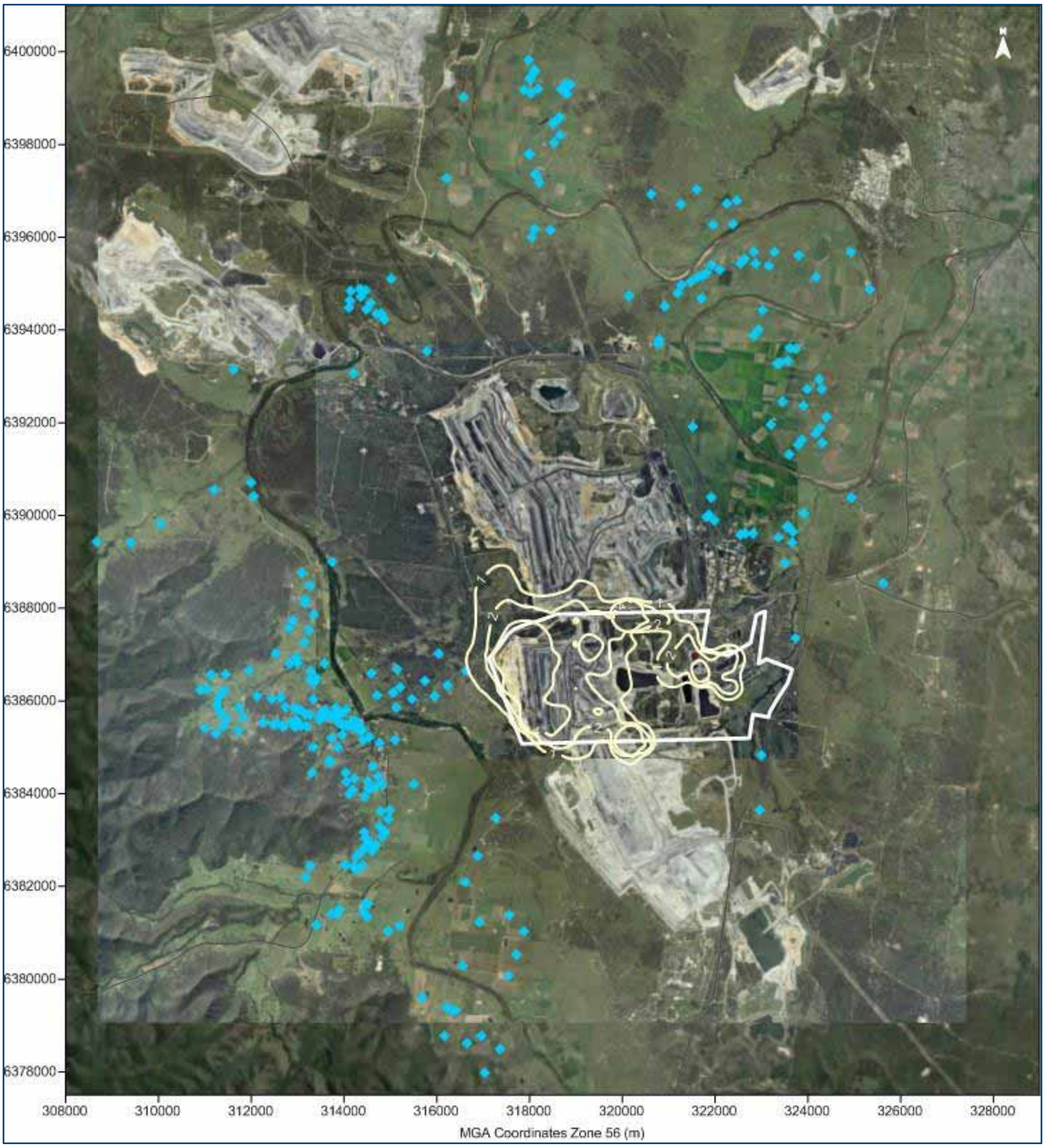

Figure E-8: Predicted annual average dust deposition levels due to emissions from the proposal in Year 3 (g/m²/month)

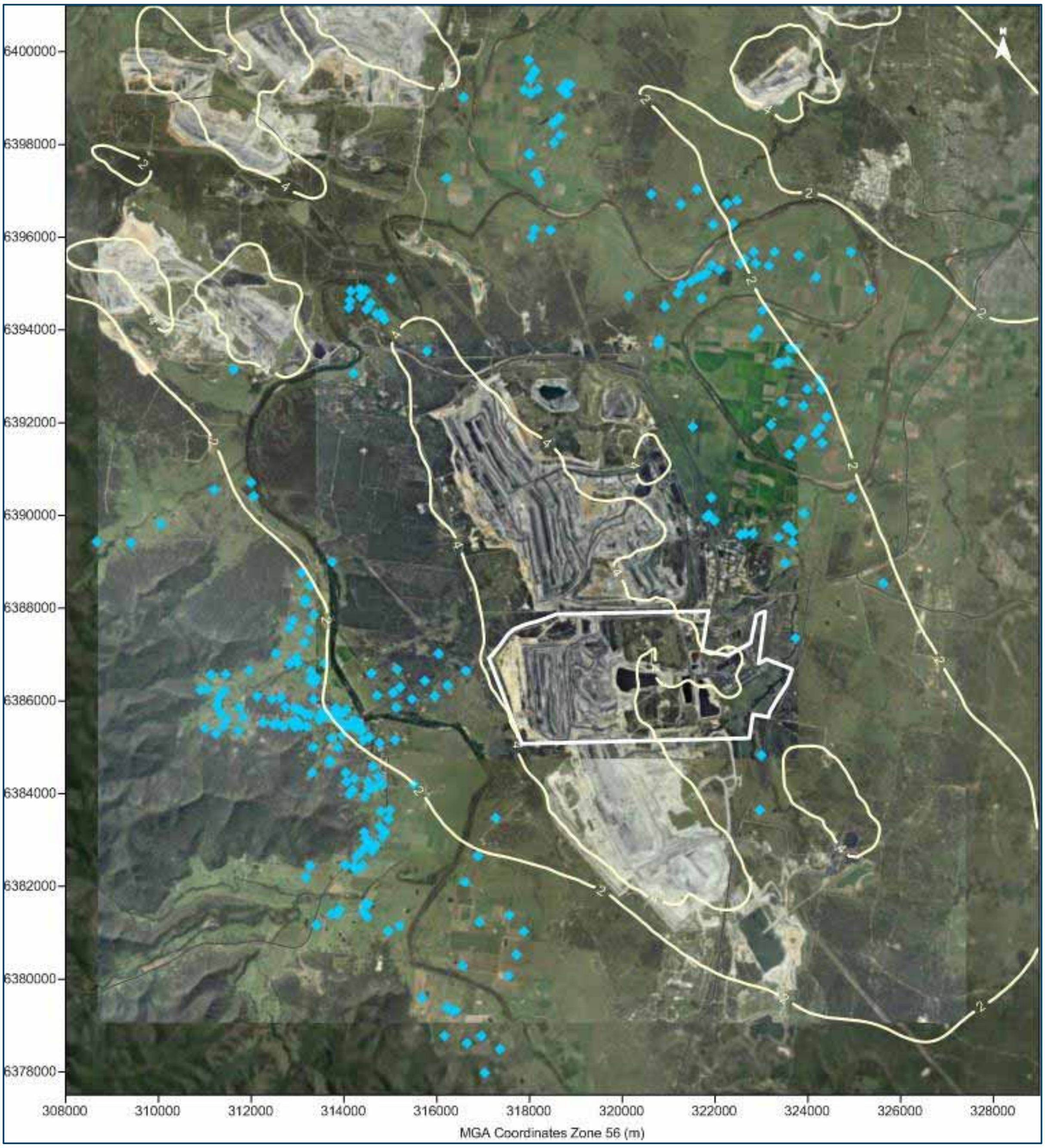

Figure E-9: Predicted annual average dust deposition levels due to emissions from the proposal and other sources in Year 3 (g/m²/month)

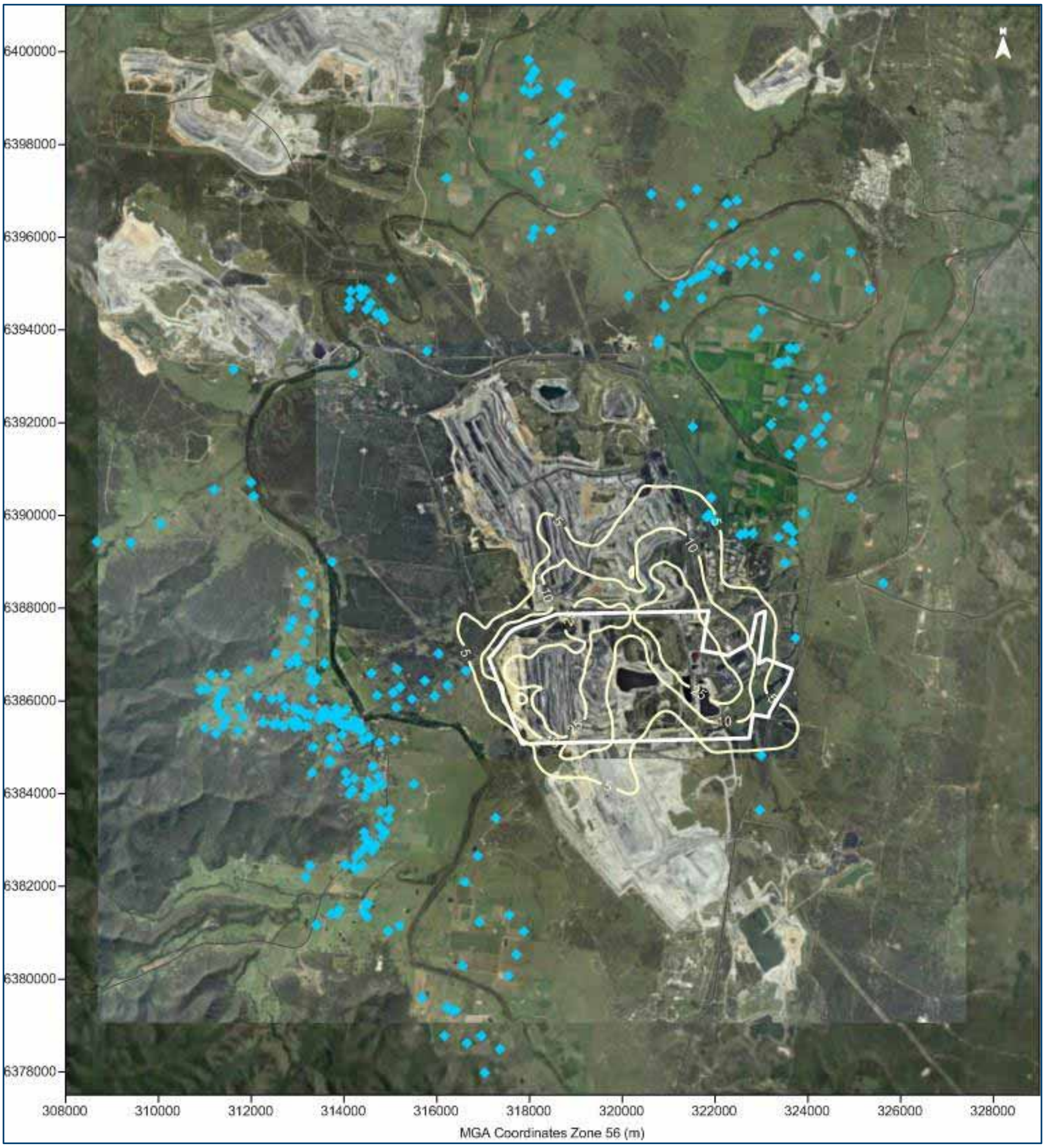

Figure E-10: Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 9 ($\mu g/m^3$)

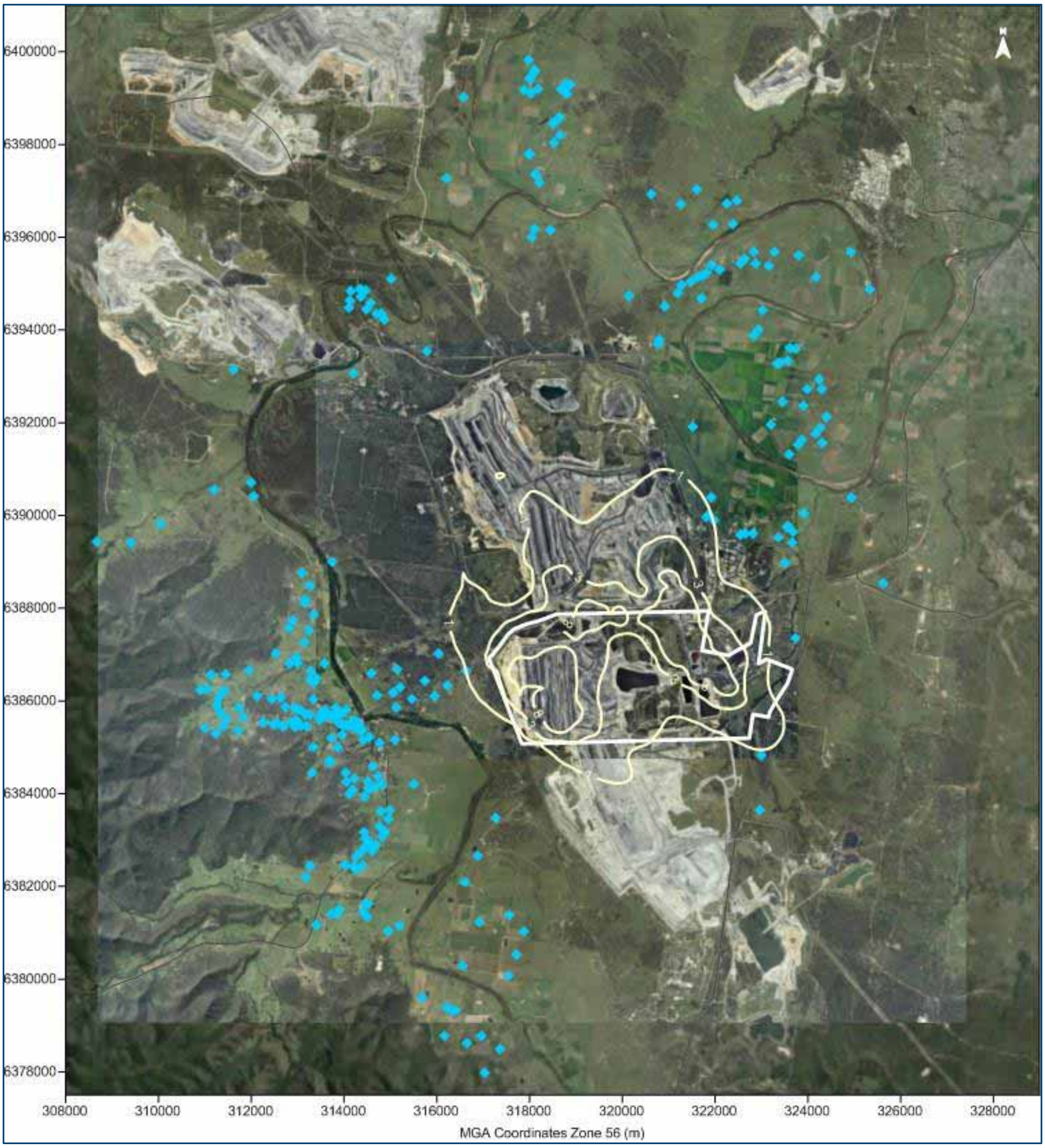

Figure E-11: Predicted annual average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 9 ($\mu g/m^3$)

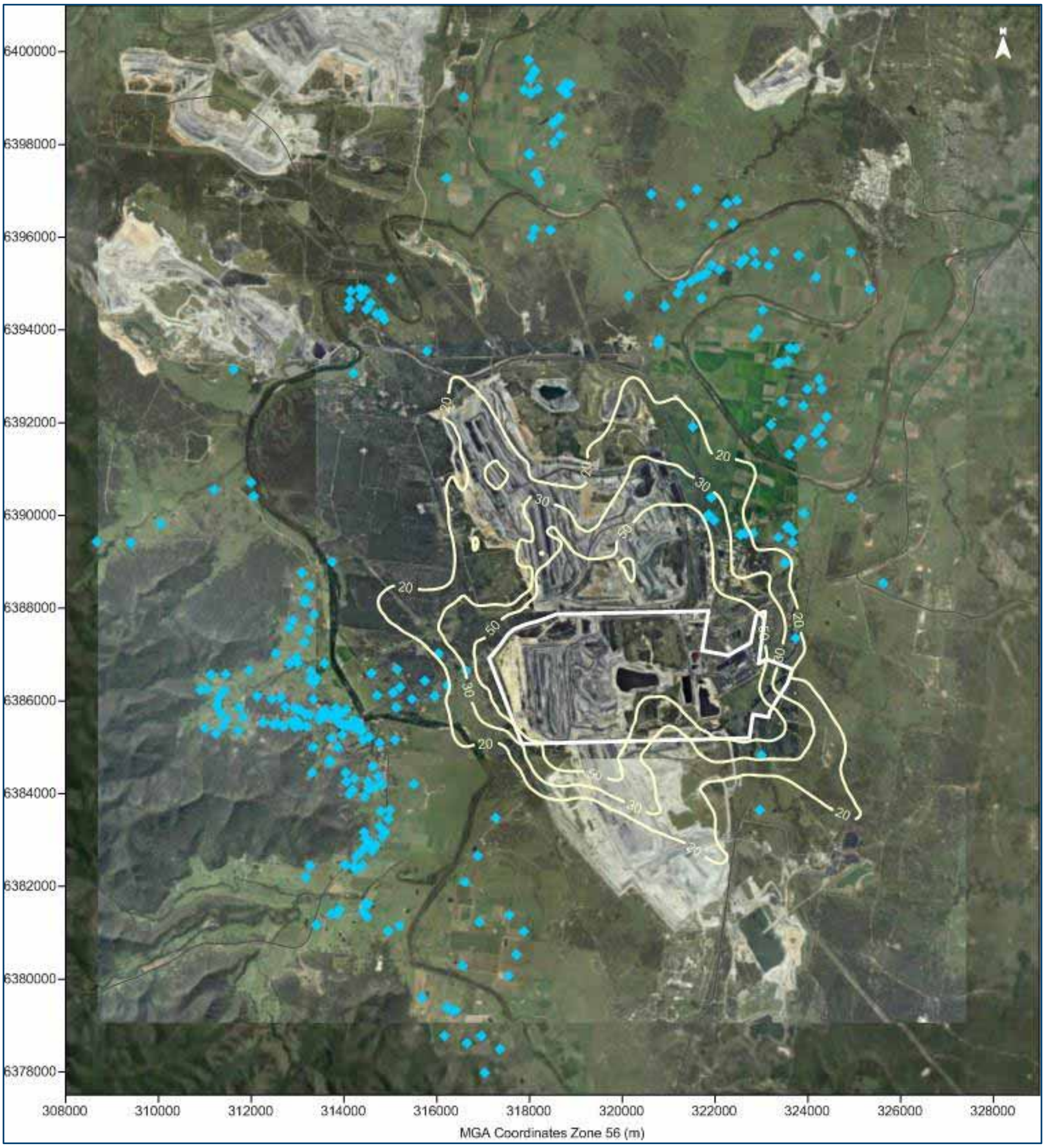

Figure E-12: Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the proposal in Year 9 (µg/m³)

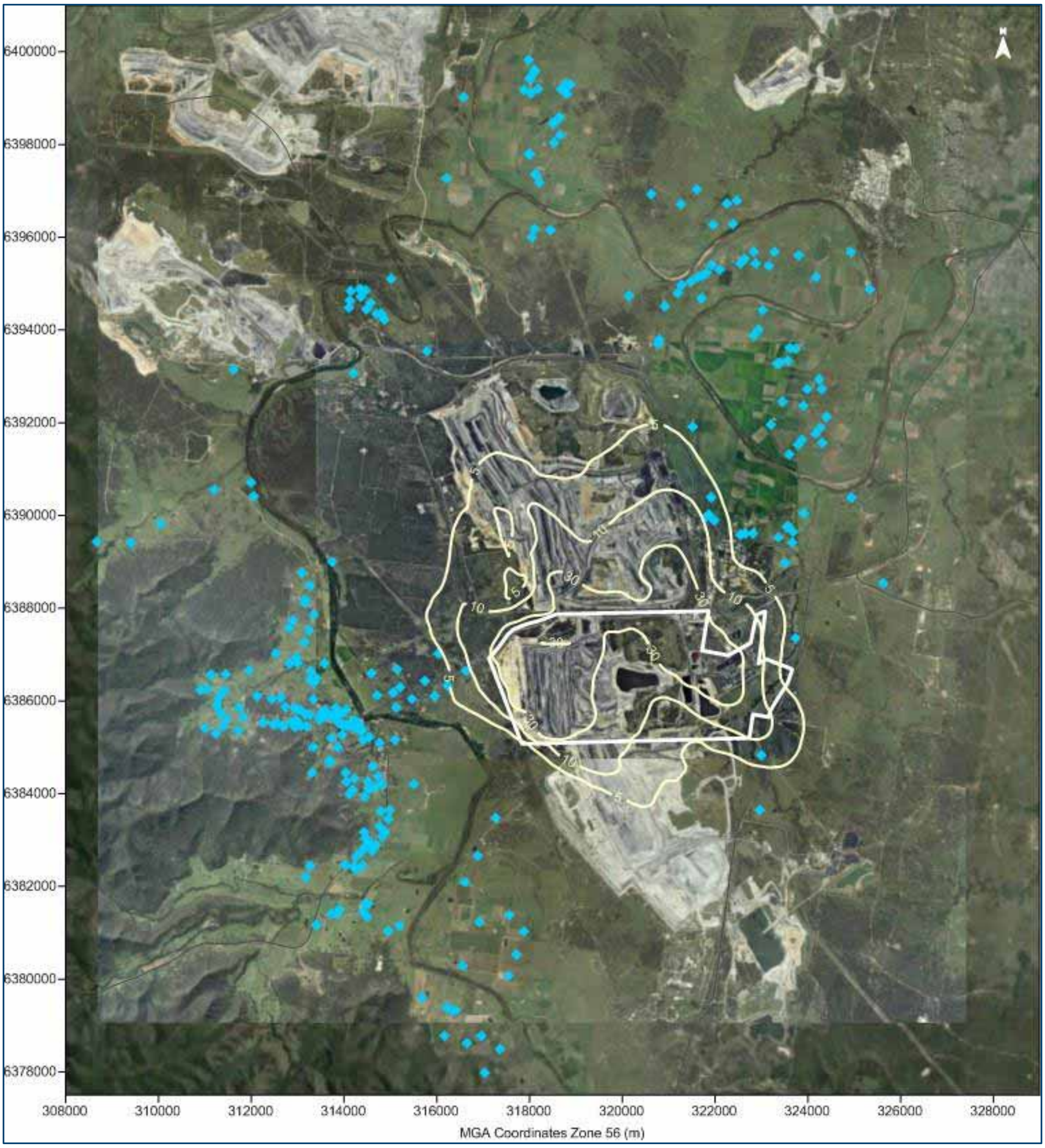

Figure E-13: Predicted annual average PM_{10} concentrations due to emissions from the proposal in Year 9 (µg/m³)

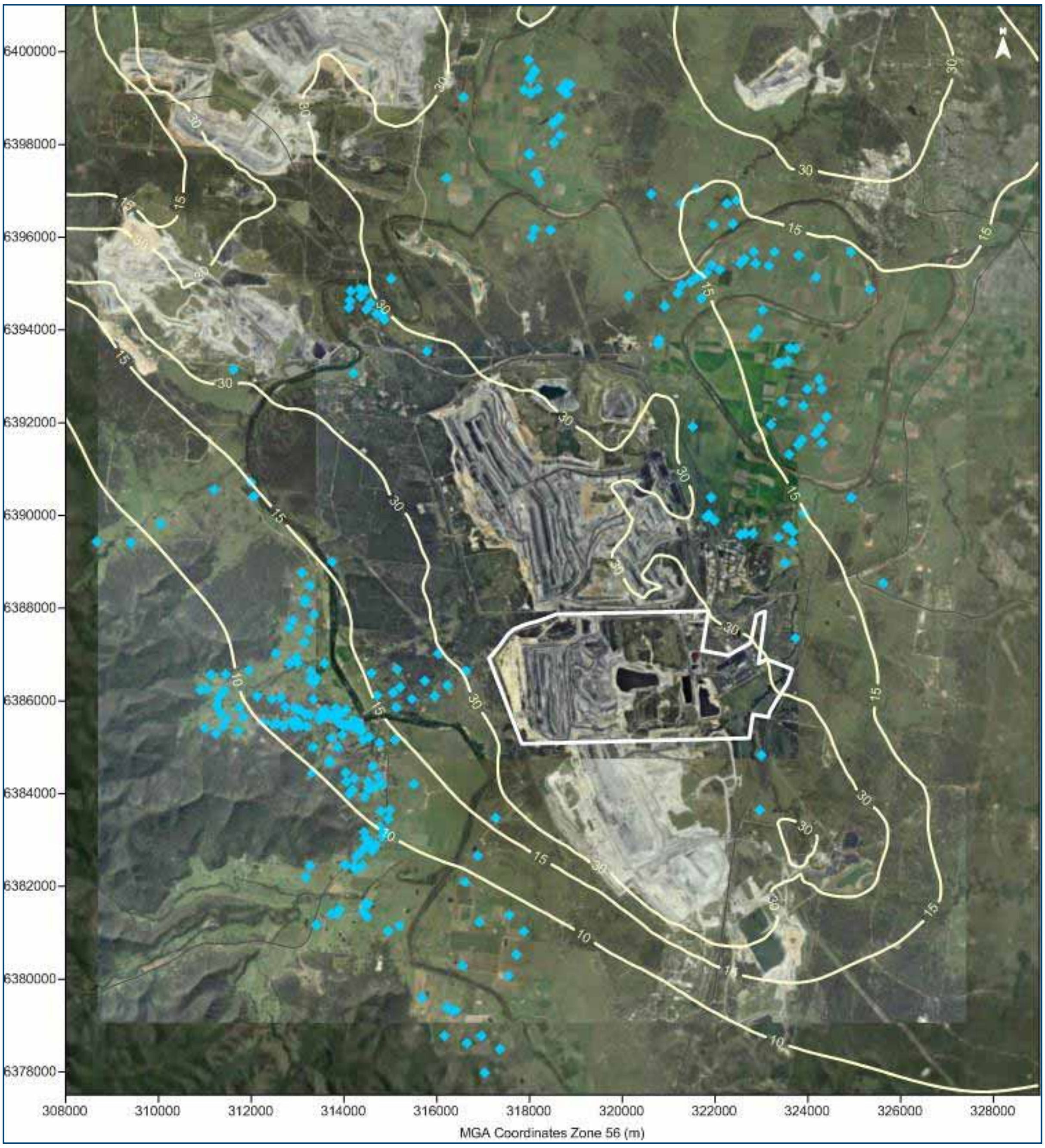

Figure E-14: Predicted annual average PM_{10} concentrations due to emissions from the proposal and other sources in Year 9 (µg/m³)

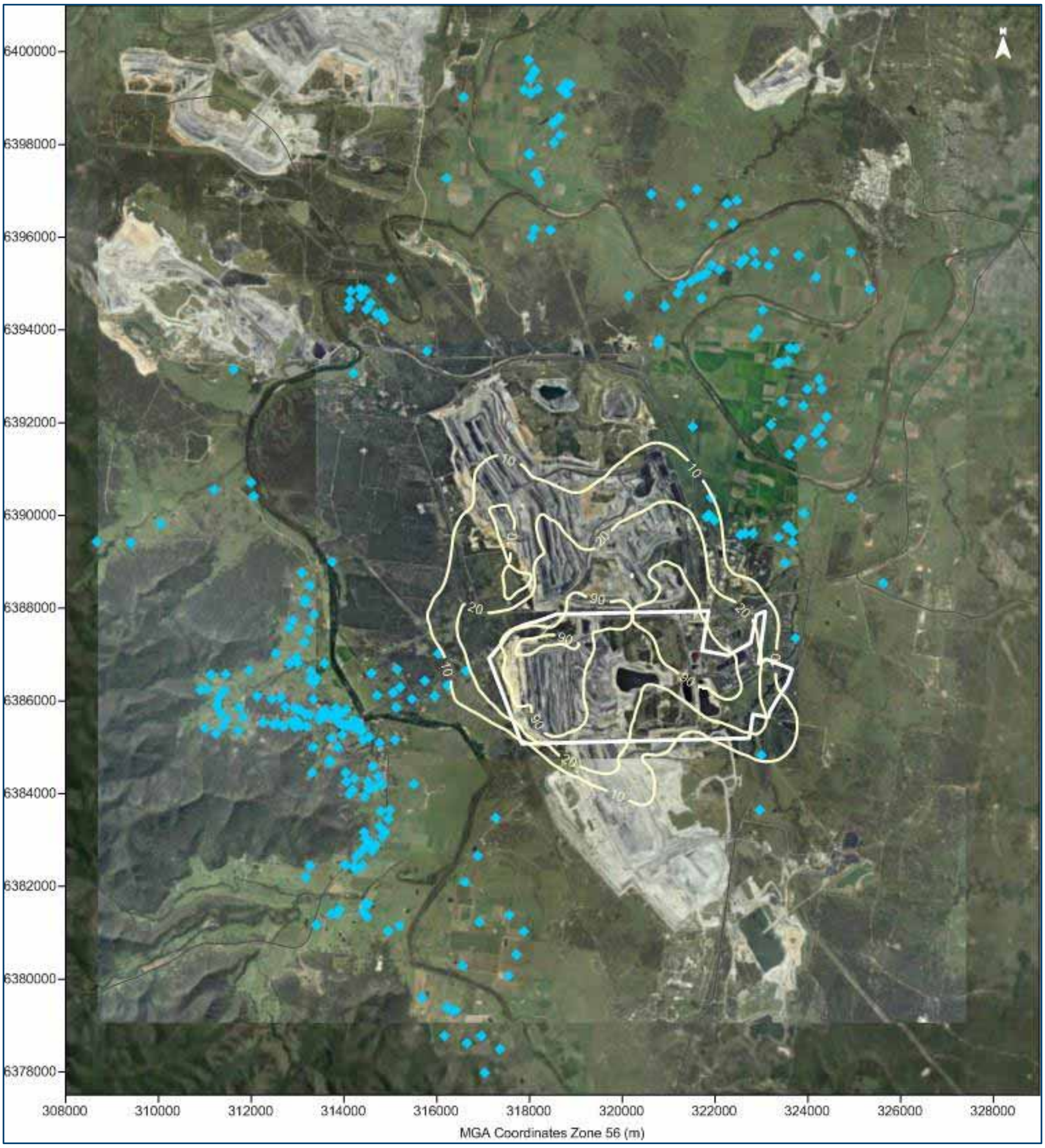

Figure E-15: Predicted annual average TSP concentrations due to emissions from the proposal in Year 9 (µg/m³)

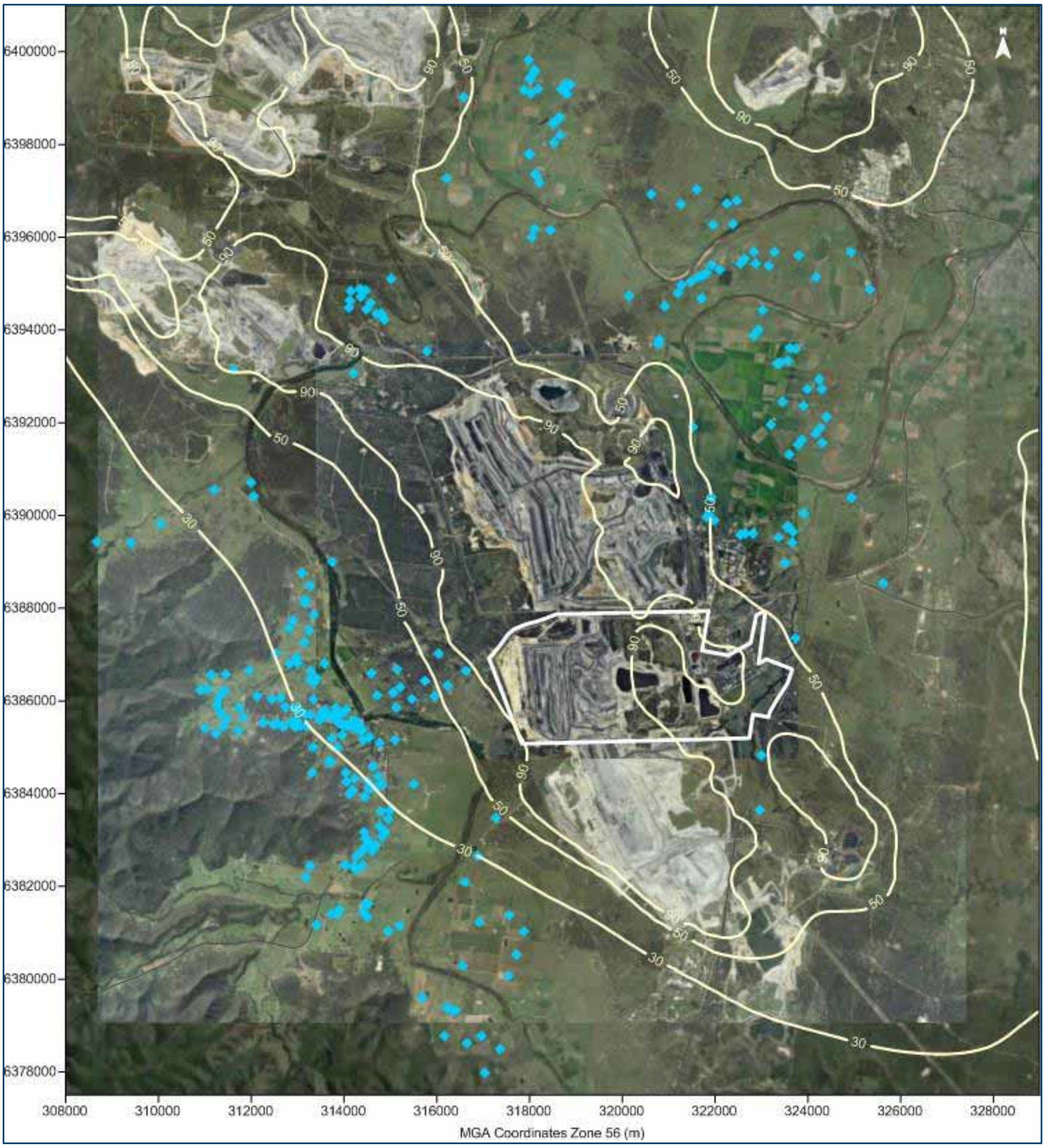

Figure E-16: Predicted annual average TSP concentrations due to emissions from the proposal and other sources in Year 9 (µg/m³)

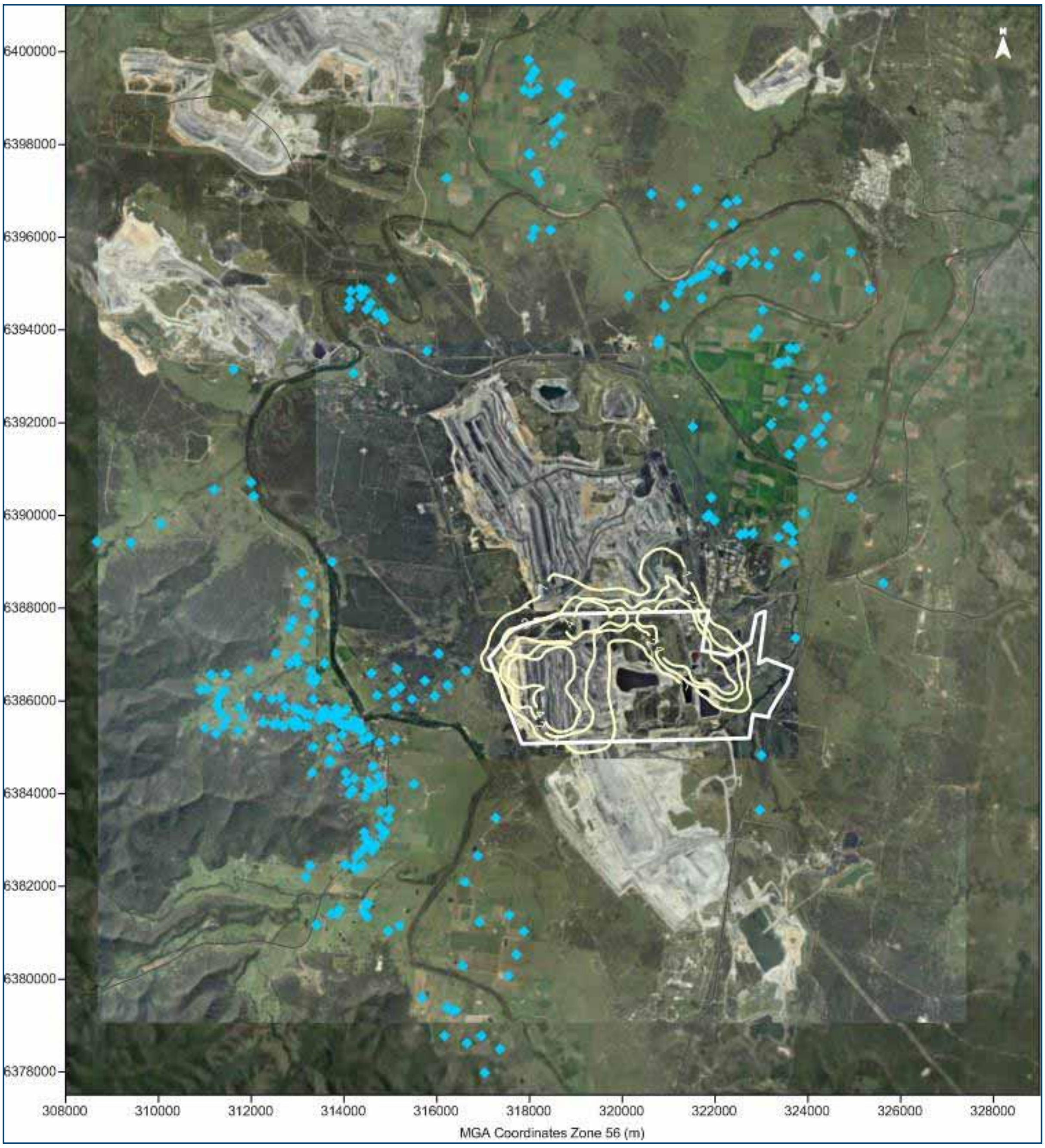

Figure E-17: Predicted annual average dust deposition levels due to emissions from the proposal in Year 9 (g/m²/month)

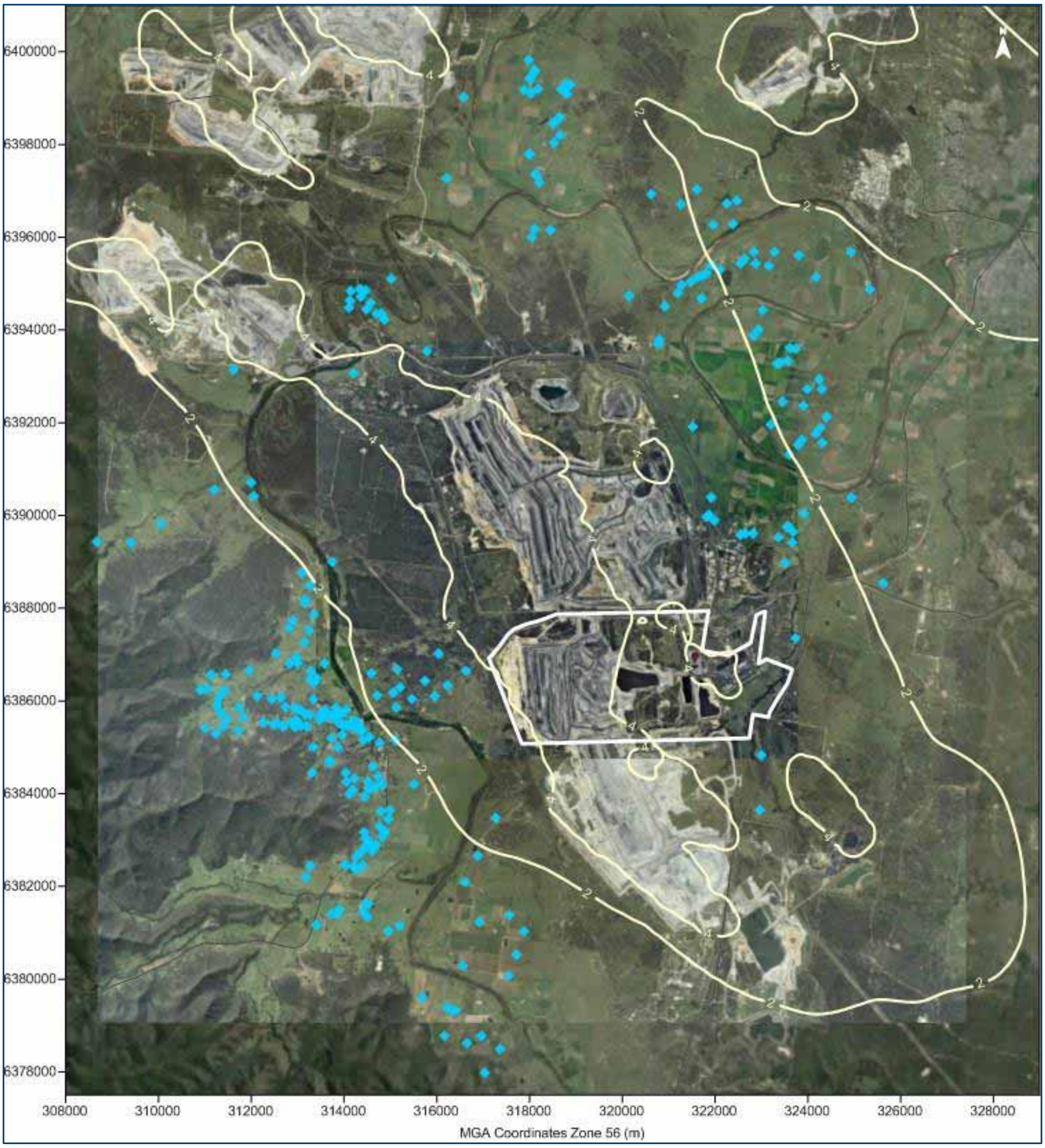

Figure E-18: Predicted annual average dust deposition levels due to emissions from the proposal and other sources in Year 9 (g/m²/month)

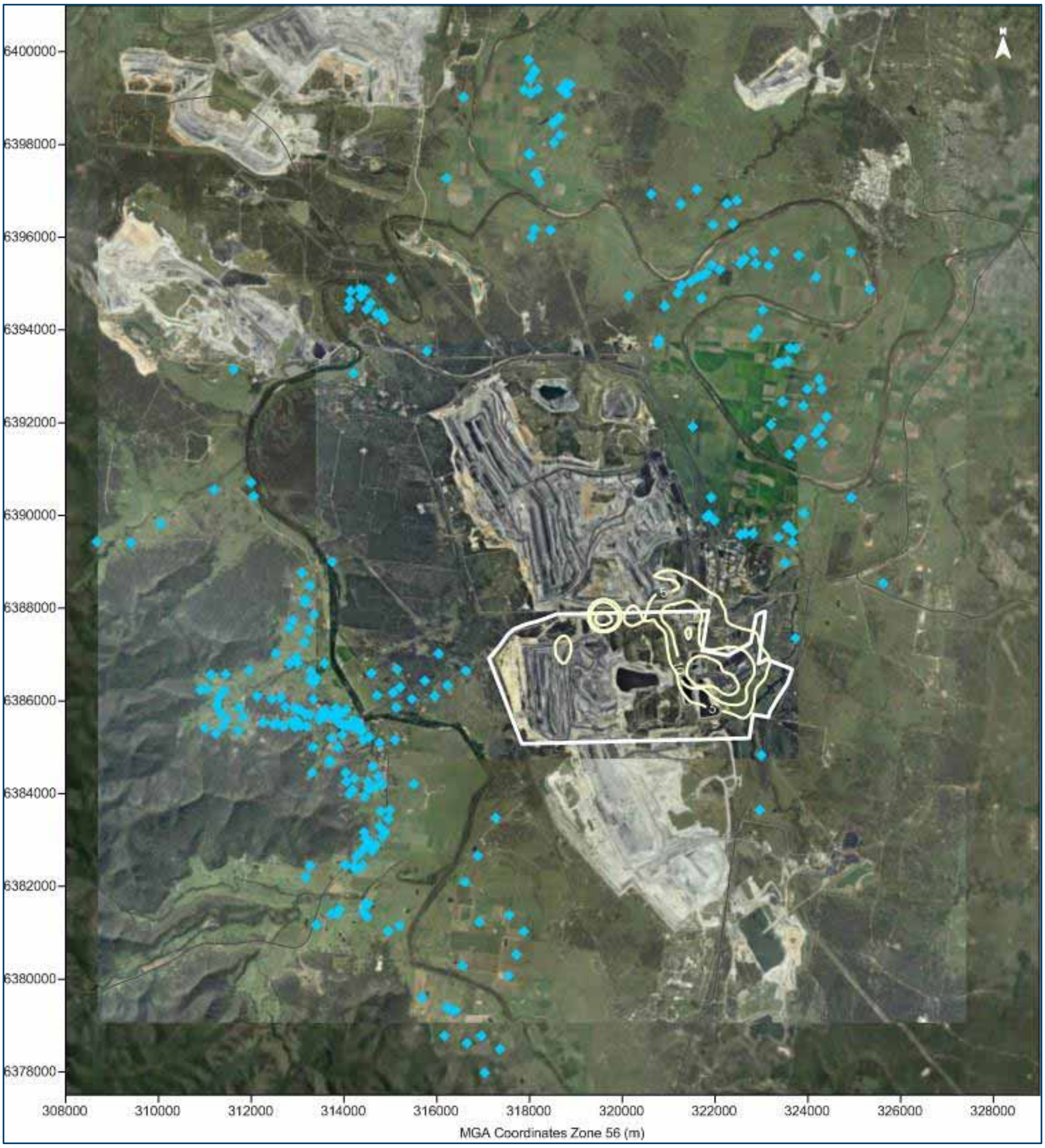

Figure E-19: Predicted maximum 24-hour average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 14 (µg/m³)

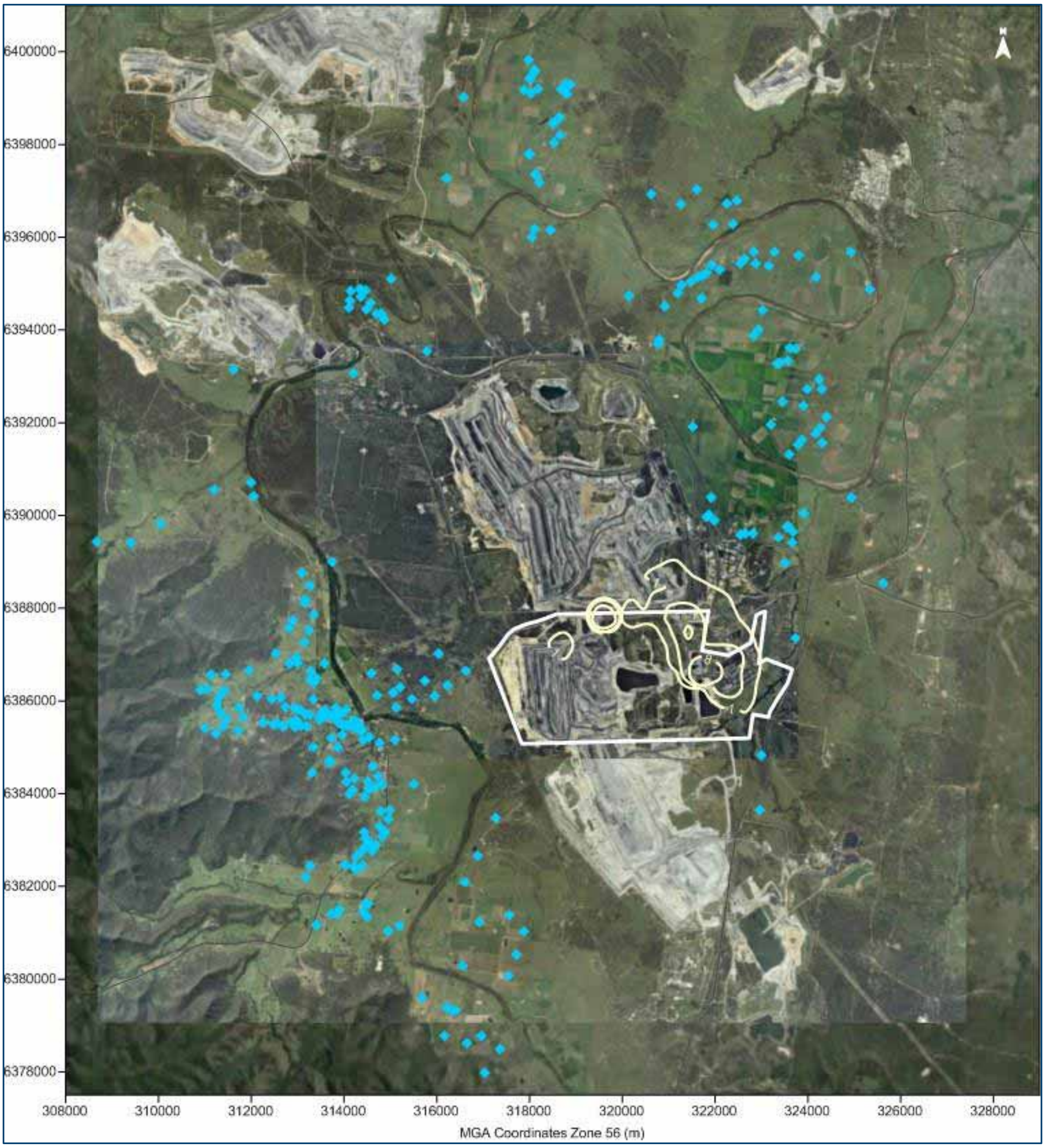

Figure E-20: Predicted annual average $PM_{2.5}$ concentrations due to emissions from the proposal in Year 14 (µg/m³)

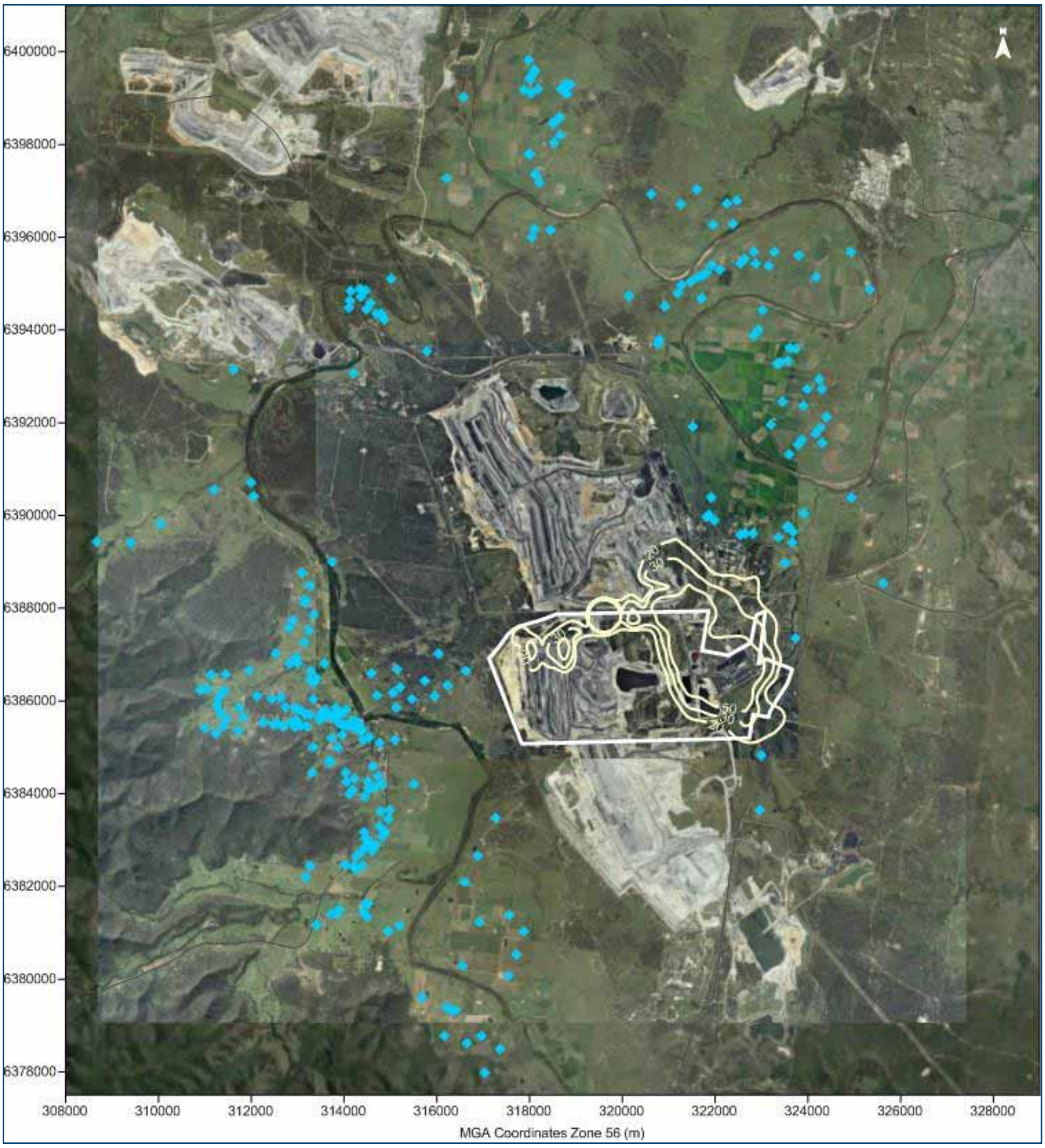

Figure E-21: Predicted maximum 24-hour average PM_{10} concentrations due to emissions from the proposal in Year 14 (µg/m³)

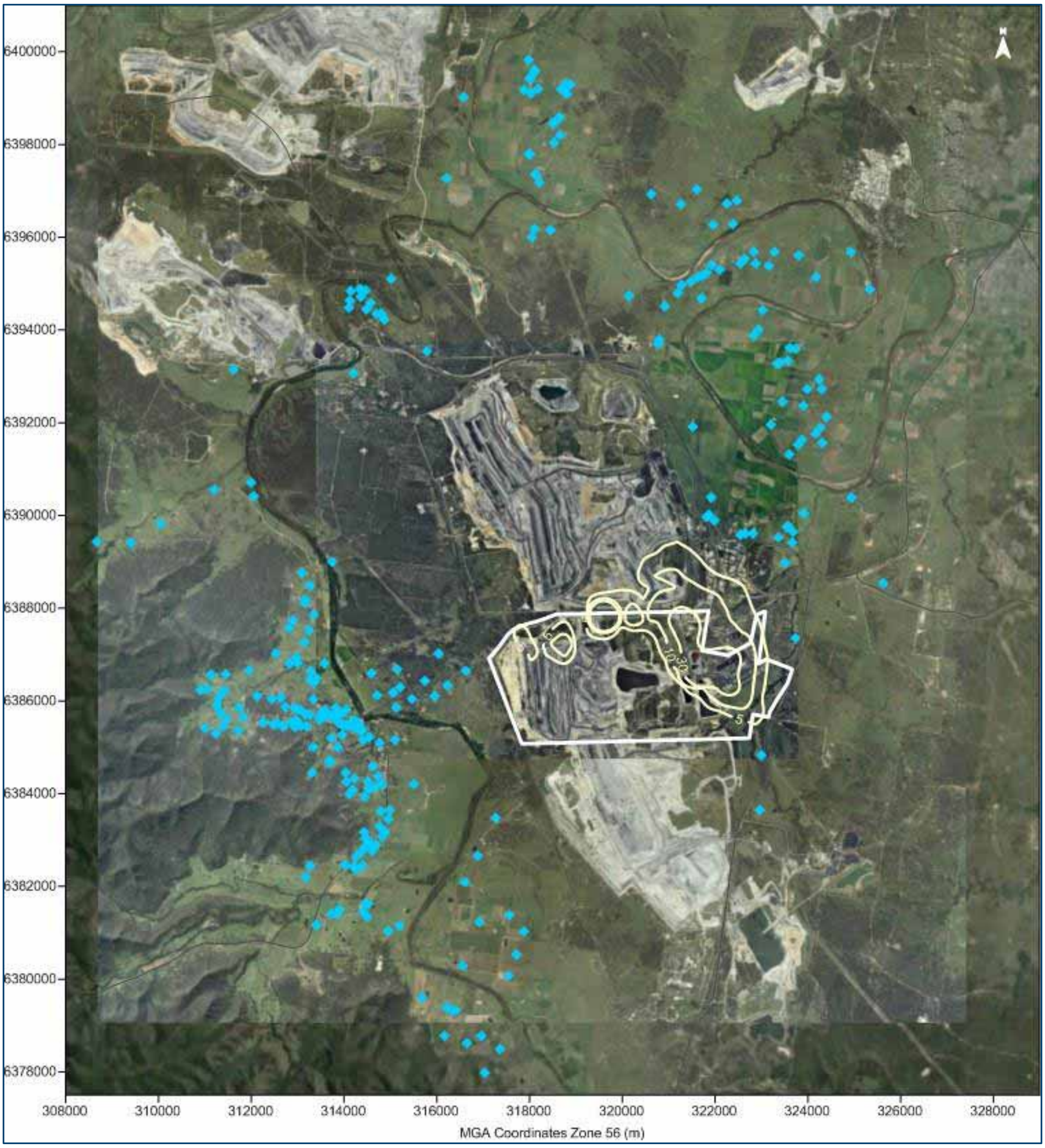

Figure E-22: Predicted annual average PM_{10} concentrations due to emissions from the proposal in Year 14 (µg/m³)

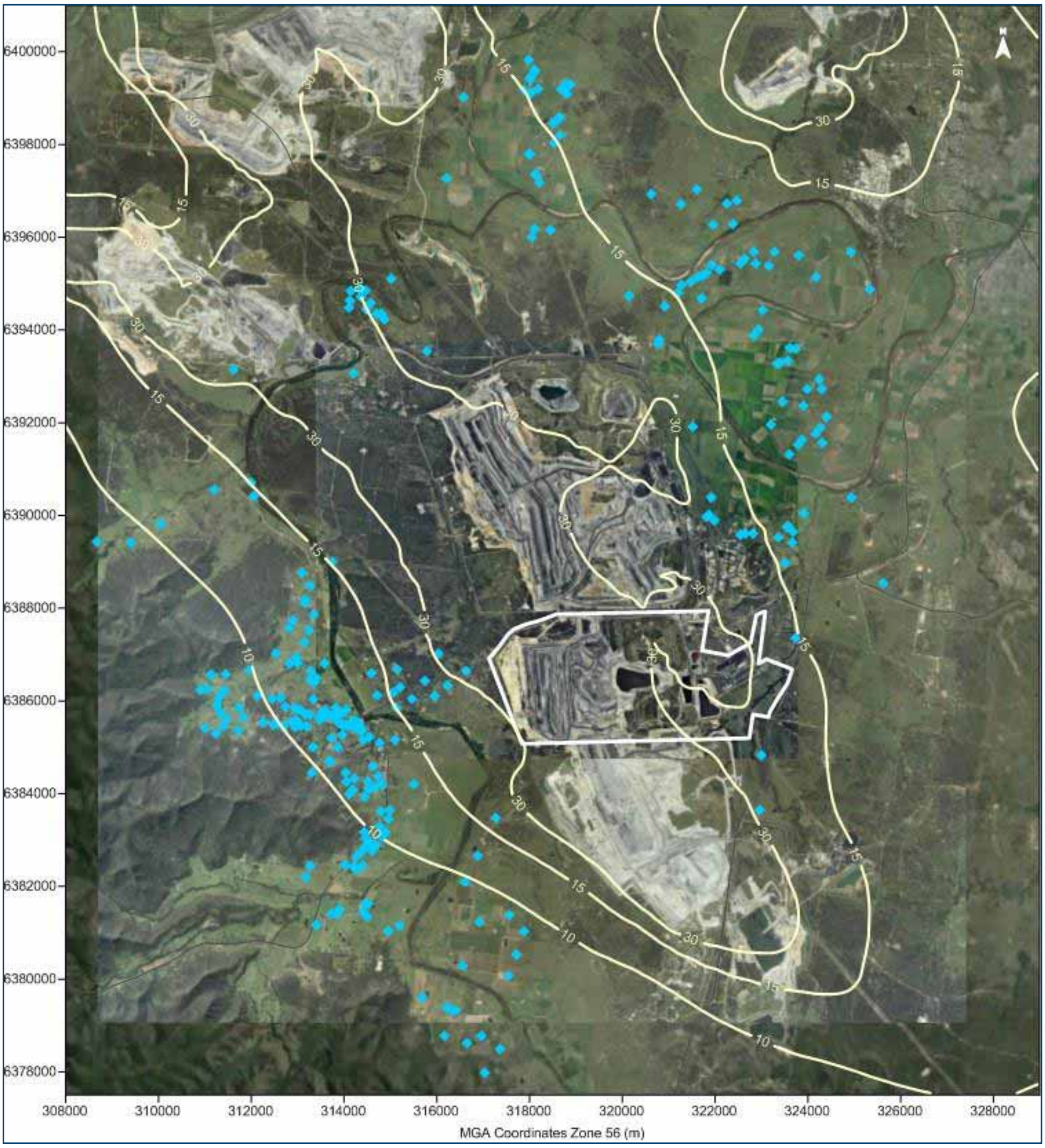

Figure E-23: Predicted annual average PM_{10} concentrations due to emissions from the proposal and other sources in Year 14 (µg/m³)

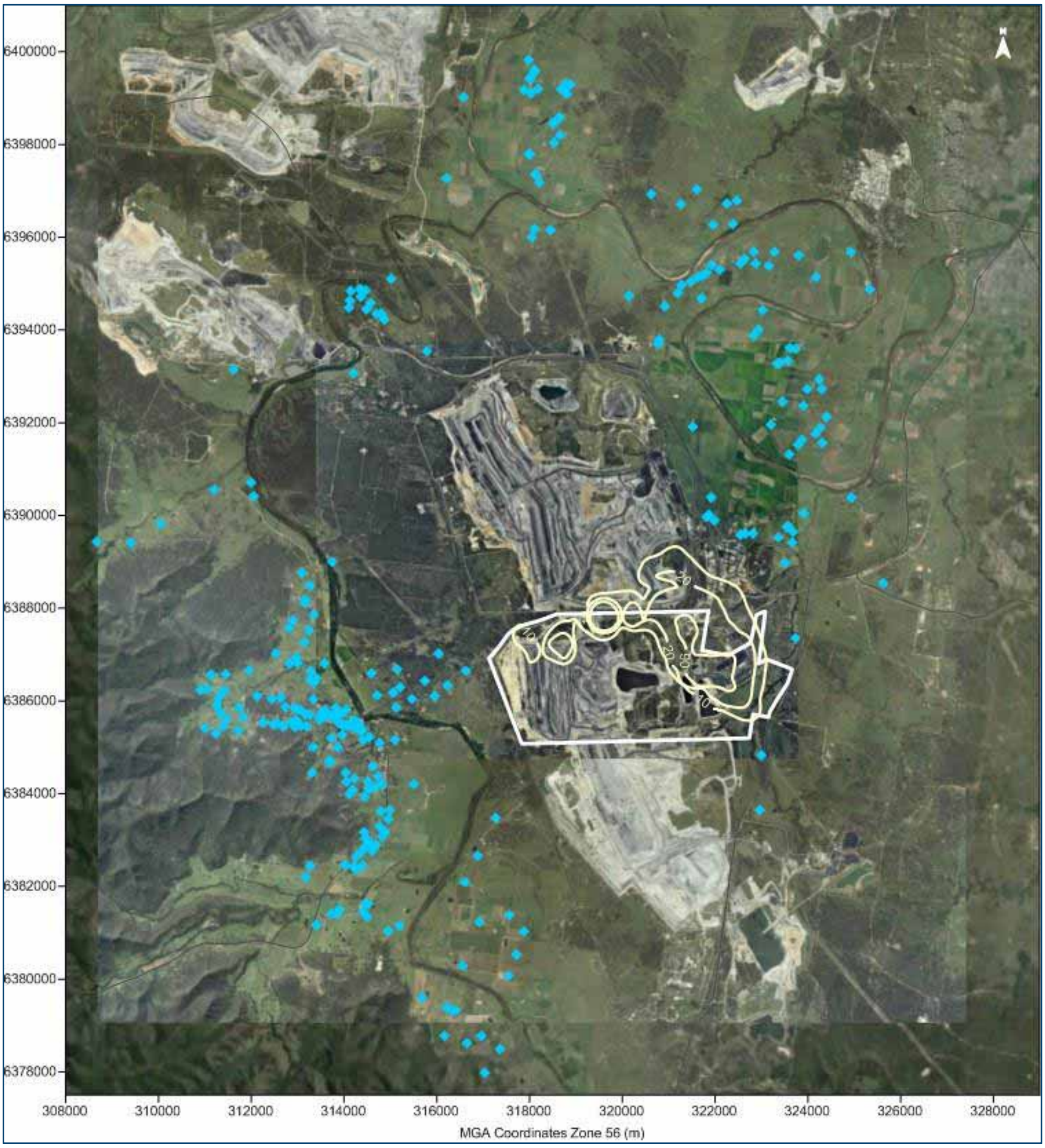

Figure E-24: Predicted annual average TSP concentrations due to emissions from the proposal in Year 14 (µg/m³)

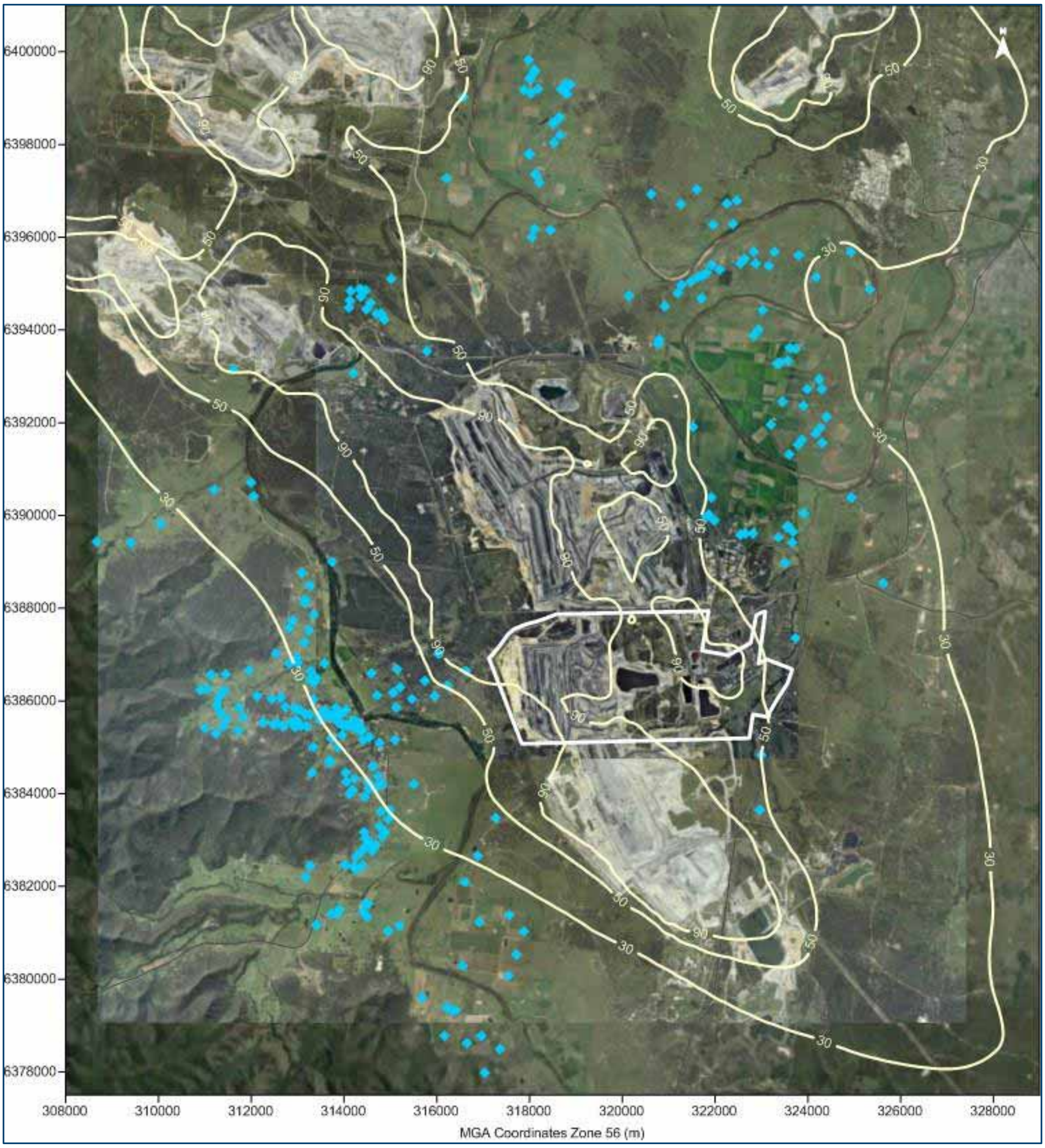

Figure E-25: Predicted annual average TSP concentrations due to emissions from the proposal and other sources in Year 14 (µg/m³)

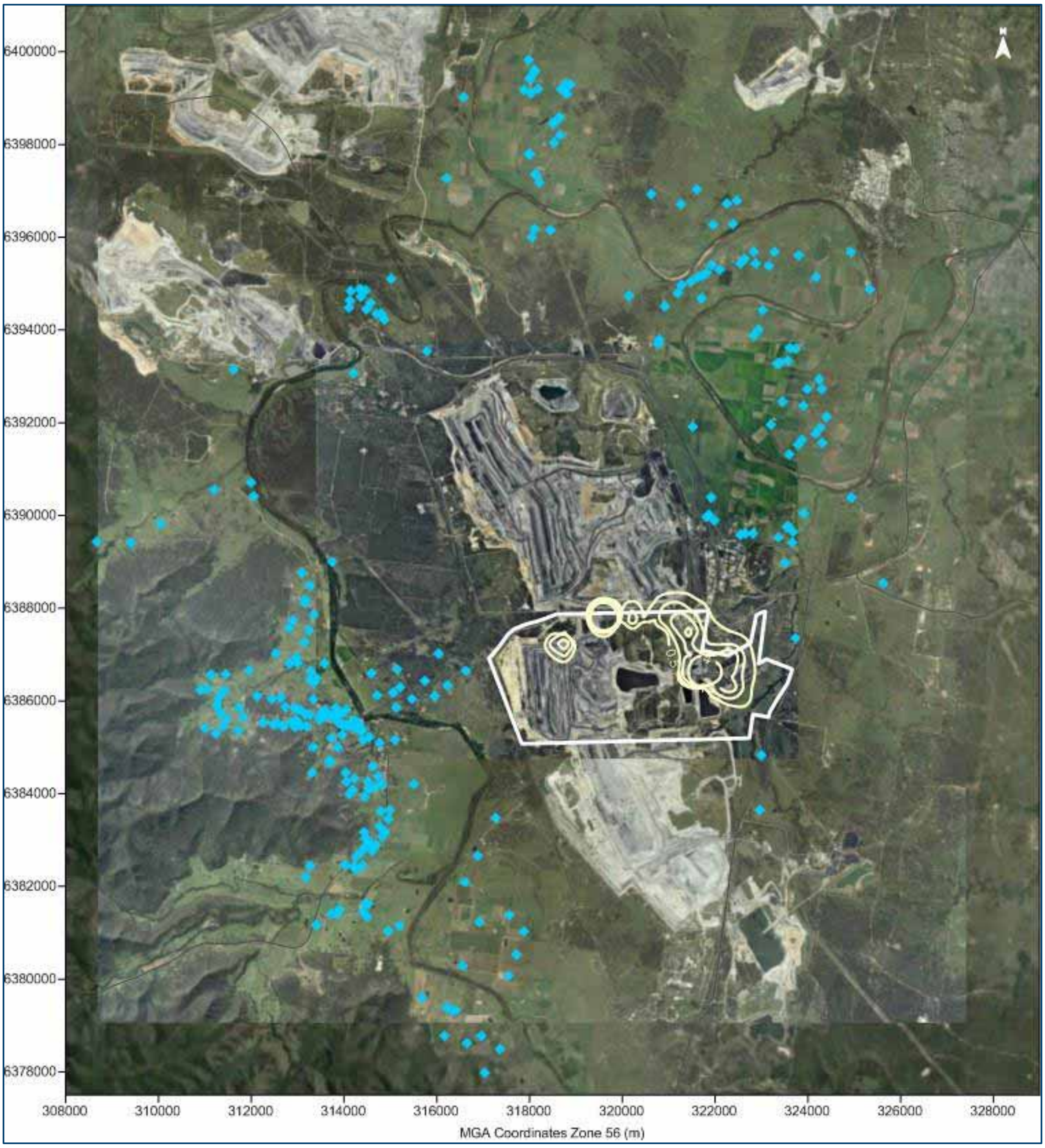

Figure E-26: Predicted annual average dust deposition levels due to emissions from the proposal in Year 14 (g/m²/month)

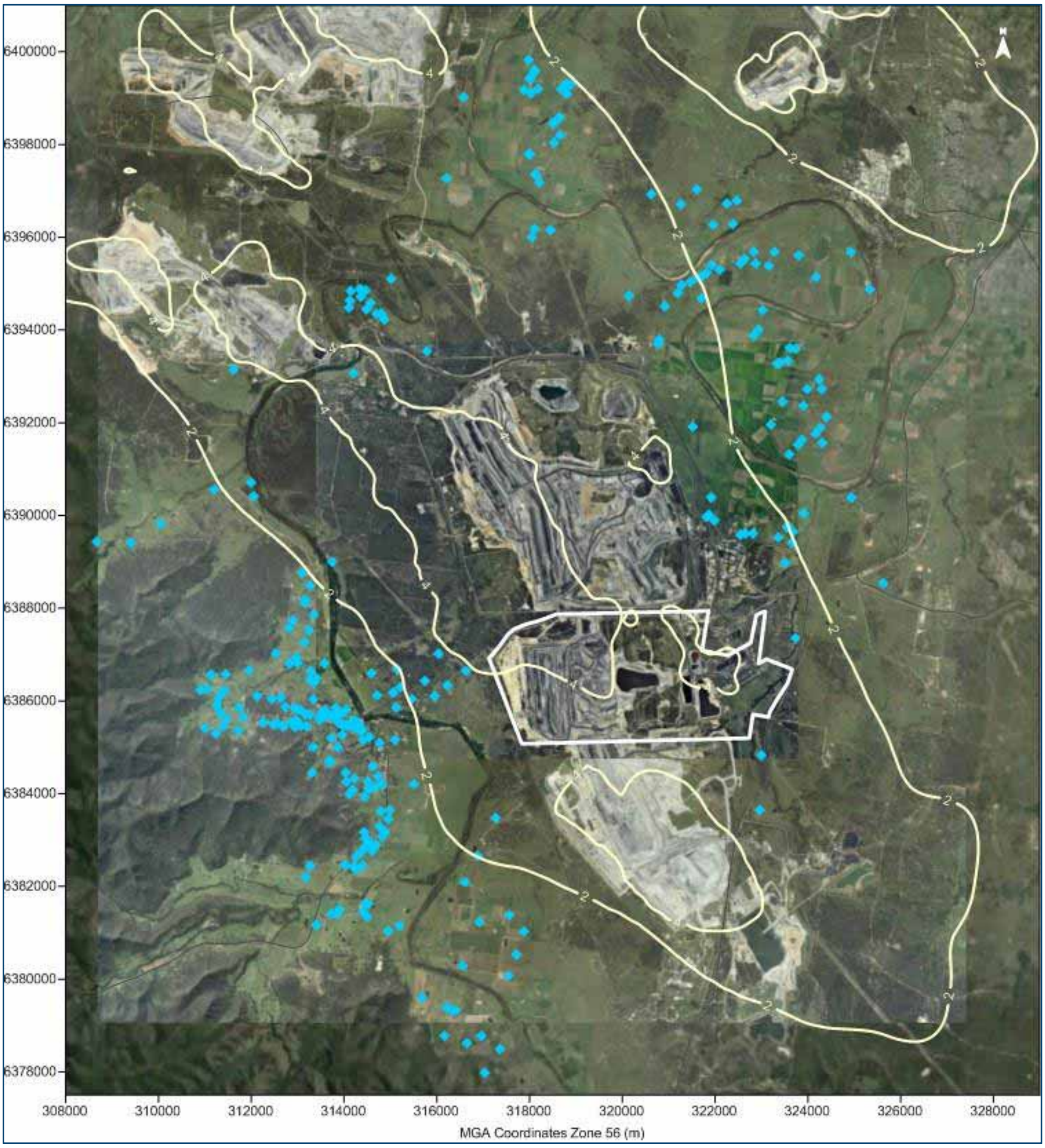

Figure E-27: Predicted annual average dust deposition levels due to emissions from the proposal and other sources in Year 14 (g/m²/month)

Appendix F

Further detail regarding 24-hour PM_{10} analysis

Table F-1: Bulga – Year 3

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
27/11/2012	56.1	-0.7	55.4	14/06/2012	ND	5.2	5.2
7/10/2012	40.9	-4.1	36.8	4/03/2012	9.8	4.3	14.2
29/09/2012	39.2	0.0	39.2	16/03/2012	ND	3.0	3.0
8/11/2012	38.7	0.3	39.0	22/04/2012	9.1	2.9	12.1
2/12/2012	37.4	-1.9	35.6	15/10/2012	11.4	2.6	14.0
22/10/2012	34.5	0.0	34.5	21/03/2012	8.3	2.0	10.3
9/01/2012	33.7	1.4	35.0	17/05/2012	13.7	1.9	15.5
6/01/2012	33.4	0.0	33.4	14/04/2012	12.1	1.8	13.9
18/08/2012	32.8	0.0	32.8	2/05/2012	15.3	1.7	17.0
19/12/2012	32.6	-0.9	31.6	25/05/2012	14.0	1.7	15.7

ND – No data

Table F-2: Wallaby Scrub Road – Year 3

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
18/10/2012	46.0	-7.0	39.0	8/06/2012	ND	7.9	7.9
7/09/2012	45.0	0.0	45.0	14/06/2012	ND	7.0	7.0
29/09/2012	44.0	0.0	44.0	1/04/2012	14.0	5.1	19.1
7/10/2012	41.0	0.5	41.5	8/07/2012	8.0	4.2	12.2
2/12/2012	41.0	1.2	42.2	22/04/2012	13.0	3.8	16.8
6/09/2012	37.0	0.0	37.0	3/09/2012	19.0	3.8	22.8
25/08/2012	36.0	0.1	36.1	22/02/2012	8.0	3.8	11.8
18/08/2012	35.0	0.0	35.0	3/04/2012	13.0	3.4	16.4
27/11/2012	34.0	-3.9	30.1	4/05/2012	10.0	3.0	13.0
19/12/2012	34.0	-2.0	32.0	8/04/2012	27.0	2.9	29.9

ND – No data

Table F-3: Warkworth – Year 3

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
19/12/2012	41.2	2.1	43.3	10/12/2012	31.7	19.0	50.7
7/11/2012	40.0	-0.4	39.6	11/12/2012	ND	11.4	11.4
7/09/2012	38.0	0.0	38.0	28/03/2012	15.9	11.3	27.2
23/10/2012	37.8	3.1	40.9	1/02/2012	12.9	11.3	24.2
27/10/2012	37.6	-0.8	36.8	13/06/2012	6.7	10.7	17.4
29/09/2012	37.3	0.0	37.3	2/06/2012	12.2	10.2	22.4
7/10/2012	36.3	1.2	37.5	5/01/2012	21.2	9.9	31.1
18/10/2012	35.9	-1.5	34.4	2/01/2012	17.8	9.2	27.0
8/11/2012	35.3	0.9	36.2	13/01/2012	ND	9.2	9.2
2/11/2012	34.7	0.5	35.2	3/01/2012	19.5	9.1	28.6

ND – No data

Table F-4: Knodlers Lane – Year 3

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
29/09/2012	56.3	0.0	56.3	2/06/2012	6.7	4.4	11.1
2/11/2012	54.5	0.0	54.5	1/03/2012	ND	3.1	3.1
26/10/2012	49.7	0.1	49.8	18/04/2012	16.0	3.0	19.0
27/10/2012	48.7	0.4	49.0	11/03/2012	14.0	3.0	17.0
17/10/2012	47.7	0.0	47.7	7/01/2012	10.5	3.0	13.5
6/10/2012	47.1	0.4	47.4	11/11/2012	14.9	2.5	17.4
18/10/2012	43.6	0.2	43.8	9/02/2012	ND	2.4	2.4
5/10/2012	42.8	0.0	42.8	14/11/2012	31.0	2.4	33.3
6/09/2012	42.3	0.0	42.3	24/01/2012	ND	2.3	2.3
21/10/2012	41.1	0.4	41.5	3/01/2012	12.0	2.2	14.2

ND – No data

Table F-5: MTIE – Year 3

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
2/11/2012	77.0	1.3	78.3	15/06/2012	19.0	9.1	28.1
14/09/2012	76.0	-2.1	73.9	17/07/2012	11.0	7.4	18.4
6/10/2012	73.0	-0.1	72.9	29/06/2012	17.0	6.4	23.4
27/10/2012	72.0	0.9	72.9	21/05/2012	35.0	5.6	40.6
18/08/2012	68.0	-0.7	67.3	21/08/2012	37.0	5.6	42.6
31/08/2012	65.0	-3.0	62.0	8/05/2012	35.0	5.3	40.3
5/10/2012	63.0	0.7	63.7	4/05/2012	10.0	5.3	15.3
4/09/2012	62.0	1.0	63.0	29/07/2012	18.0	5.1	23.1
23/08/2012	59.0	-1.6	57.4	27/09/2012	ND	5.1	5.1
6/09/2012	59.0	-12.1	46.9	22/08/2012	23.0	5.0	28.0

ND – No data

Table F-6: Bulga – Year 9

PM$_{10}$ 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
27/11/2012	56.1	-1.7	54.4	14/06/2012	ND	14.8	14.8
7/10/2012	40.9	-6.0	34.9	8/06/2012	5.9	12.8	18.7
29/09/2012	39.2	0.0	39.2	22/04/2012	9.1	12.3	21.5
8/11/2012	38.7	2.8	41.5	4/03/2012	9.8	11.8	21.6
2/12/2012	37.4	-1.9	35.5	16/03/2012	ND	10.8	10.8
22/10/2012	34.5	0.0	34.5	3/04/2012	11.9	9.2	21.1
9/01/2012	33.7	-0.4	33.3	17/05/2012	13.7	9.1	22.8
6/01/2012	33.4	0.3	33.7	14/04/2012	12.1	8.9	21.0
18/08/2012	32.8	0.0	32.8	30/10/2012	16.3	8.2	24.5
19/12/2012	32.6	-3.8	28.8	15/10/2012	11.4	8.0	19.4

ND – No data

Table F-7: Wallaby Scrub Road – Year 9

PM_{10} 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
18/10/2012	46.0	-4.8	41.2	8/06/2012	ND	16.9	16.9
7/09/2012	45.0	0.0	45.0	3/09/2012	19.0	16.7	35.7
29/09/2012	44.0	0.0	44.0	8/07/2012	8.0	11.3	19.3
7/10/2012	41.0	3.8	44.8	22/04/2012	13.0	11.1	24.1
2/12/2012	41.0	3.3	44.3	1/04/2012	14.0	10.2	24.2
6/09/2012	37.0	0.0	37.0	4/05/2012	10.0	10.0	20.0
25/08/2012	36.0	0.0	36.0	13/01/2012	18.0	9.7	27.7
18/08/2012	35.0	0.0	35.0	19/02/2012	22.0	8.6	30.6
27/11/2012	34.0	-0.6	33.4	20/04/2012	9.0	8.3	17.3
19/12/2012	34.0	1.1	35.1	6/10/2012	20.0	7.6	27.6

ND – No data

Table F-8: Warkworth – Year 9

PM_{10} 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
19/12/2012	41.2	-11.5	29.7	10/12/2012	31.7	56.3	88.0
7/11/2012	40.0	0.2	40.2	11/12/2012	ND	50.1	50.1
7/09/2012	38.0	0.0	38.0	12/06/2012	6.6	45.7	52.3
23/10/2012	37.8	14.9	52.7	17/04/2012	23.7	44.6	68.3
27/10/2012	37.6	-2.2	35.4	12/08/2012	10.6	41.9	52.5
29/09/2012	37.3	0.0	37.3	11/06/2012	11.5	38.5	50.0
7/10/2012	36.3	-1.7	34.6	10/07/2012	12.0	38.0	50.0
18/10/2012	35.9	-15.5	20.4	21/07/2012	10.5	35.5	46.0
8/11/2012	35.3	-0.6	34.7	6/07/2012	11.0	34.5	45.5
2/11/2012	34.7	0.8	35.5	7/03/2012	17.1	34.0	51.1

ND – No data

Table F-9: Knodlers Lane – Year 9

PM_{10} 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
29/09/2012	56.3	0.0	56.3	1/05/2012	17.1	3.2	20.3
2/11/2012	54.5	0.8	55.3	9/06/2012	8.6	3.2	11.8
26/10/2012	49.7	0.9	50.6	27/10/2012	48.7	3.2	51.8
27/10/2012	48.7	3.2	51.8	28/05/2012	12.6	2.9	15.5
17/10/2012	47.7	0.0	47.7	30/04/2012	18.1	2.7	20.9
6/10/2012	47.1	0.1	47.2	24/09/2012	24.3	2.2	26.4
18/10/2012	43.6	-0.1	43.5	26/06/2012	10.0	2.2	12.2
5/10/2012	42.8	0.1	42.8	9/07/2012	15.9	2.2	18.1
6/09/2012	42.3	0.0	42.3	31/07/2012	6.0	2.1	8.1
21/10/2012	41.1	0.3	41.4	30/03/2012	16.1	2.0	18.1

Table F-10: MTIE – Year 9

PM$_{10}$ 24-hour average (µg/m³)							
Date	**Background**	**Predicted increment**	**Total**	**Date**	**Background**	**Highest predicted increment**	**Total**
2/11/2012	77.0	5.2	82.2	26/07/2012	18.0	10.4	28.4
14/09/2012	76.0	-2.8	73.2	22/09/2012	45.0	10.1	55.1
6/10/2012	73.0	0.0	73.0	31/07/2012	36.0	9.4	45.4
27/10/2012	72.0	2.3	74.3	30/07/2012	17.0	9.2	26.2
18/08/2012	68.0	-3.5	64.5	10/03/2012	21.0	8.7	29.7
31/08/2012	65.0	-4.6	60.4	24/05/2012	47.0	8.6	55.6
5/10/2012	63.0	-9.1	53.9	5/05/2012	18.0	8.3	26.3
4/09/2012	62.0	2.0	64.0	3/07/2012	20.0	7.3	27.3
23/08/2012	59.0	-6.0	53.0	13/09/2012	42.0	7.3	49.3
6/09/2012	59.0	-13.6	45.4	11/07/2012	36.0	7.1	43.1

Table F-11: Bulga – Year 14

PM$_{10}$ 24-hour average (µg/m³)							
Date	**Background**	**Predicted increment**	**Total**	**Date**	**Background**	**Highest predicted increment**	**Total**
27/11/2012	56.1	-3.0	53.1	4/03/2012	9.8	18.9	28.7
7/10/2012	40.9	-10.7	30.1	14/06/2012	ND	18.9	18.9
29/09/2012	39.2	0.0	39.2	8/06/2012	5.9	17.0	22.9
8/11/2012	38.7	3.3	42.0	30/10/2012	16.3	16.6	32.8
2/12/2012	37.4	-5.6	31.8	20/09/2012	10.8	15.3	26.1
22/10/2012	34.5	0.0	34.4	17/05/2012	13.7	14.8	28.5
9/01/2012	33.7	-3.2	30.4	16/03/2012	ND	14.7	14.7
6/01/2012	33.4	0.3	33.7	22/04/2012	9.1	14.2	23.3
18/08/2012	32.8	0.0	32.8	3/04/2012	11.9	11.1	23.0
19/12/2012	32.6	-8.3	24.2	20/04/2012	ND	10.9	10.9

ND – No data

Table F-12: Wallaby Scrub Road – Year 14

PM$_{10}$ 24-hour average (µg/m³)							
Date	**Background**	**Predicted increment**	**Total**	**Date**	**Background**	**Highest predicted increment**	**Total**
18/10/2012	46.0	-13.4	32.6	8/06/2012	ND	23.3	23.3
7/09/2012	45.0	0.0	45.0	22/04/2012	13.0	18.5	31.5
29/09/2012	44.0	0.0	44.0	3/09/2012	19.0	17.7	36.7
7/10/2012	41.0	4.9	45.9	4/05/2012	10.0	16.1	26.1
2/12/2012	41.0	4.6	45.6	8/07/2012	8.0	15.2	23.2
6/09/2012	37.0	0.0	37.0	20/04/2012	9.0	13.2	22.2
25/08/2012	36.0	0.0	36.0	13/01/2012	18.0	12.5	30.5
18/08/2012	35.0	0.0	35.0	1/04/2012	14.0	12.3	26.3
27/11/2012	34.0	-4.3	29.7	30/10/2012	17.0	11.9	28.9
19/12/2012	34.0	-1.8	32.2	27/04/2012	13.0	10.7	23.7

ND – No data

Table F-13: Warkworth – Year 14

PM10 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
19/12/2012	41.2	-12.4	28.8	6/06/2012	6.9	65.4	72.3
7/11/2012	40.0	-1.1	38.9	10/12/2012	31.7	57.3	89.0
7/09/2012	38.0	0.0	38.0	11/12/2012	ND	45.0	45.0
23/10/2012	37.8	-1.4	36.4	26/06/2012	9.1	37.2	46.3
27/10/2012	37.6	-2.2	35.4	5/07/2012	9.8	37.1	46.9
29/09/2012	37.3	0.0	37.3	21/07/2012	10.5	35.1	45.6
7/10/2012	36.3	-0.8	35.5	11/06/2012	11.5	34.1	45.6
18/10/2012	35.9	-17.1	18.8	21/02/2012	13.7	33.1	46.8
8/11/2012	35.3	-0.9	34.4	12/08/2012	10.6	32.5	43.1
2/11/2012	34.7	2.8	37.5	11/04/2012	12.3	31.9	44.2

ND – No data

Table F-14: Knodlers Lane – Year 14

PM10 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
29/09/2012	56.3	0.0	56.4	27/10/2012	48.7	4.1	52.8
2/11/2012	54.5	0.3	54.8	20/07/2012	12.1	3.5	15.6
26/10/2012	49.7	0.3	50.0	31/07/2012	6.0	1.4	7.4
27/10/2012	48.7	4.1	52.8	7/10/2012	27.3	1.1	28.5
17/10/2012	47.7	0.0	47.7	1/11/2012	28.9	1.0	29.9
6/10/2012	47.1	0.2	47.3	10/01/2012	ND	0.9	0.9
18/10/2012	43.6	-0.1	43.5	28/05/2012	12.6	0.9	13.5
5/10/2012	42.8	0.1	42.9	20/05/2012	25.0	0.9	25.9
6/09/2012	42.3	0.0	42.3	15/09/2012	11.6	0.7	12.4
21/10/2012	41.1	-0.1	41.0	6/12/2012	24.7	0.6	25.3

ND – No data

Table F-15: MTIE – Year 14

PM10 24-hour average (µg/m³)							
Date	Background	Predicted increment	Total	Date	Background	Highest predicted increment	Total
2/11/2012	77.0	-0.1	76.9	2/06/2012	19.0	1.6	20.6
14/09/2012	76.0	-9.9	66.1	31/05/2012	13.0	1.4	14.4
6/10/2012	73.0	-0.4	72.6	8/10/2012	34.0	1.2	35.2
27/10/2012	72.0	0.3	72.3	16/09/2012	51.0	0.9	51.9
18/08/2012	68.0	-4.0	64.0	30/05/2012	12.0	0.8	12.8
31/08/2012	65.0	-12.2	52.8	4/02/2012	5.0	0.8	5.8
5/10/2012	63.0	-9.7	53.3	12/02/2012	16.0	0.8	16.8
4/09/2012	62.0	-6.2	55.8	1/05/2012	24.0	0.7	24.7
23/08/2012	59.0	-7.9	51.1	14/03/2012	17.0	0.7	17.7
6/09/2012	59.0	-16.1	42.9	13/03/2012	21.0	0.7	21.7

Appendix G

Isopleth Diagrams – Diesel emissions

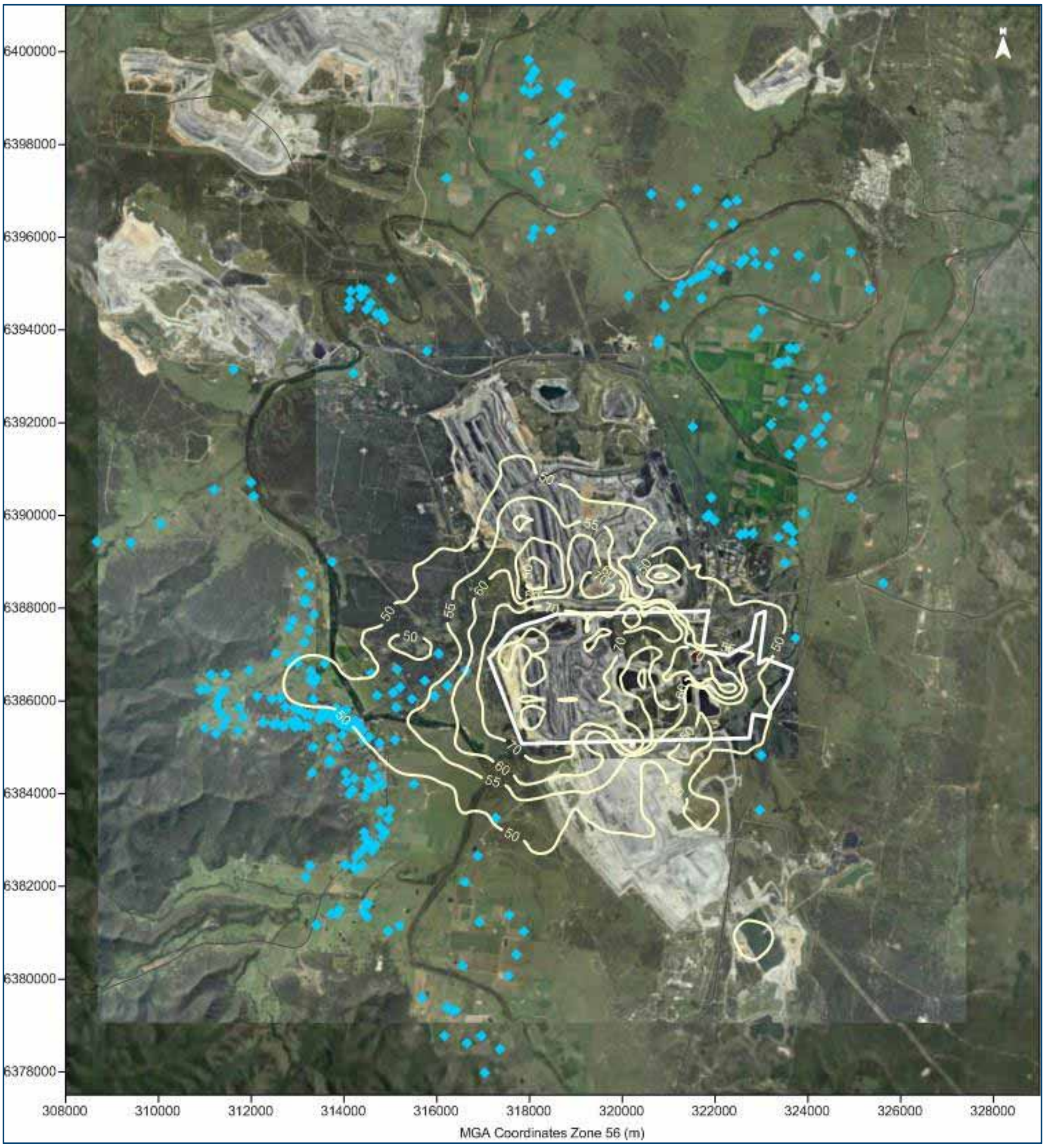

Figure G-1: Predicted 1-hour average NO_2 concentrations due to emissions from the proposal in Year 3 (µg/m³)

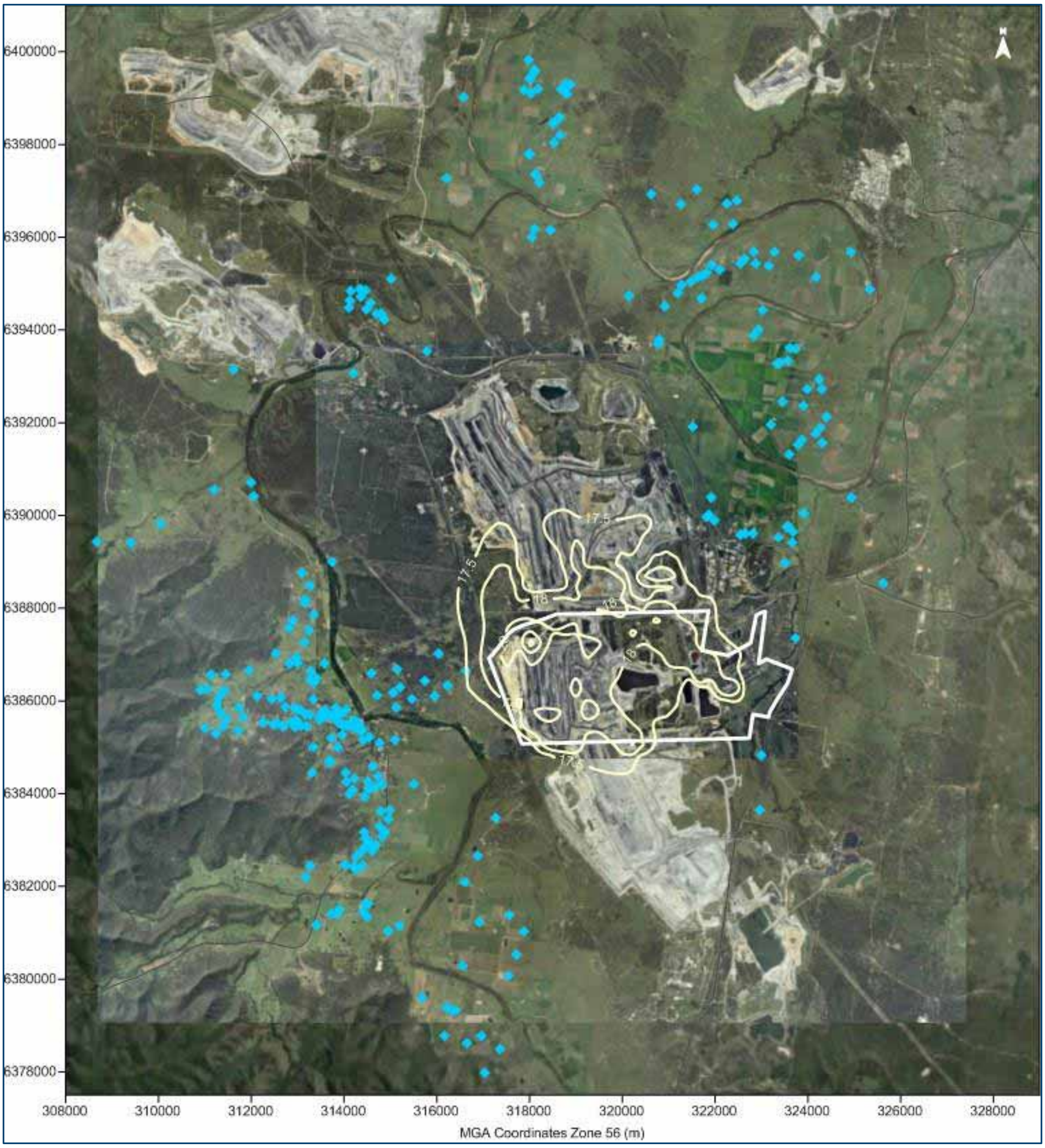

Figure G-2: Predicted annual average NO_2 concentrations due to emissions from the proposal in Year 3 (µg/m³)

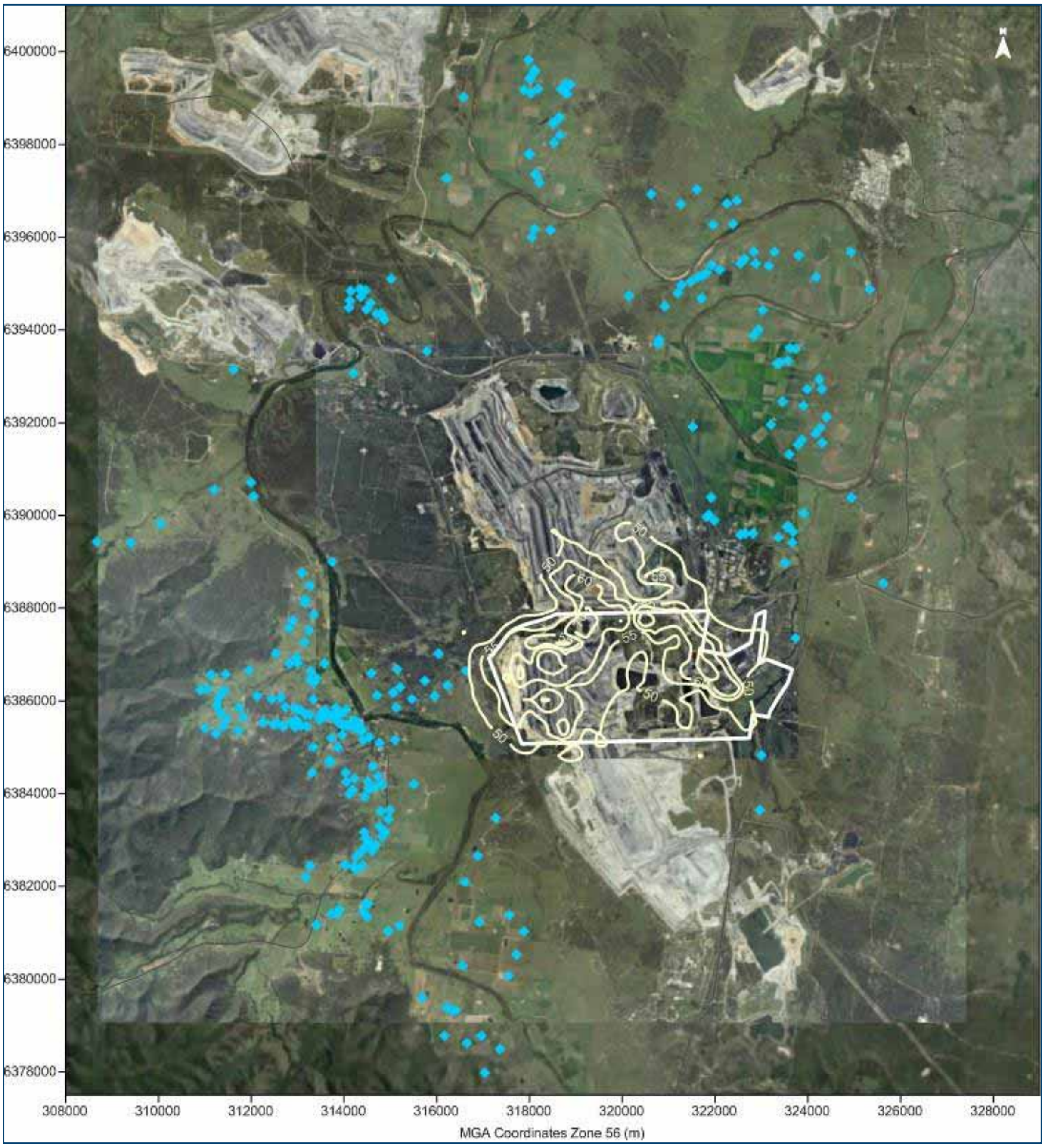

Figure G-3: Predicted 1-hour average NO_2 concentrations due to emissions from the proposal in Year 9 (µg/m³)

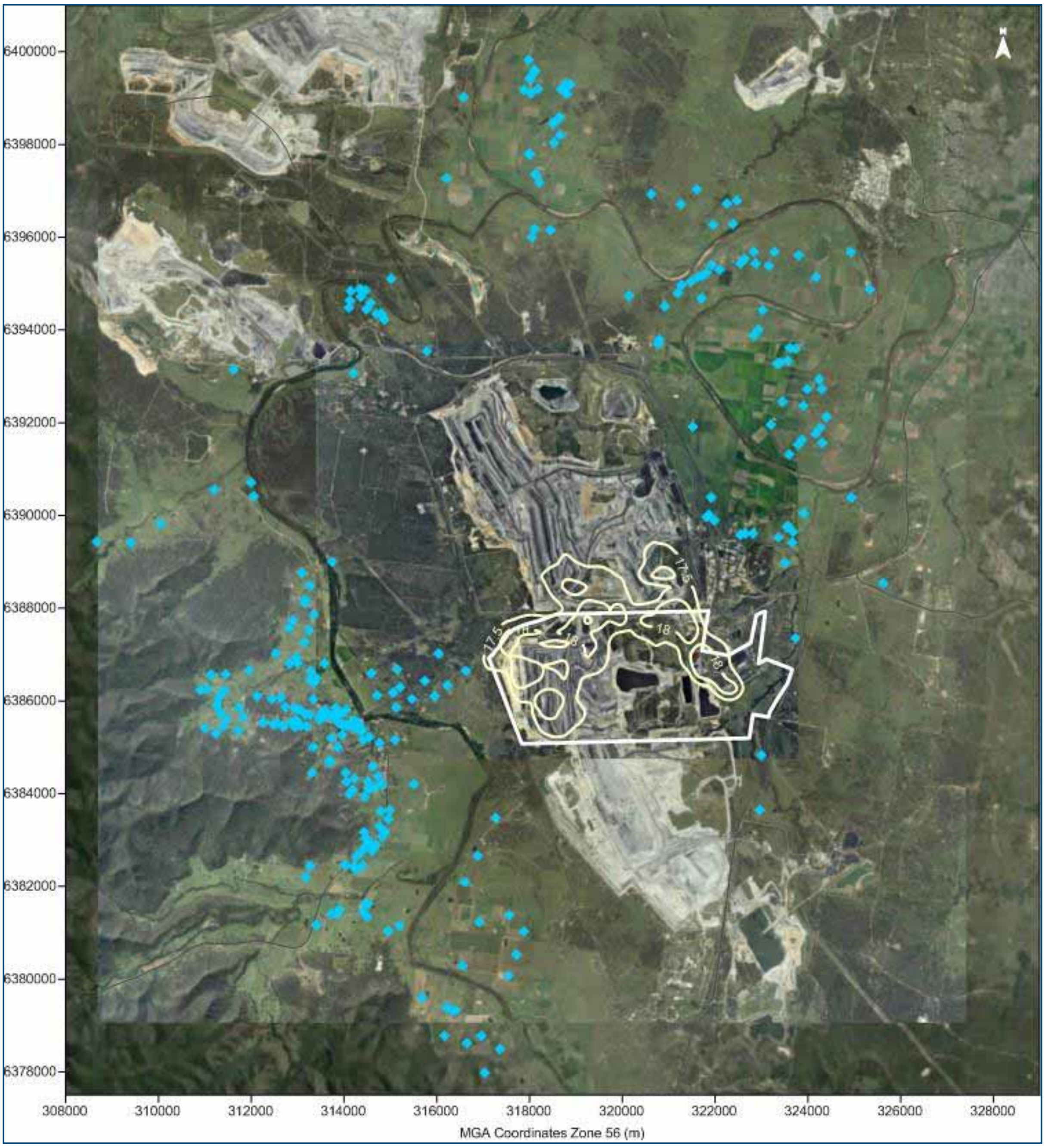

Figure G-4: Predicted annual average NO_2 concentrations due to emissions from the proposal in Year 9 (µg/m³)

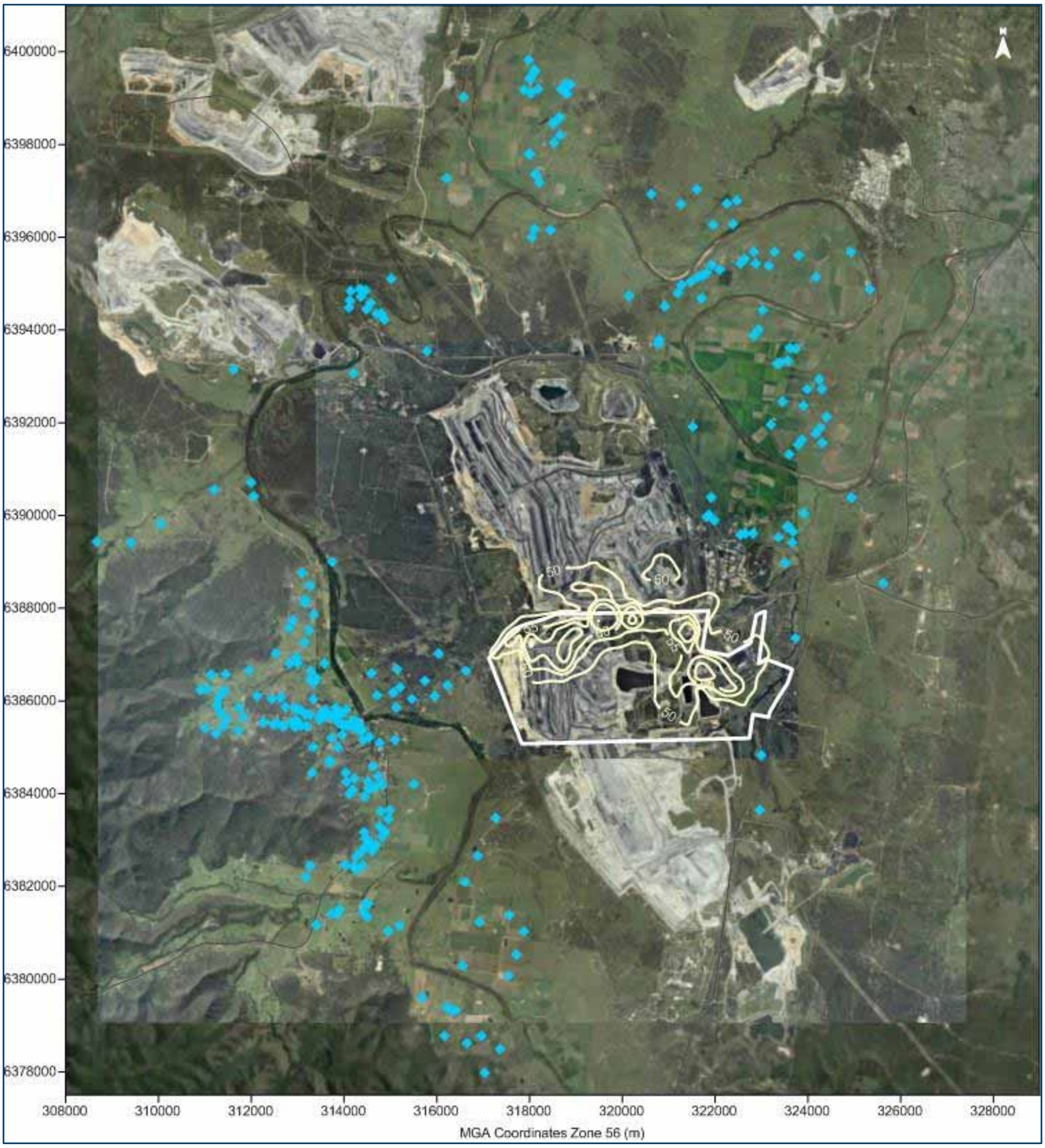

Figure G-5: Predicted 1-hour average NO_2 concentrations due to emissions from the proposal in Year 14 (µg/m³)

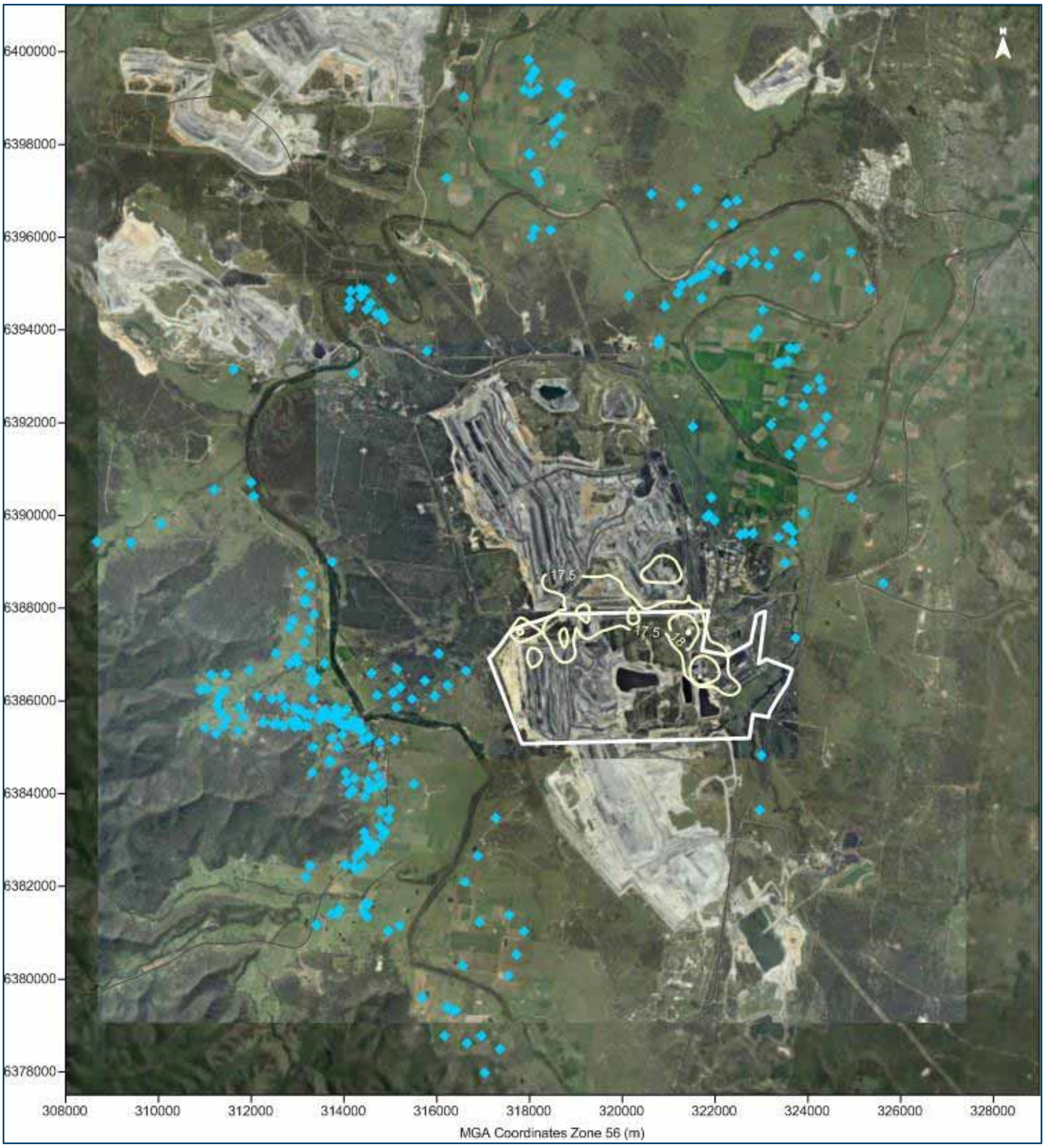

Figure G-6: Predicted annual average NO_2 concentrations due to emissions from the proposal in Year 14 (µg/m³)

Appendix H

Isopleth Diagrams – Blast emissions

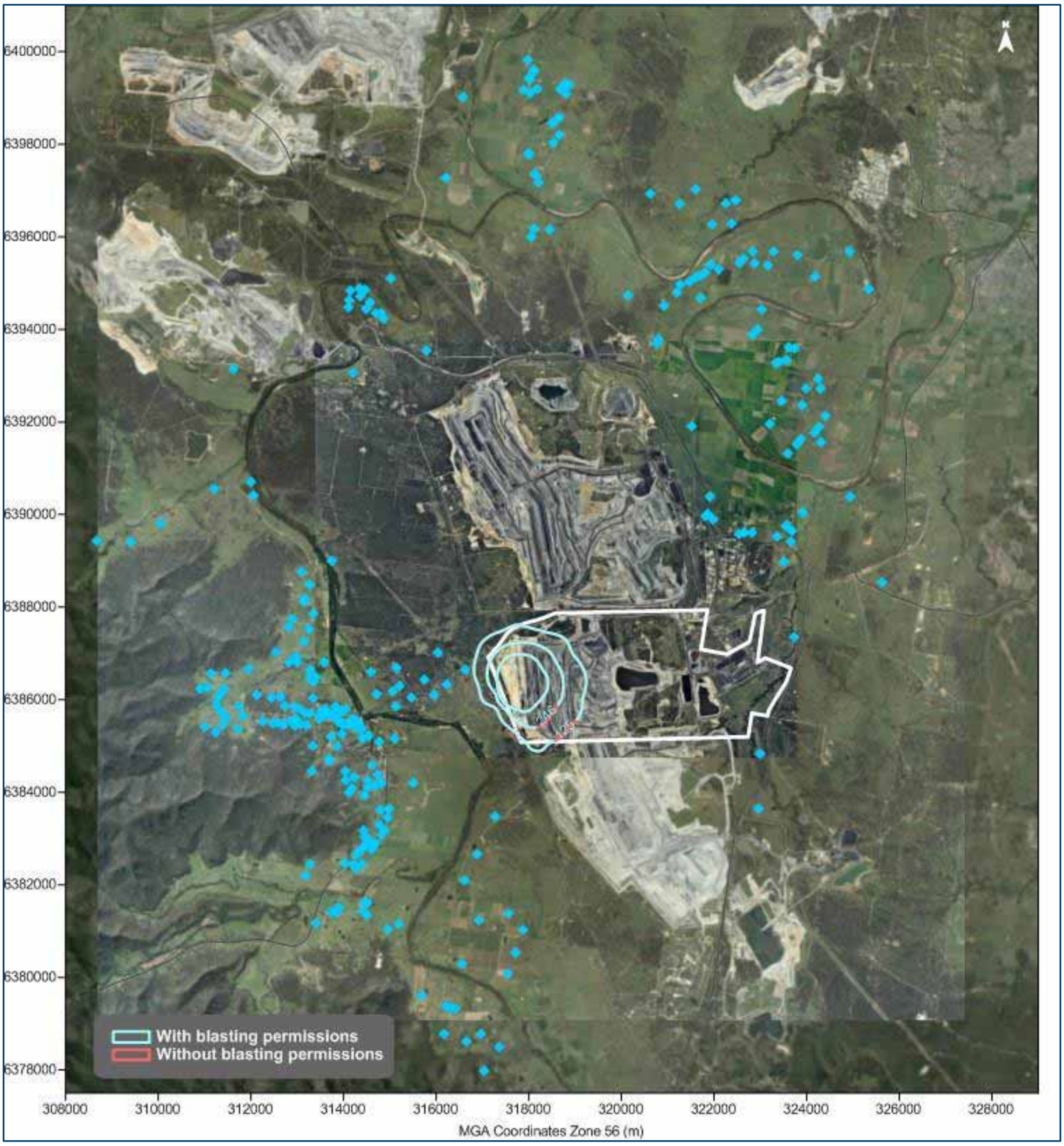

Figure H-1: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 09:00 (NO_2 concentrations µg/m³)

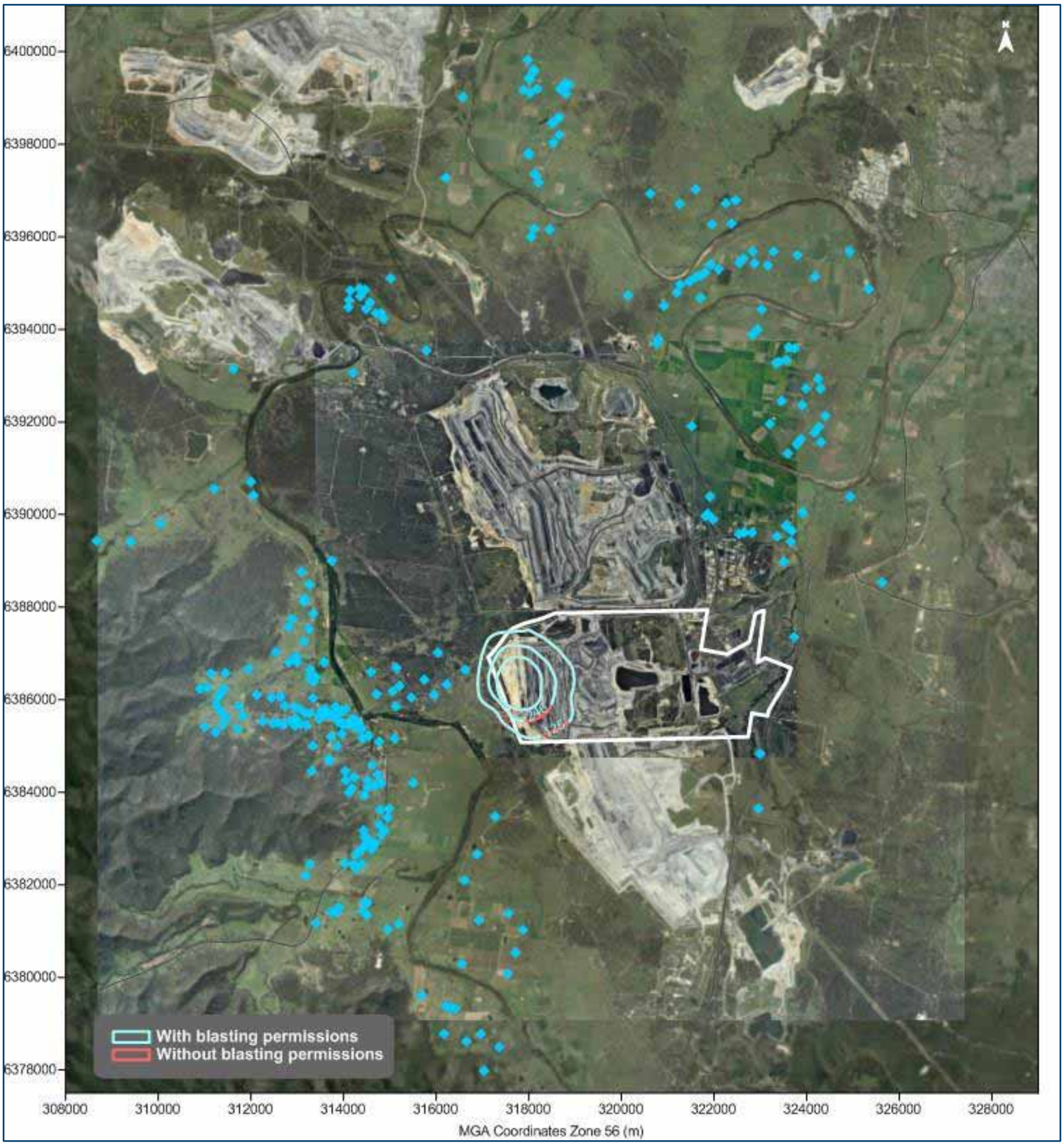

Figure H-2: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 10:00 (NO_2 concentrations µg/m³)

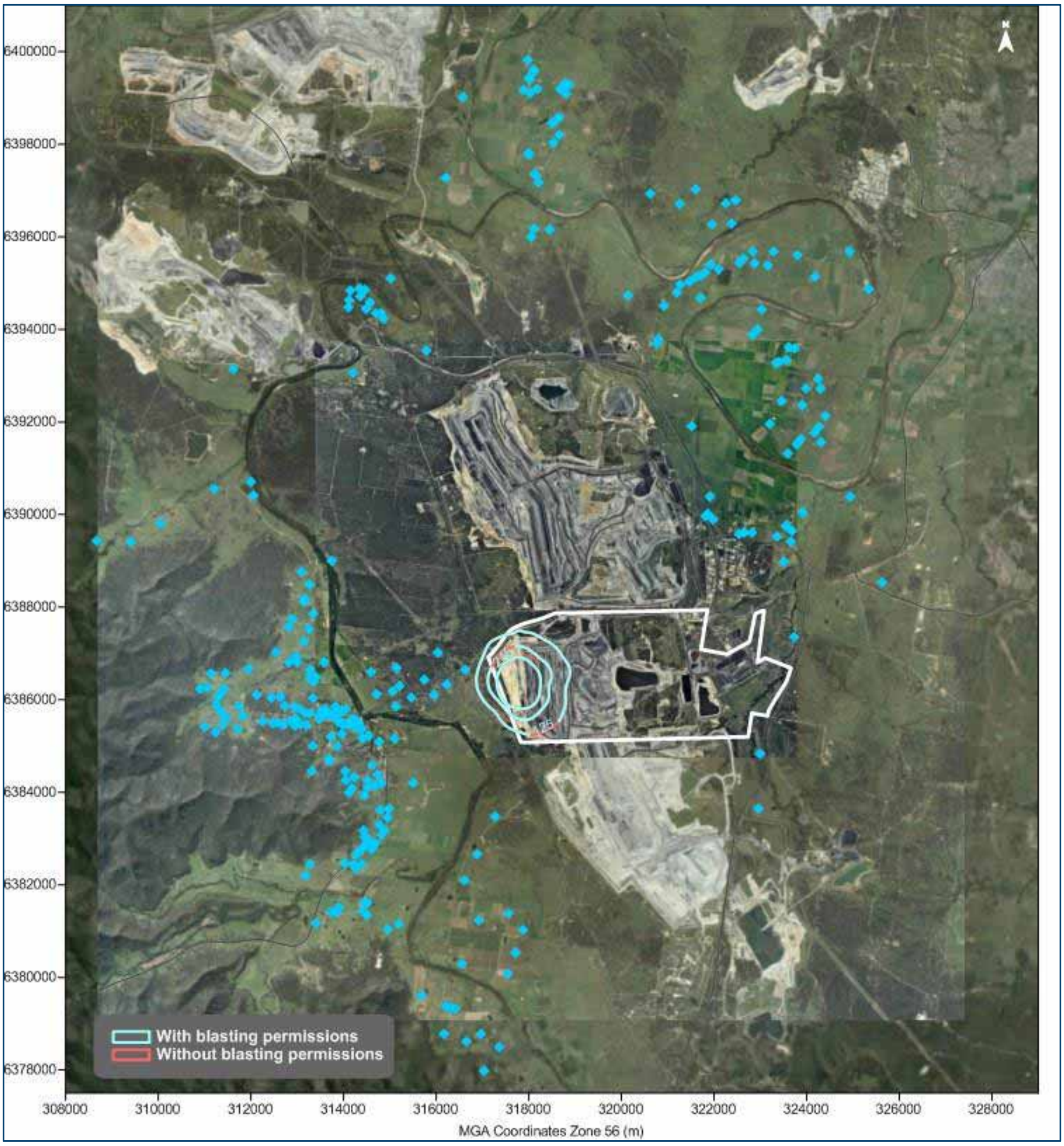

Figure H-3: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 11:00 (NO_2 concentrations µg/m³)

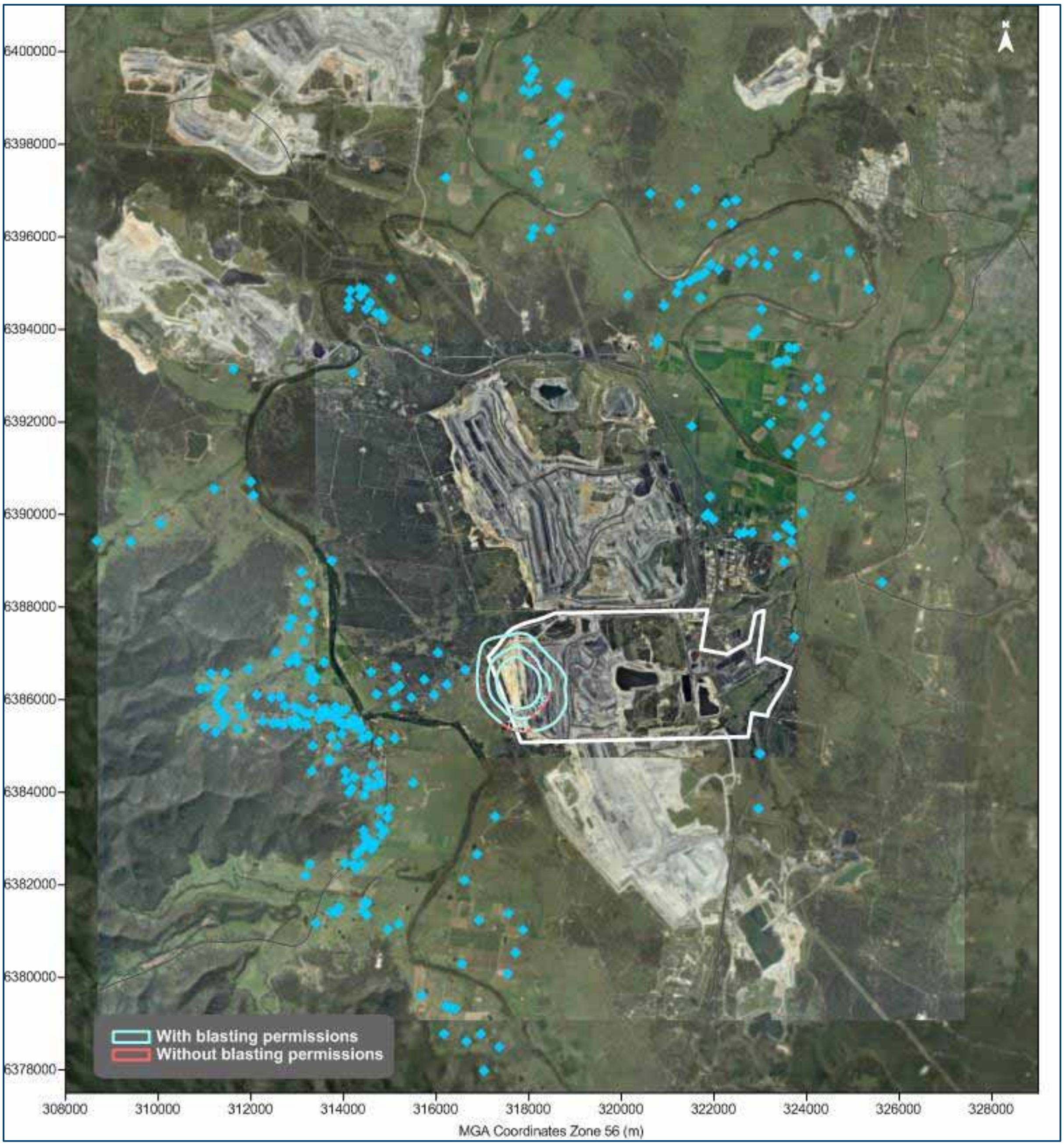

Figure H-4: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 12:00 (NO_2 concentrations µg/m³)

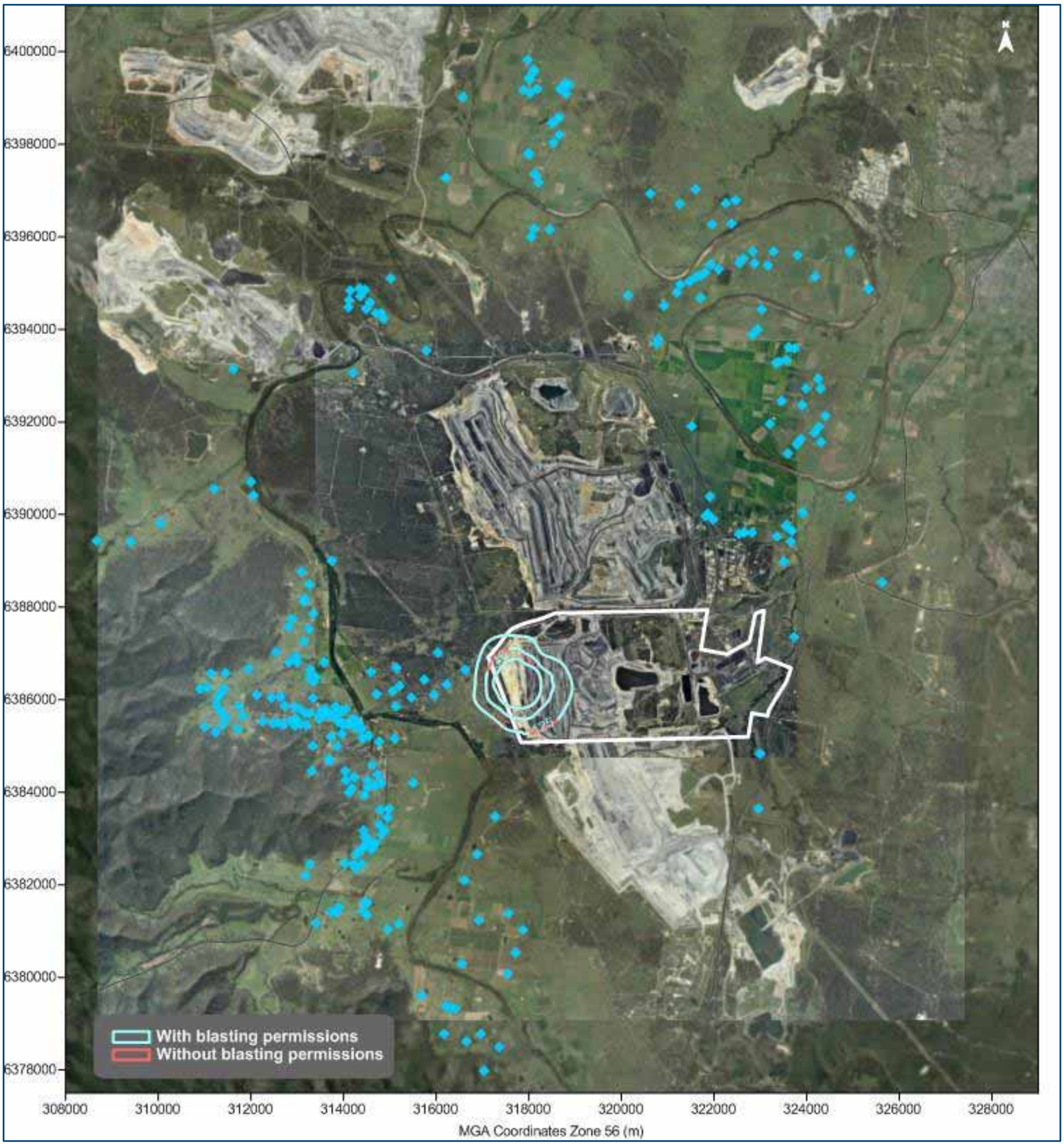

Figure H-5: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 13:00 (NO_2 concentrations µg/m³)

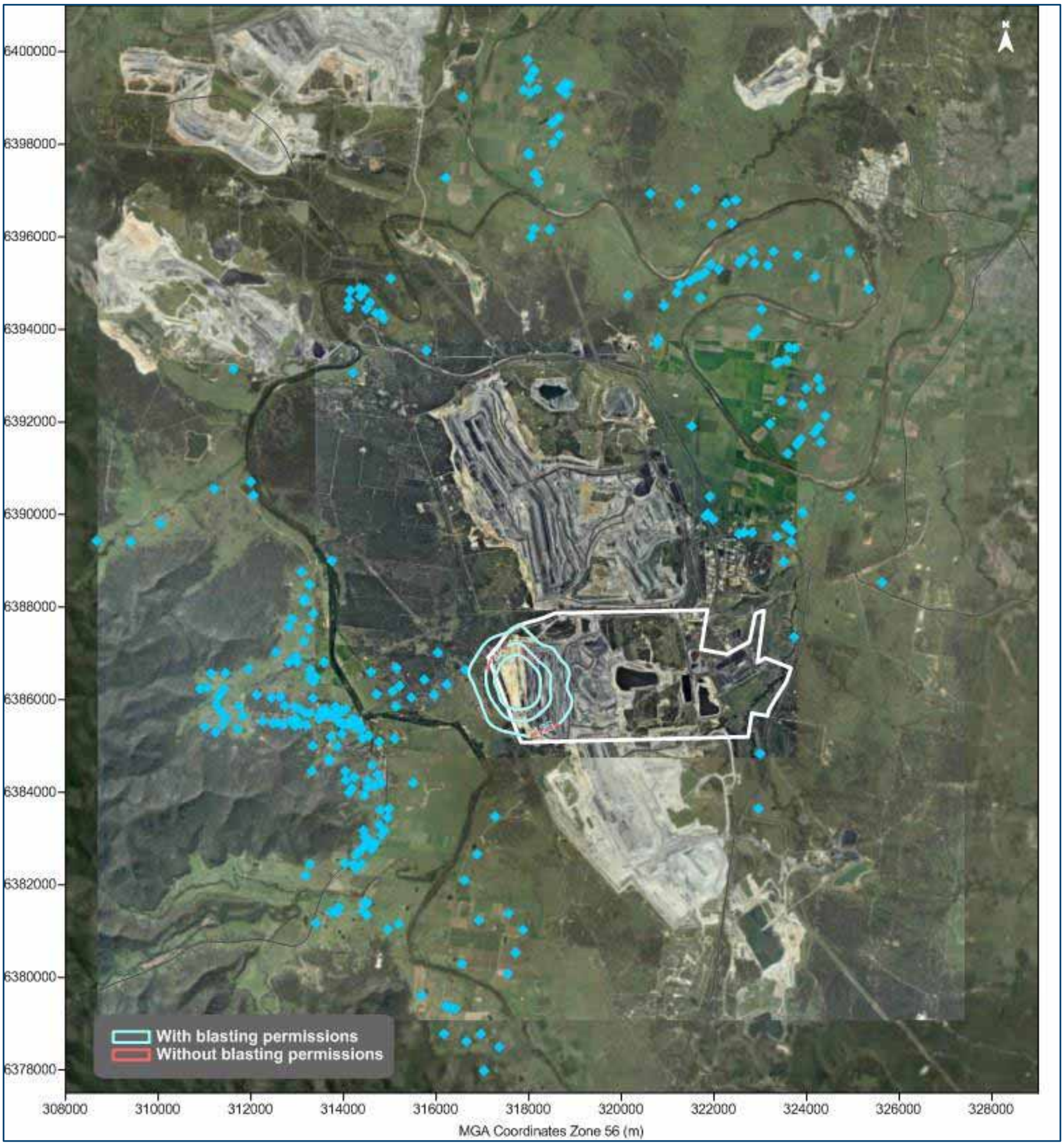

Figure H-6: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 14:00 (NO_2 concentrations µg/m³)

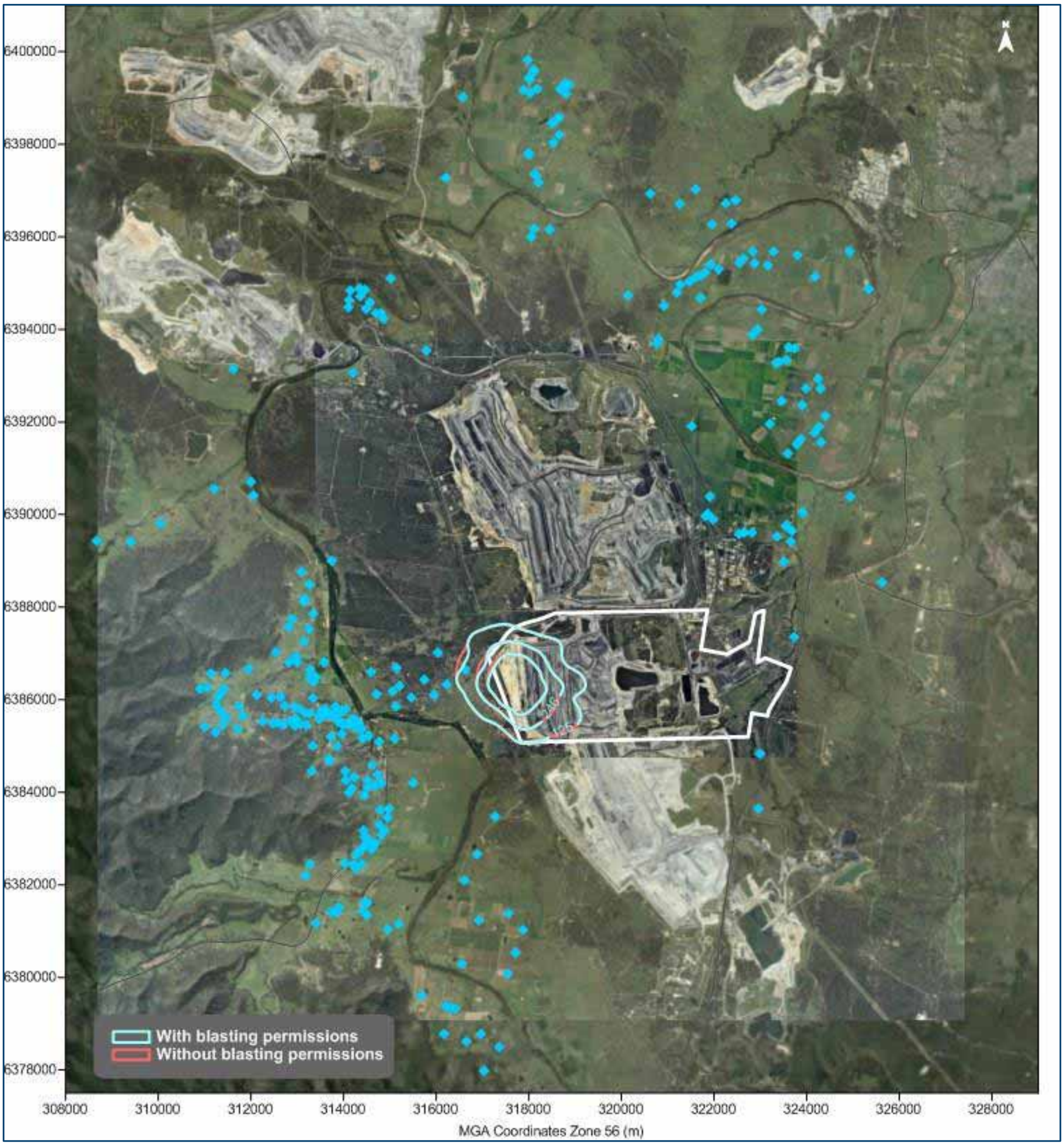

Figure H-7: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 15:00 (NO_2 concentrations µg/m³)

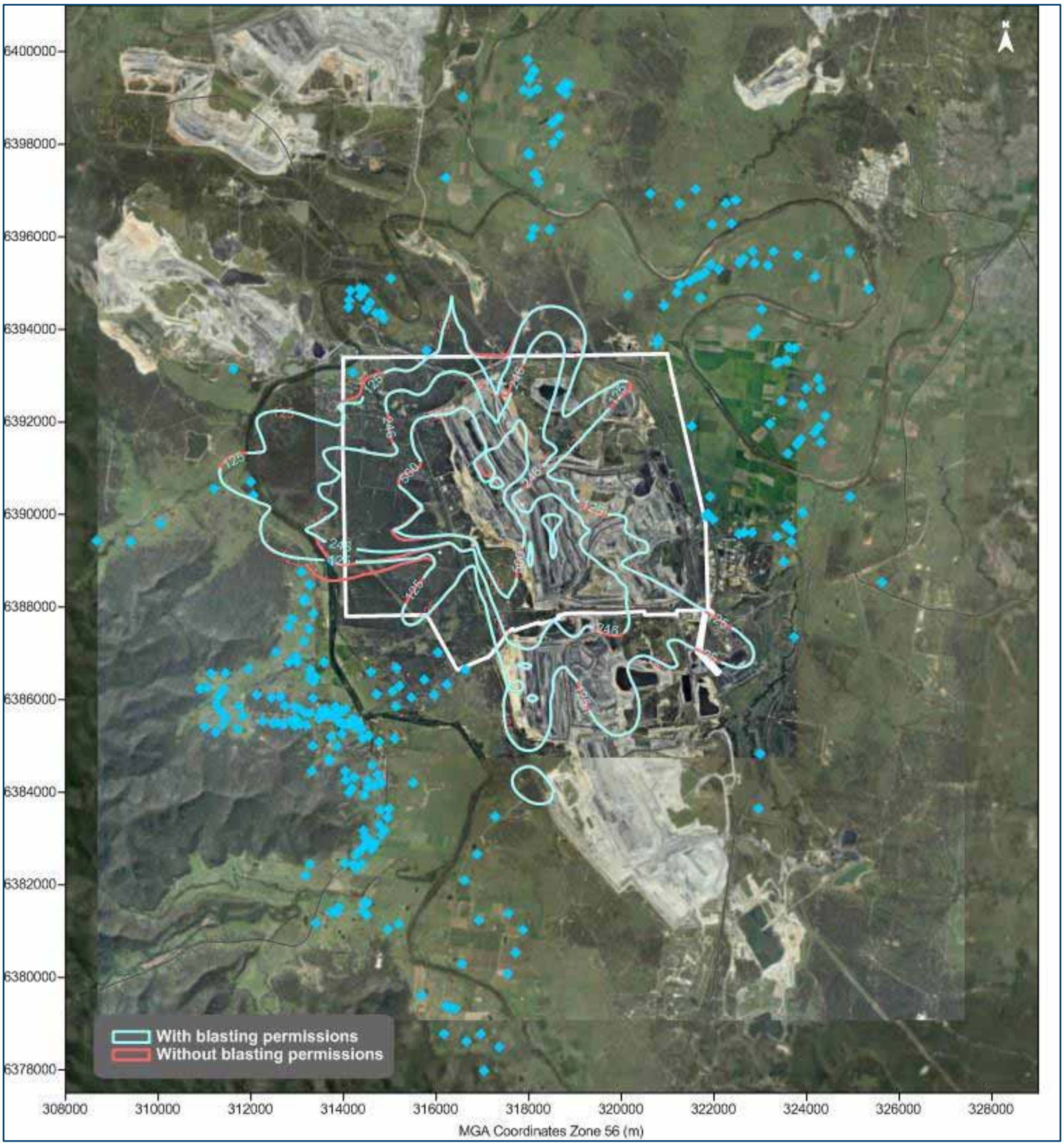

Figure H-8: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 16:00 (NO_2 concentrations µg/m³)

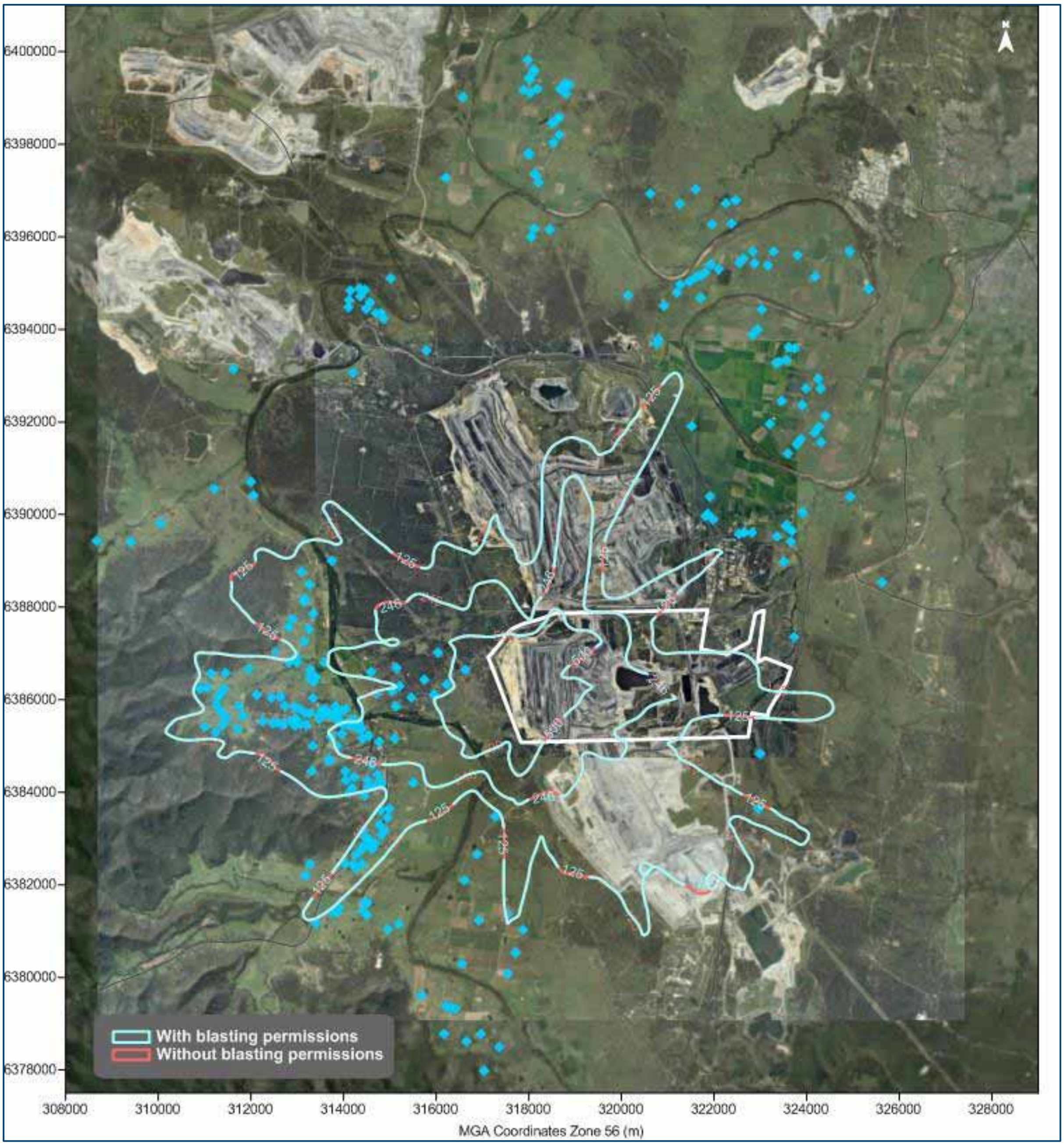

Figure H-9: Predicted maximum 1-hour average blast emissions from the proposal in Year 3 – 17:00 (NO_2 concentrations µg/m³)

Appendix H

Visual amenity study

Appendix H — Visual amenity study

H

MOUNT THORLEY OPERATIONS 2014
VISUAL IMPACT ASSESSMENT

PREPARED FOR MT THORLEY OPERATIONS PTY LIMITED
JUNE 2014

www.integrateddesignsolutions.com.au

INTEGRATED DESIGN SOLUTIONS

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Visual Impact Assessment

Prepared for	**Mt Thorley Operations Pty Limited**
Prepared by	Esther Dickins
Position	Principal Landscape Architect
Signature	
Date	2 June 2014

Document control

Version	Date	Prepared by	Reviewed by
A	25 May 2014	Integrated Design Solutions Esther Dickins	DP
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Contents

Figures

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Executive Summary

Coal & Allied (Operations) Pty Limited is seeking development consent for the Mount Thorley Operations (MTO) 2014 (the proposal). It is important to note that potential visual impacts under the proposal are generally consistent with those currently approved. For example, all coal extraction will occur within the limits of existing approval. The proposal will, however, extend the time frame of potential visual impacts. This visual impact assessment provides a contemporary assessment of the potential visual impacts from MTO's ongoing operations and a robust framework for their management.

Through the analysis of the existing environment surrounding Mount Thorley Operations (MTO), potential visual impacts on the surrounding landscape were assessed. This analysis has determined that ongoing operations at MTO would have a range of visual effects and that these are in keeping with those typically resulting from open cut coal mining activities in a similar rural environment. Importantly, it is noted that the environment in which the proposal is to be undertaken contains significant existing mining activity which is now part of the landscape against which it will be viewed. This results in a reduction in the general level of contrast and subsequent visual impacts.

The visual impacts of the proposal will not vary noticeably from those under the existing approvals. The visual assessment considers how these existing impacts could be mitigated over the period of operations at MTO. These impacts have largely been assessed as low; however, some sensitive assessment locations would potentially experience high impacts. The majority of the western sector will benefit from existing screening provided by the intervening topography and vegetation. Those residences which may experience high impacts are located in elevated areas around Bulga Village and are likely to require site specific mitigation measures.

Instrumental to the minimisation of the potential visual impacts is the proposed suite of mitigation measures. These measures aim to reduce the impacts of the proposal at all significant viewing points though vegetation planting and bund screening along the boundaries and site specific mitigation to individual residences where a moderate to high impact has been identified.

The progressive establishment of extensive landscape rehabilitation at MTO will reduce the level of visual impact over time and will ultimately result in a high level of integration with the surrounding visual environment.

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1. Introduction

1.1 BACKGROUND

Mount Thorley Operations (MTO) is an open cut coal mine approximately 10.5 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). The site currently operates under Development Consent No. DA 34/95 (the development consent) issued by the then Minister for Planning on 22 June 1996 under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Immediately to the north is Warkworth Mine. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for all the operations. Equipment, personnel, water, rejects and coal preparation are all shared between the mines. The MTW operations involve an existing operation of approximately 1,300 persons, which includes full-time personnel and a small number of short-term contractors. Ownership of the two mines remains separate.

Mining activities approved under DA 34/95 have mostly been completed with the exception of Loders Pit and Abbey Green North Pit (AGN) with rehabilitation well-progressed on the east of the site. Run-of-mine (ROM) coal from MTO is transported to either the MTO or Warkworth Mine coal preparation plants (CPP) for processing. Extraction of coal from other pits has been completed; overburden emplacement is ongoing. Product coal from the CPPs is transported via conveyor to the Mount Thorley Coal Loader (MTCL). Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The MTO 2014 (the proposal) seeks an approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

1.2 DESCRIPTION OF PROPOSAL

MTO has approval to mine until 22 June 2017 under its development consent. The proposal seeks a 21 year development consent period from the date of approval. If approval is granted in late 2014, operations at MTO are forecast to continue to the end of 2035, an 18 year extension over the current approval. The proposal seeks a continuation of all aspects of MTO as it presently operates and extends or alters them, including:

> mining in Loders Pit and AGN Pit. Mining in Loders Pit is expected to be completed in approximately 2020. Mining in AGN Pit is yet to commence; however, it is anticipated to take approximately two years and be completed before 2022;
> transfer of overburden between MTO and Warkworth Mine to assist in rehabilitation and development of the final landform;
> maintain existing extraction rate of 10 million tonnes per year (Mtpa) of ROM coal;
> maintain and upgrade the integrated MTW water management system (WMS), including:
  - upgrade to the approved discharge point and rate of discharge into Loders Creek from 100Ml/d to 300Ml/d via the Hunter River Salinity Trading Scheme (HRSTS);
  - ability to transfer and accept mine water from neighbouring operations (ie Bulga Coal Complex, Wambo Mine, Warkworth Mine and Hunter Valley Operations);
  - increase in the storage capacity of the southern out-of-pit (SOOP) dam from 1.6 giga litres (GL) to 2.2GL
> maintain and upgrade the integrated MTW tailings management:
  - including use of the northern part of Loders Pit as a TSF after completion of mining; and
  - Wall lift to Centre Ramp Tailings Facility to approximately RL150
> upgrade to the MTO CPP to facilitate an increase in maximum throughput to 18Mtpa with the ability to receive this coal from Warkworth Mine;
> acknowledge all approved interactions with Bulga Coal Complex (see Section 1.4.1); and
> continuation of coal transfer between Warkworth Mine and MTO and transportation of coal via the MTCL to Port of Newcastle.

All activities, including coal extraction will be within disturbance areas approved under the existing development consent.

The proposal is shown in Figure 1.1.

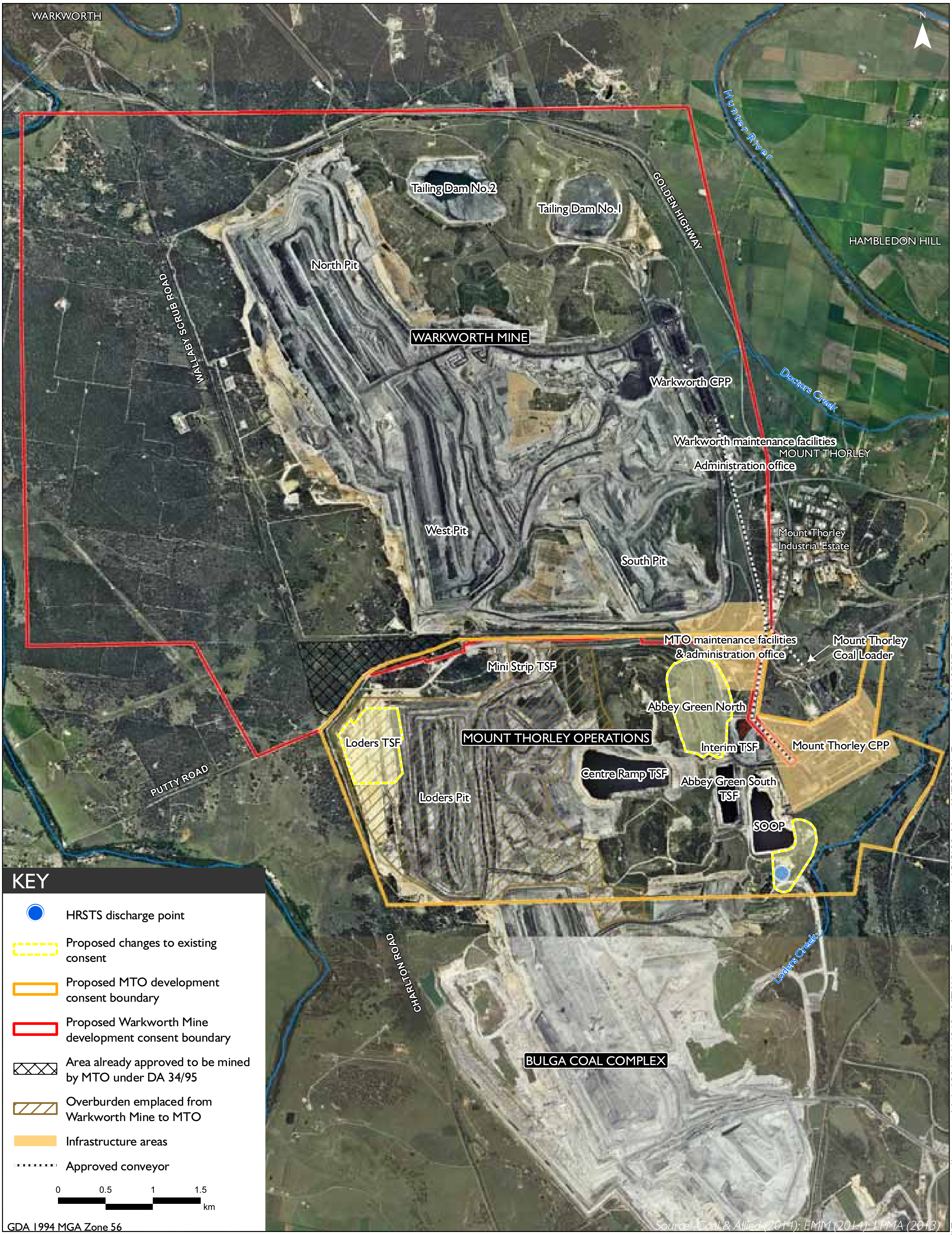

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Figure 1.1 The Proposal

1.3 REPORT FINDINGS SUMMARY

This Visual Impact Assessment (VIA) has determined that the overall visual impact of the proposal is not likely to be noticeably different from those under the existing approvals. These existing impacts are generally assessed as low however there is the potential for high impacts in some areas, including elevated residential properties around Bulga Village.

Visual impact mitigation measures are recommended to be put in place to reduce the potential impacts on the overall surrounding landscape including vegetation and bund screening to the proposal site's boundaries. In addition specific mitigation measures are proposed for individual properties determined to have high visual impacts. The progressive rehabilitation of the site will reduce the level of contrast of the operations in the viewing landscape and will ultimately result in a high level of visual integration.

1.4 SCOPE OF THE VISUAL IMPACT ASSESSMENT

Integrated Design Solutions (IDS) was commissioned by EMGA Mitchell McLennan (EMM) on behalf of Coal & Allied to prepare this VIA, as required by the Secretary's requirements, to be submitted as part of the Mount Thorley Operations 2014 Environmental Impact Statement.

It is important to note that potential visual impacts under the proposal are generally consistent with those currently approved. For example, all coal extraction will occur within the limits of existing approval. The proposal will, however, extend the time frame of potential visual impacts. This visual impact assessment provides a contemporary assessment of the potential visual impacts from MTO's ongoing operations and a robust framework for their management.

The VIA utilises information from the Warkworth Extension Project Visual Impact Assessment Study (VIAS) (Integral Landscape Architecture and Visual Planning, 2010) and the Warkworth Extension Visual Impact Management Plan (Integrated Design Solutions (IDS), 2012) relevant to the proposal.

1.5 ASSESSMENT REQUIREMENTS

This Visual Impact Assessment has been prepared in accordance with the Secretary's requirements.

1.6 OBJECTIVES OF THE VISUAL IMPACT ASSESSMENT

The overall intent of this VIA is to provide an assessment of the potential impacts of the proposal on the existing landscape and visual character of the surrounding area. It provides a description of the potential visual changes that could occur, assesses the associated impacts in terms of their significance and proposes mitigation measures to reduce the level of impact where possible.

The objectives of the VIA are as follows:

> Identify areas of the public domain and individual residences within the primary visual catchment which are likely to have significant direct views, in comparison to the current approved operations;
> Develop management and mitigation strategies to ameliorate adverse visual impacts and appearance of structures;
> Detail the process for implementing the mitigation strategies;
> Provide details on the establishment and maintenance of vegetation, construction of structures and bunding for the purposes of maintaining satisfactory visual amenity; and
> Identify potential site specific measures to be undertaken for individual residences to mitigate visual impacts.

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2. Method

Visual impact is determined by firstly analysing the existing visual environment and how it is seen from various key viewing locations. Through this analysis the visual character and its visual sensitivity can be determined. The visual effects are then determined by considering a development in this context. The combination of the visual sensitivity and the effect determines the level of impact for which an appropriate level of mitigation can be considered.

This VIA utilises a methodology consistent with that used for the VIAS (2010) as follows.

2.1 EVALUATION OF THE VISUAL ENVIRONMENT

The evaluation of the existing visual environment was undertaken in the VIAS by examining the existing landscape and determining key viewing locations within it based on the existing land uses. This analysis remains relevant to the proposal.

The existing landscape setting is defined through the areas topography, vegetation, waterways and developed features. Visual Character Units (VCUs) were defined to group areas with similar features within the landscape. This allows an understanding of the setting in which the proposal will be viewed.

2.2 ANALYSIS OF THE PROPOSAL

This analysis considers the proposal within the landscape setting defined by the VCUs and provides the basis for determining the visual effect and the sensitivity of the key viewing locations. It is based on the specific characteristics of both the landscape setting and the proposal including form, shape, colour and texture and the level of differences between them.

2.3 ANALYSIS OF VISUAL EFFECTS

The visual effect is a measure of the level of either contrast or integration, between a development and its setting. Mining activities tend to have a varied level of visual effect at various project stages. During extraction operations the pits and overburden emplacement can have a high level of contrast however as vegetation is re-established and final landforms are softened the level of integration can be higher.

In the case of MTO the existing visual environment contains extensive elements of mining operations and therefore, the proposal extends these elements which means the visual effect is reduced as the contrast to the existing landscape setting is less pronounced.

The magnitude of a development's visual effect is determined by considering the level of contrast or integration with its surroundings and the proportion of the view that includes the proposed development for the given level of contrast or integration. The proportion of the view is determined by measuring the occupied percentage of the Primary View Zone (PVZ), the area occupied by an arc created by sight lines radiating vertically and horizontally at angles of 30 degrees around the centre view line from the eye.

The visual effect on the various viewing locations and in particular individual residences may range from high to low depending on screening provided by topography, buildings or vegetation, the viewing distance and orientation towards the development (directly or indirectly).

2.4 VISUAL SENSITIVITY

The visual sensitivity is a measure of how critically the change to the visual environment will be perceived by those viewing it from different land use areas in the vicinity. For the purpose of this VIA consideration is given to both the existing environment and the currently approved operations for MTO.

The level of sensitivity varies for different land uses. Residential, tourism and recreation areas tend to have higher visual sensitivity than other land uses such as industrial, agricultural or road / transport corridors. This is because the perceived quality of these sensitive land uses is in part, dependent on the visual amenity of their surroundings. This sensitivity is also dependant on the distance of the nearest visible elements.

2.5 VISUAL IMPACT

The significance of the visual impact is dependent on the interaction between the visual effect and the visual sensitivity as defined in the VIAS (see Figure 2.1). When considering the visual impact of the proposal a significant impact is considered to be high.

The visual effect of assessment locations for the proposal was determined by review of the VIAS field assessment and examination of a GIS model and computer generated three-dimensional model. Allowance was made for the intervening vegetation, included at a height to 12m, however, detailed determination of the precise levels of vegetation screening and orientation towards views is not possible through this process. The assessment undertaken is considered conservative in this context. The levels of impact may be less should orientation be indirect or vegetation screening exist.

Figure 2.1
Visual Impact – Effect v Sensitivity (VIAS 2010)

Visual Effect	Visual Sensitivity		
	High	Moderate	Low
High	High Visual Impact	High / Moderate Visual Impact	Moderate / Low Visual Impact
Moderate	High / Moderate Visual Impact	Moderate Visual Impact	Moderate / Low Visual Impact
Low	Moderate / Low Visual Impact	Moderate / Low Visual Impact	Low Visual Impact

2.6 VISUAL IMPACT MITIGATION

Visual mitigation measures can be implemented on-site, off-site or in combination to reduce the visual impact on an assessment location. This is typically done by reducing either the level of contrast of the development (e.g. through revegetation) or the proportion of the view in which it can be seen from the assessment location.

3. Analysis of the Visual Environment

The proposal will occur in an area where mining is an established feature of the landscape. The proposal site is located in the Hunter Valley coalfields with surrounding land uses predominantly mines and supporting infrastructure including the Warkworth Mine, Hunter Valley Operations, Wambo Mine and Redbank Power Station to the north, MTCL and Mount Thorley Industrial Estate to the east and Bulga Coal Complex to the south. To the west of the proposed site are a number of rural and rural residential properties and Bulga village. The existing visual character of the proposal site includes views of mining operations, grazing and cropping.

The landscape character of the local area is dominated by moderate to gently sloping hills with several locally dominant ridges. The highest natural points are Charlton Ridge within MTO, and Saddleback Ridge within Warkworth. From these ridges the land slopes down to the undulating land along the Hunter River and Wollombi Brook. Within this context there are open views along and across the flood-plains and cleared rural lands. Rehabilitated overburden emplacement areas are a significant feature of the existing landscape including areas within MTO, Warkworth Mine, Bulga Open Cut Spoils and the Wambo Mine.

The Primary Visual Catchment (PVC) is the area containing the majority of views of the proposal and is defined primarily by the surrounding topography. The PVC and VCUs of the proposal site were identified in the VIAS and remain relevant to the proposal (see Figure 3.7). The VCUs are areas of visual uniformity which make up the overall landscape setting. The VCUs are rarely seen in isolation, rather in combination and the mining development will combine with these to create the new view as seen from a particular location.

The VCUs within the PVC are as follows:

> Hunter River and Wollombi Brook flood-plains;
> Rural hills;
> Rural footslopes;
> Town and village areas;
> Surrounding ranges; and
> Mine and industrial areas.

Hunter River and Wollombi Brook flood-plains

The Hunter River floodplain is characterised by expansive river flats with green grass and croplands in contrast to the dryland grasses and scattered woodlands of the rural lands and foothills. The Wollombi Brook floodplain is less expansive than the Hunter River floodplain and is visually less dominant however it does create a contrast to the surrounding landscape. The flatness of these areas and grass crop cover allow for distant views towards the proposal.

Figure 3.1 Hunter River Flood-Plain (VIAS 2010)

Figure 3.2 Wollombi Brook Flood-Plain (VIAS 2010)

Rural Hills

This VCU includes the foothills to the north, east, south and west surrounding the proposal site. This landscape type is largely located adjacent to the flood-plains and consists of gently undulating hills. Vegetation includes open forest woodlands and scattered trees in grasslands.

The elevation rises in these areas to approximately 100m in the vicinity of the Golden Highway and Putty Road limiting visibility of the proposal from the north and east including from the Singleton urban area. The southern hills have elevations in the order of 150 – 170m and includes the Singleton Military Area which retains the rural character apart from the base which is visually similar to a village. Saddleback and Charlton ridges rising to 165m and 155m, respectively, form part of this VCU.

Figure 3.3 Rural Hills (VIAS 2010)

Rural Footslopes

The rural footslopes are located between Wollombi Brook to the east and the steep forested ranges to the west. The area generally has gentle topography but becomes steeper closer to the ranges in the west. It is dominated by grassland with scattered trees and woodland.

Figure 3.4 Rural Footslopes (VIAS 2010)

Town and Village areas

Singleton, around 10.5km to the north-east and the smaller villages of Warkworth, Broke and Bulga are included in this VCU. These villages vary greatly in size and have a varying mix of residential, institutional, commercial and industrial land uses. This land use mix along with the open space creates their visual character. These towns contain the majority of residents in the area and this VCU has high sensitivity where it is exposed to the proposal.

Due to intervening topography the proposal is screened from much of Singleton however distant views are possible in some areas. Bulga is a widely scattered rural village approximately 2.5km from Warkworth Mine. Putty Road Bulga has a combination of spread out buildings, varied landscape treatments and surrounding rural areas. Wollemi Peak Road, Inlet Road and Wambo Road each lead from the village to the respective southern, western and northern rural residences within the rural footslopes. Areas of Bulga do experience views of Warkworth Mine.

Broke is located approximately 12km to the south and is shielded from the mine by the hills immediately to the north of the village and local street features. Similarly, Warkworth is shielded by vegetation and topography including Watts Peak.

Figure 3.5 Towns (VIAS 2010)

Surrounding ranges

The surrounding mountain ranges define the edges of the PVC and are located on the western and southern sides of the Hunter Valley. These ranges are steep and have closed forest cover with elevations of 240 – 400m above the valley and foothills below.

The ranges are generally located a significant distance from Mount Thorley Operations but often create the backdrop to the views. Ridges in the Wollemi National Park rise to over 500m and overlook Mount Thorley Operations and although the proposal would be visible from some locations, the bush would restrict most views. Typically these points are only accessible to bushwalkers or horse riders.

Figure 3.6 Surrounding Ranges (VIAS 2010)

Mine and Industrial areas

Warkworth, Mount Thorley and the Bulga Coal Complex are visually dominated by the overburden emplacements which are visible from various parts of the surrounding areas. The Warkworth CPP is also visible from locations to the north and east, particularly along the Golden Highway. The mines and the Mount Thorley Industrial Estate have a strong industrial character.

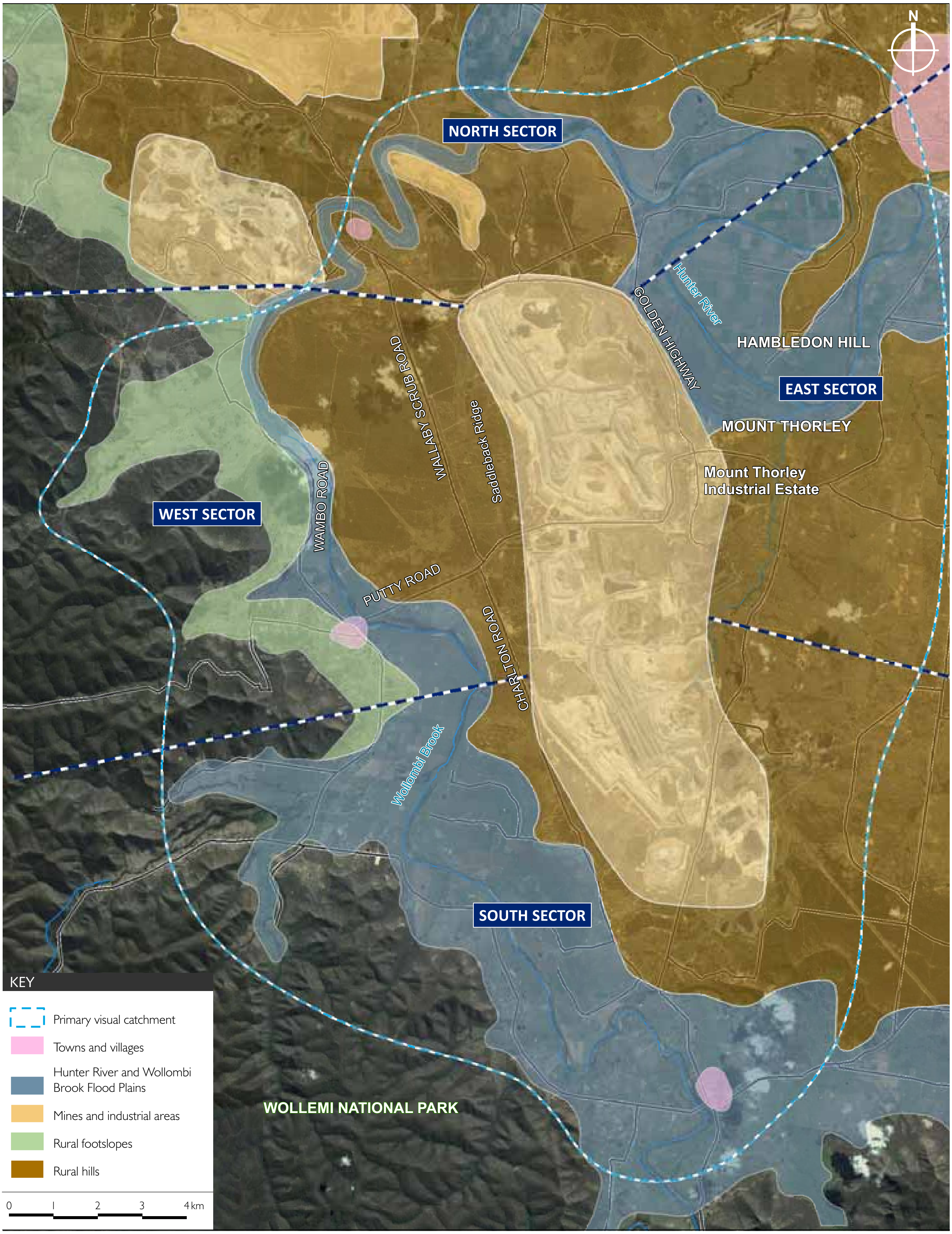

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Figure 3.1 Primary Visual Catchment and Visual Character Units (VIAS 2010)

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4. The Proposal

4.1 INDICATIVE MINE PLANS

The mining operations over the life of the proposal are indicatively shown for years three, nine and fourteen in Figures 4.1, 4.2 and 4.3. The year three, nine and fourteen mine plans were chosen as representative snapshots for the EIS.

The key visual feature of the indicative year three plan is the emplacement continuing at the final height which has already been achieved under the current approval, with overburden from Warkworth Mine being hauled through the proposed underpass beneath Putty Road to MTO and the emplacement areas progressing west. The approved emplacement and subsequent rehabilitation at the common boundary landform development along the southern boundary with Bulga Coal Complex will be undertaken and completed by year three. The rehabilitation works will continue to progress from east to west as the landform is completed.

The indicative plan at year nine represents the point at which extractive mining at MTO will be complete. The mining of Abbey Green North will have been completed and tailings emplacement to the Abbey Green North void will be occurring. Mining in Abbey Green North will have required the removal of some areas of existing northern vegetation which will have been re-established in non-tailings areas by this stage. The MTO void has been infilled to 50m AHD with overburden from Warkworth Mine continuing to be hauled to MTO. The MTO emplacement areas will be progressively rehabilitated with the advancement of completed landform from east to west.

This period represents the time of highest impact for views from the west and south-west as overburden emplacement continues to its western most extent. Following year nine the progressive rehabilitation will incrementally reduce the overall level of contrast of the ongoing operations. By year nine, approximately 50% of rehabilitation at MTO is planned to be complete.

At year fourteen, the Site is almost completely rehabilitated. Overburden emplacement at Loders pit will be complete, with the western and southern faces completed to final landforms, and Tailings Storage Facility (TSF) operations occurring in this area. Tailings emplacement continues at Abbey Green South prior to completion the final landform and rehabilitation continues across the site as final landform is achieved.

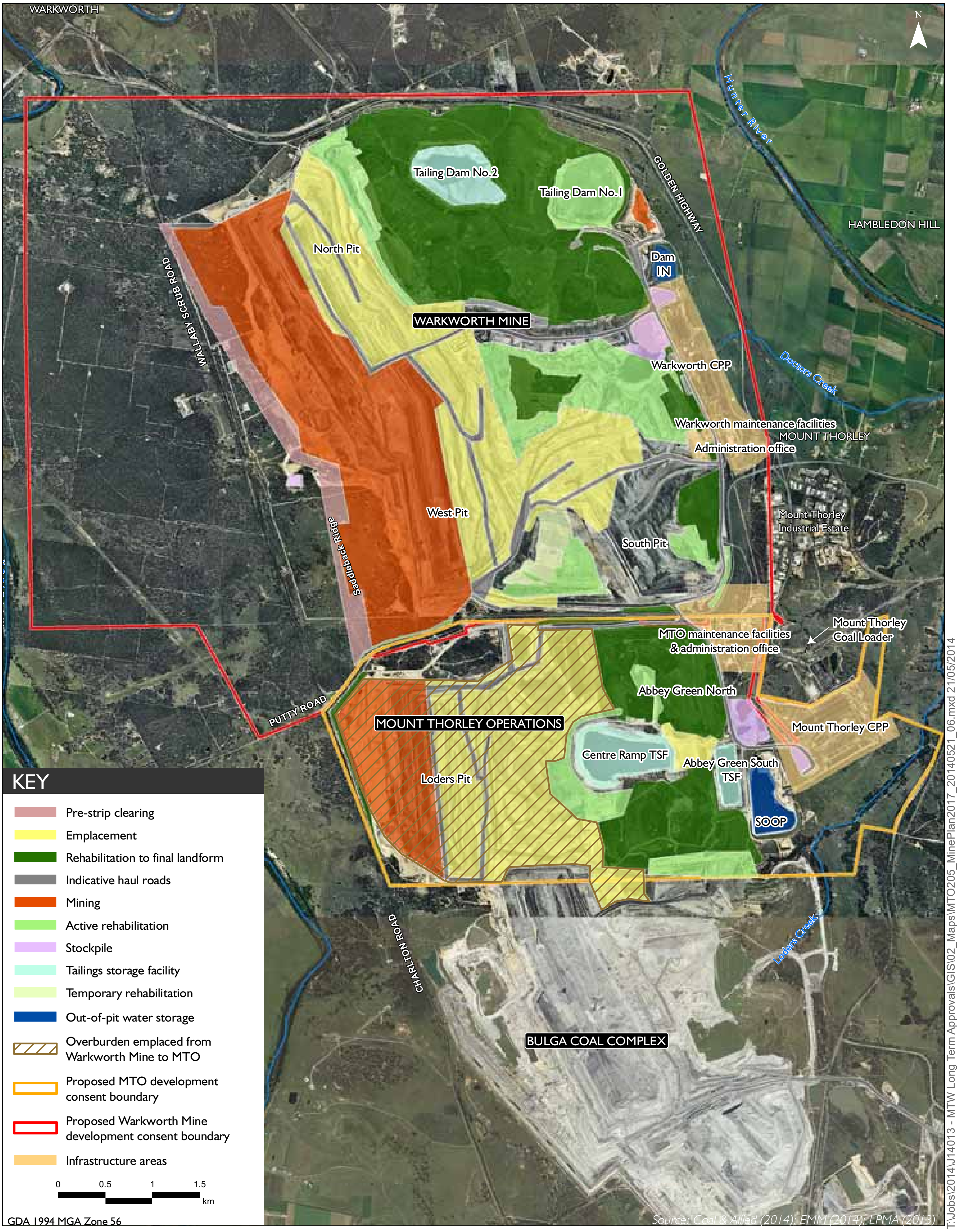

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Figure 4.1 Indicative Year 3 Mine Plan

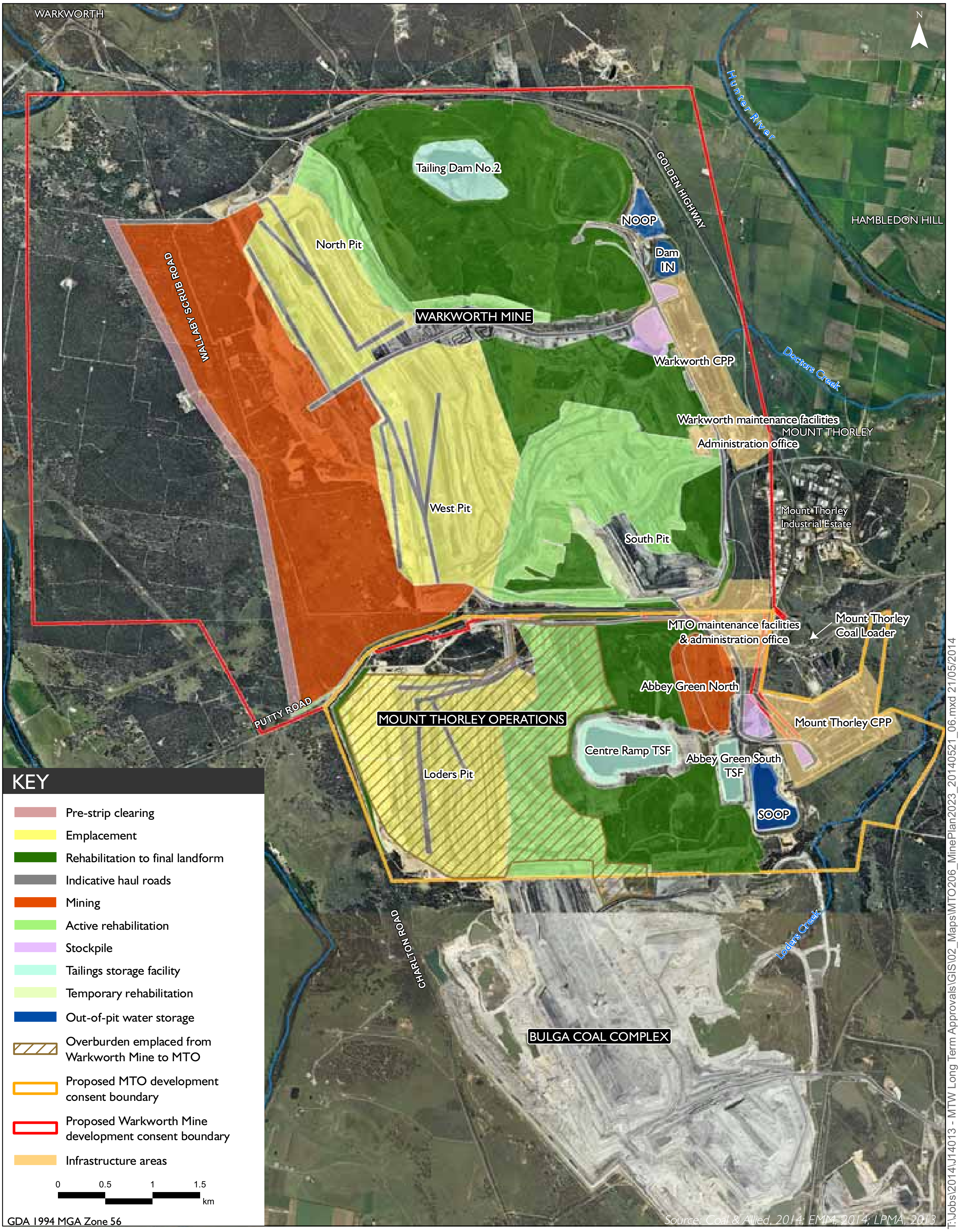

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Figure 4.2 Indicative Year 9 Mine Plan

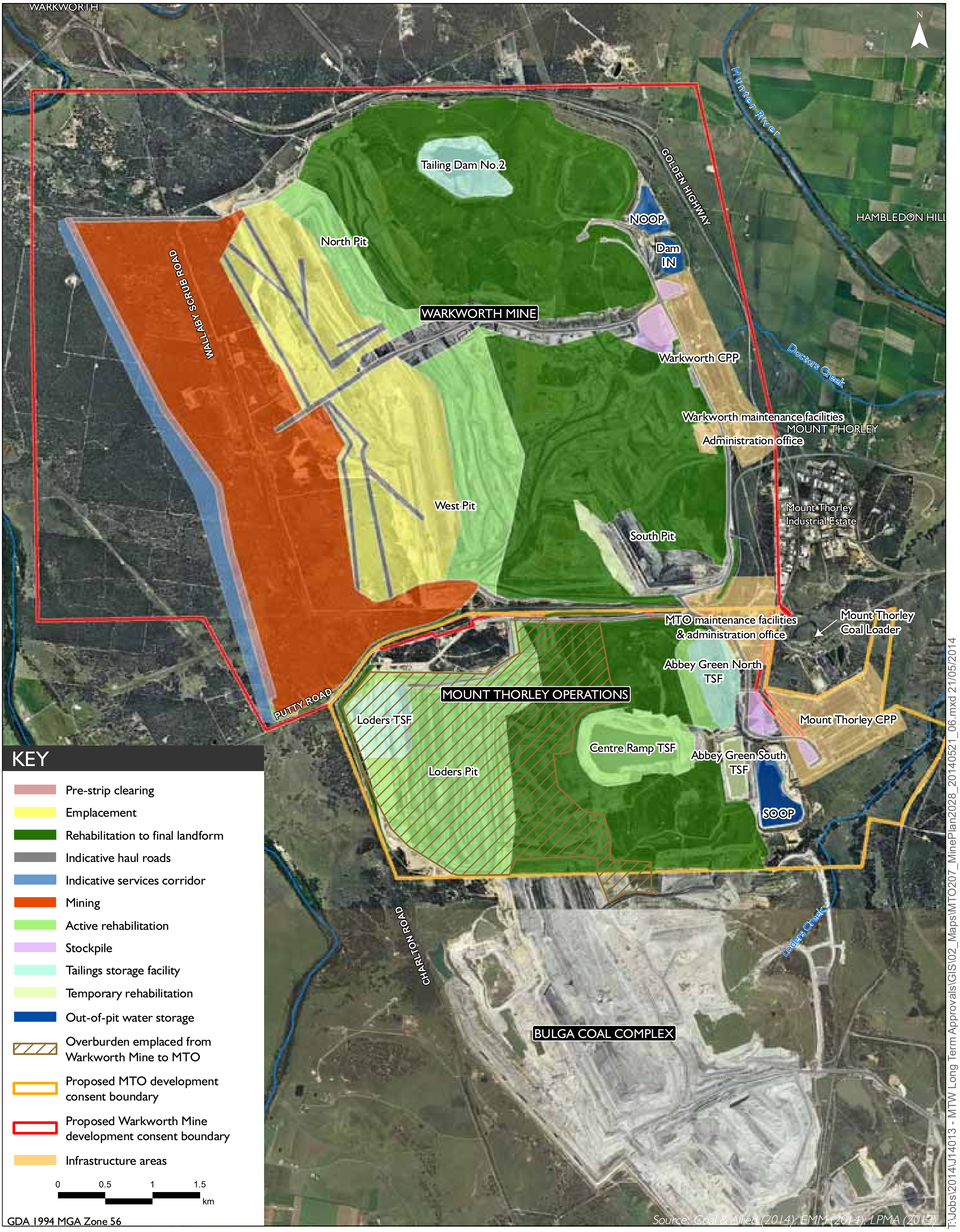

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Figure 4.3 Indicative Year 14 Mine Plan

4.2 REHABILITATION

Rehabilitation will be undertaken progressively across the mined area in accordance with rehabilitation strategy presented in the MTW Mining Operations Plan (MOP). In general, the site will be rehabilitated with a mix of grassland and woodland.

4.3 FINAL LANDFORM AND LAND USE

Existing mining operations including overburden emplacement, final voids, tailings storage facilities, roads and infrastructure, have resulted in alterations to the local landform. The MOP outlines the proposed operational and environmental management of MTW, including the final landform and post mining land use vision. As described in the MOP, the conceptual final landscape across MTO is designed to provide native woodland, grassland and agricultural land predominantly for cattle grazing consistent with the pre mining land uses.

The final landform will be designed to blend in with the surrounding topography, subject to operational constraints (see Figure 4.4). Slopes will be generally 10 degrees for overburden emplacement and up to 18 degrees for internally draining areas such as low walls and ramps.

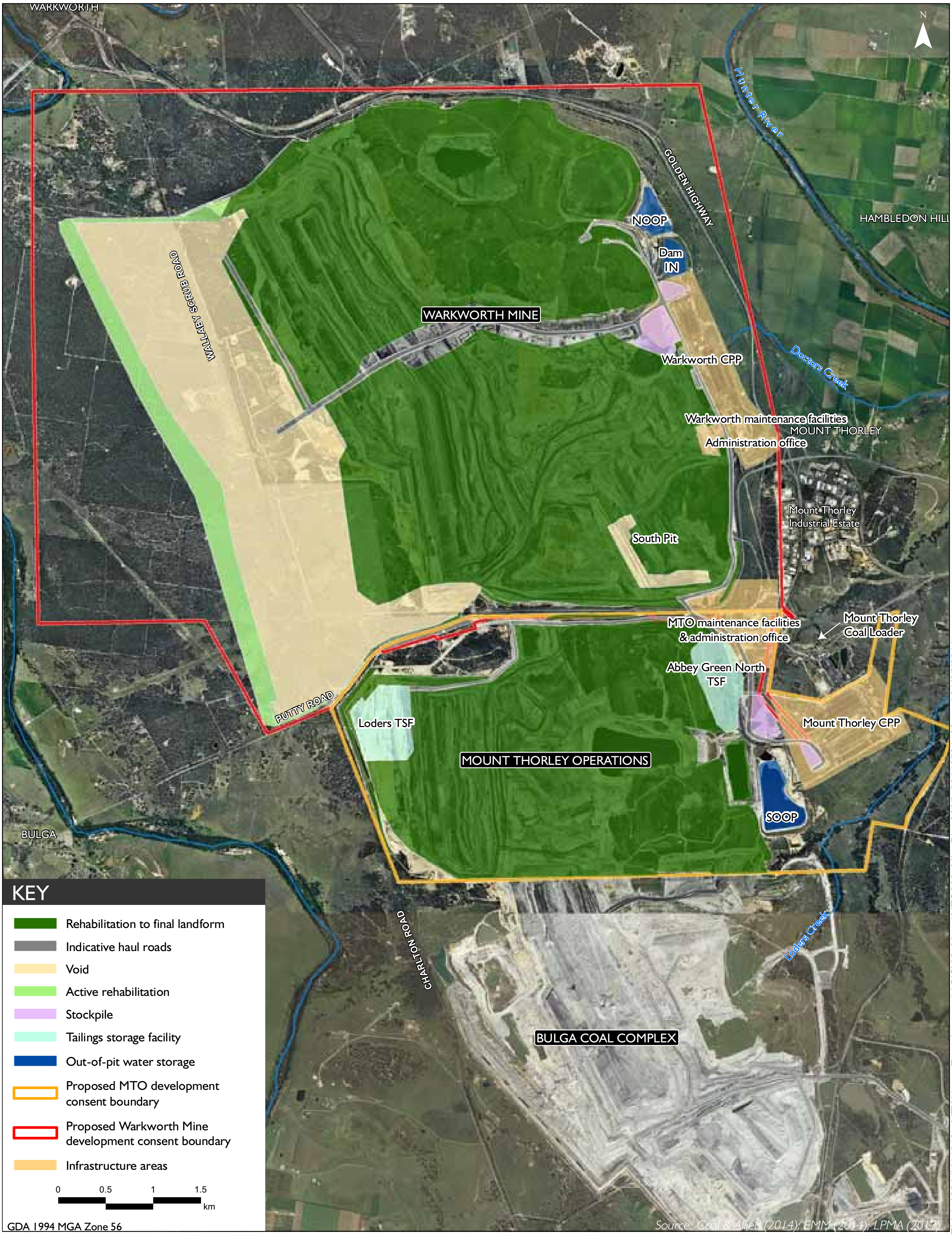

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Figure 4.4 Indicative Final Landform

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5. Visual Impact Assessment

5.1 POTENTIAL VISUAL EFFECTS

Visual effect is a measure of the level of contrast a development will have within its landscape setting. The visual effect of a mine changes through time with open pits having high contrast and low visual integration, creating high impacts at low levels of exposure. Rehabilitated mined land however, creates a low contrast and higher integration levels.

Mining operations typically have visual characteristics with a high contrast with the existing landscape. In this case the continued operations at MTO will extend elements which are already present in the landscape and as a result will not contrast significantly.

The visual effects associated with the proposal considered below are all activities which will exist under current approved operations at MTO. These activities are as follows:

> The progressive advancement of the open cut Loders pit westwards to completion (i.e. towards Charlton Road) and mining of Abbey Green North;
> The overburden emplacement continuing west including transfer from Warkworth Mine to assist in the final landform (remaining within existing approved height limits);
> Construction of new haul roads; and
> Continued night lighting upon overburden emplacement areas and on large mining equipment.

The proposal includes the transfer of overburden from Warkworth Mine to assist in the final landform which represents a minor alteration to approved operations. The infill of the void in the final landform that would remain as part of the current approvals. This will create a final landform more in keeping with the pre mining environment but will not result in additional visual impacts.

The main variation compared to the existing MTO approvals will be the extension of the development consent period to 2035. Assuming the approval is granted in late 2014 this would represent a 18 year extension to the operations. This will extend the period over which the visual effects are experienced.

POTENTIAL VISUAL SENSITIVITY

Visual sensitivity is the measure of how critically a change to the existing landscape will be viewed by any particular land use within the PVC. The land uses and their sensitivity levels were defined in the VIAS and remain relevant to the proposal as illustrated in Figure 5.1.

The urban or rural residences within the PVC of the proposal are located within a range of up to 7.5km and as such the sensitivity of these residences where the mine is viewed will be high or high / moderate.

Figure 5.1
Visual Sensitivity (VIAS 2010)

Land Use	Visual Sensitivity Levels			
	Nearest visible mine elements less than 2.5km away	Nearest visible mine elements between 2.5km – 7.5km away	Nearest visible mine elements between 7.5km – 12.5km away	Nearest visible mine elements more than 12.5km away
Urban & Rural Dwellings	High Sensitivity	High / Moderate Sensitivity	Moderate Sensitivity	Low Sensitivity
Tourist destination of visually sensitive land uses e.g. horse studs, vineyards etc	High Sensitivity	High / Moderate Sensitivity	Moderate / Low Sensitivity	Low Sensitivity
Designated tourist roads & main roads (Golden Hwy and Putty Road)	High Sensitivity	Moderate Sensitivity	Low Sensitivity	Low Sensitivity
Other roads (Hambledon Hill, Charlton, Wallaby Scrub and Wambo Roads	Moderate Sensitivity	Low Sensitivity	Low Sensitivity	Low Sensitivity
Minor local roads in rural zone	Moderate / Low Sensitivity	Low Sensitivity	Low Sensitivity	Low Sensitivity
Broad acre rural lands	Low Sensitivity	Low Sensitivity	Very Low Sensitivity	Very Low Sensitivity

5.2 POTENTIAL VISUAL IMPACTS

The significance of the visual impact will be low / moderate for the majority of the PVC of MTO. The most significant impacts will be to residences in elevated locations in and around Bulga village.

The visual impact on individual residences may range from high to low, depending on the following additional factors:

> Screening effects of any intervening topography, building or vegetation – residences with well screened views will experience lower visual impacts than those with open views;
> The viewing distance from the residence to visible areas of the proposal – the further the distance the lower the visual impact experienced; and
> The general orientation of the residence to the proposal – residences with direct orientation will experience higher visual impacts than those with an oblique orientation.

The potential impacts identified in the North, East, South and West sectors, as shown in Figure 3.7, are described below.

5.2.1 NORTH SECTOR

Warkworth Mine is situated directly to the north of MTO. This mine and intervening topography and vegetation means there are no views from Warkworth village or the rural foothills to the north of the Warkworth Mine. To the north east there would be views from some sections of the Hunter River flood-plain and rural foothills. Residences in the north east will also have views to the site, however, the visual effects will not be noticeably different from those under the current approvals. High to moderate effects may be experienced from residences with views due to their high sensitivity, this would result in a temporary high impact until rehabilitation was completed.

Putty Road forms the northern boundary to the proposal site, the visual effects from this area would be low and the views will not be noticeably different from those under the current approvals. Due to its proximity it has a high sensitivity, however, the visual impact will be low.

5.2.2 EAST SECTOR

The overburden emplacement areas at MTO are screened from sensitive viewing locations in the east. Views of MTO from the east exist from minor local roads, the closely located industrial estate and rural land but will be screened by intervening vegetation. These will not be noticeably different from those under the current approvals and impacts will be low.

5.2.3 SOUTH SECTOR

Views from the south are largely concealed by topography, vegetation and the mining activities at the Bulga Coal Complex. Some exposed viewpoints, do however, exist from the southwest. From these exposed areas the existing overburden emplacements at MTO can be widely viewed as currently approved, and will continue to advance westwards. The overburden emplacement would have a high/moderate visual effect prior to rehabilitation and these locations have a high visual sensitivity. This may result in high visual impacts in comparison to the existing conditions. The visual impact in comparison to the current approvals would, however, be low.

5.2.4 WEST SECTOR

A visual bund has been constructed along Charlton Road and extending north along Putty Road. The bund has been vegetated and native trees and shrubs are establishing on the faces. This bund screens views from these roads and reduces views of the overburden emplacement from more distant locations to the west.

The extent of mine views will be dependent on the position of the viewing location. Views from some south westerly view points along Putty Road as well as from some parts of Bulga village will exist and the visual effects would range from low to high in comparison to the existing conditions but would not be significantly different to those under the existing approvals. Bulga village has a high level of sensitivity, views in the lower lying areas including Wambo Road are screened and the visual impacts would be low to moderate. More open views exist in locations around Bulga including along Inlet Road and Putty Road south of the Bulga bridge, where impacts would be moderate.

All residential properties in this area will have a high level of sensitivity and properties in elevated locations throughout Bulga may experience high visual impacts depending on the orientation of the property and intervening screening provided by vegetation. Site Specific Visual Assessments (SSVA) would be undertaken where requested by the landowner and potential site specific mitigation measures determined through this process. See Section 6 for further discussion of proposed mitigation measures.

Viewshed analysis from Bulga Village for the indicative year years three, nine and fourteen mine plans and final landform are shown in Figures 5.2 to 5.5. Following these the photomontages presented in the 2010 VIAS are presented depicting the visual effects from viewpoints in and around Bulga (Figures 5.6 - 5.10). These montages remain representative of the effects of the proposal.

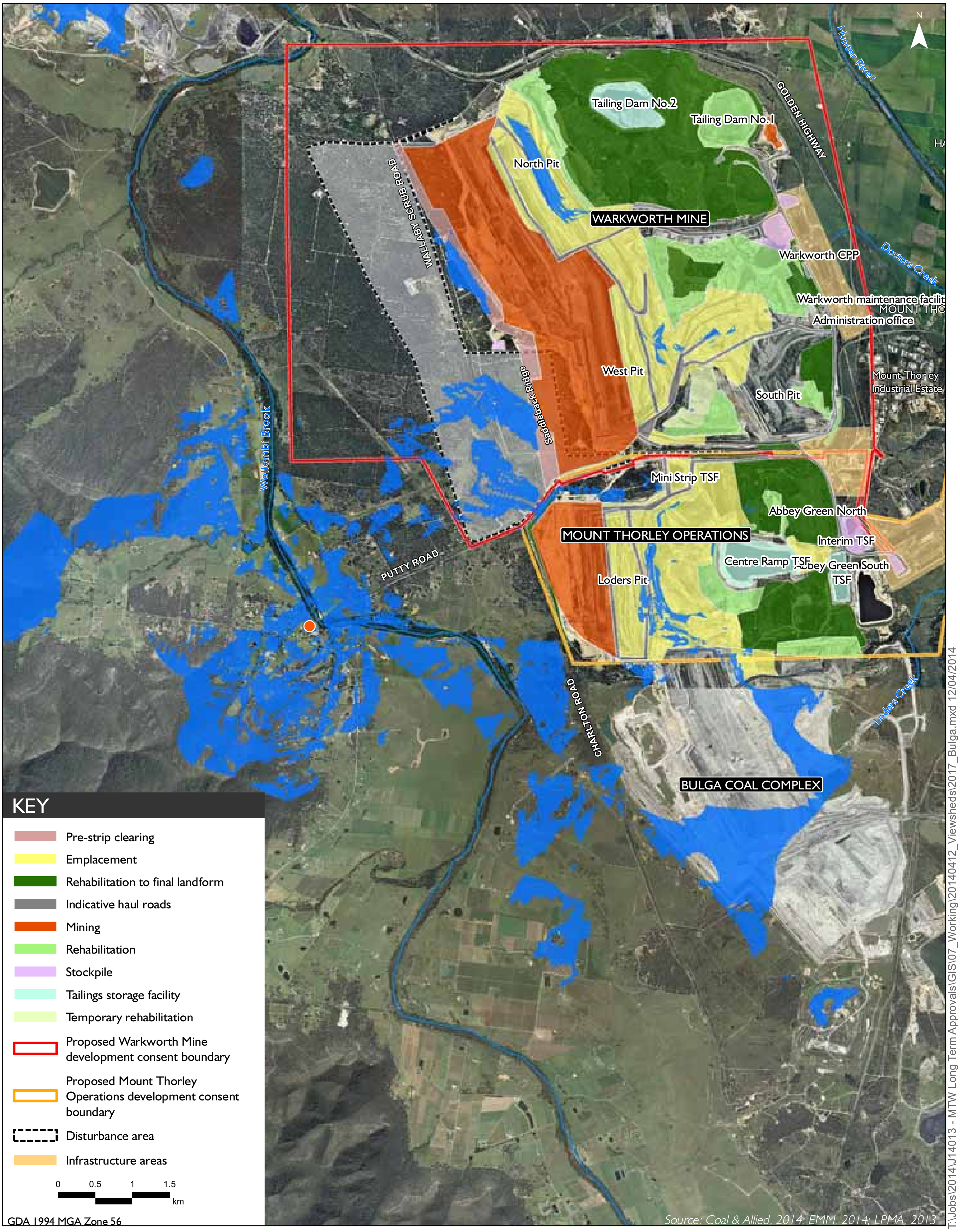

Figure 5.2 Viewshed Analysis Bulga Village (Indicative Year 3 Mine Plan)

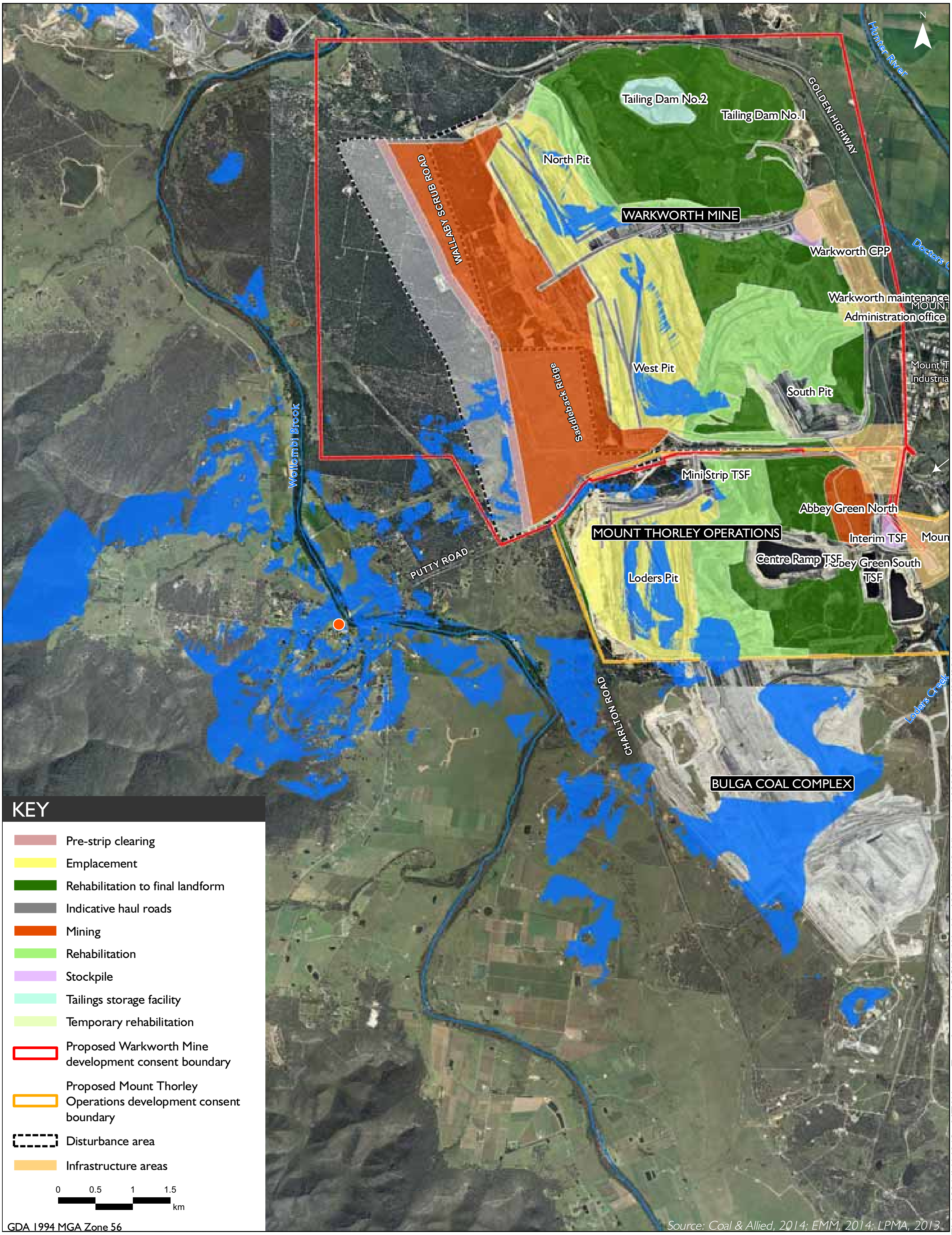

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Figure 5.3 Viewshed Analysis Bulga Village (Indicative Year 9 Mine Plan)

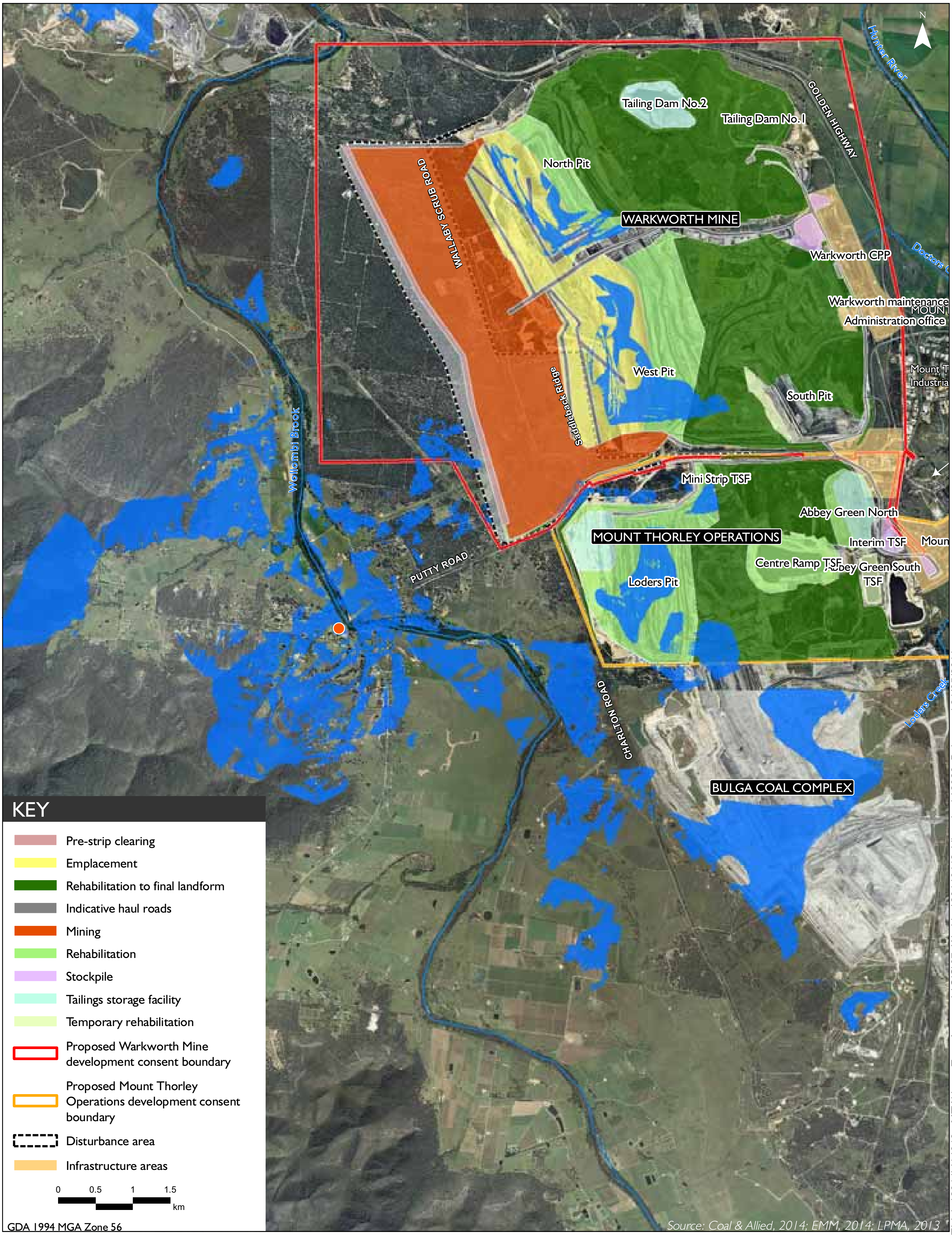

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Figure 5.4 Viewshed Analysis Bulga Village (Indicative Year 14 Mine Plan)

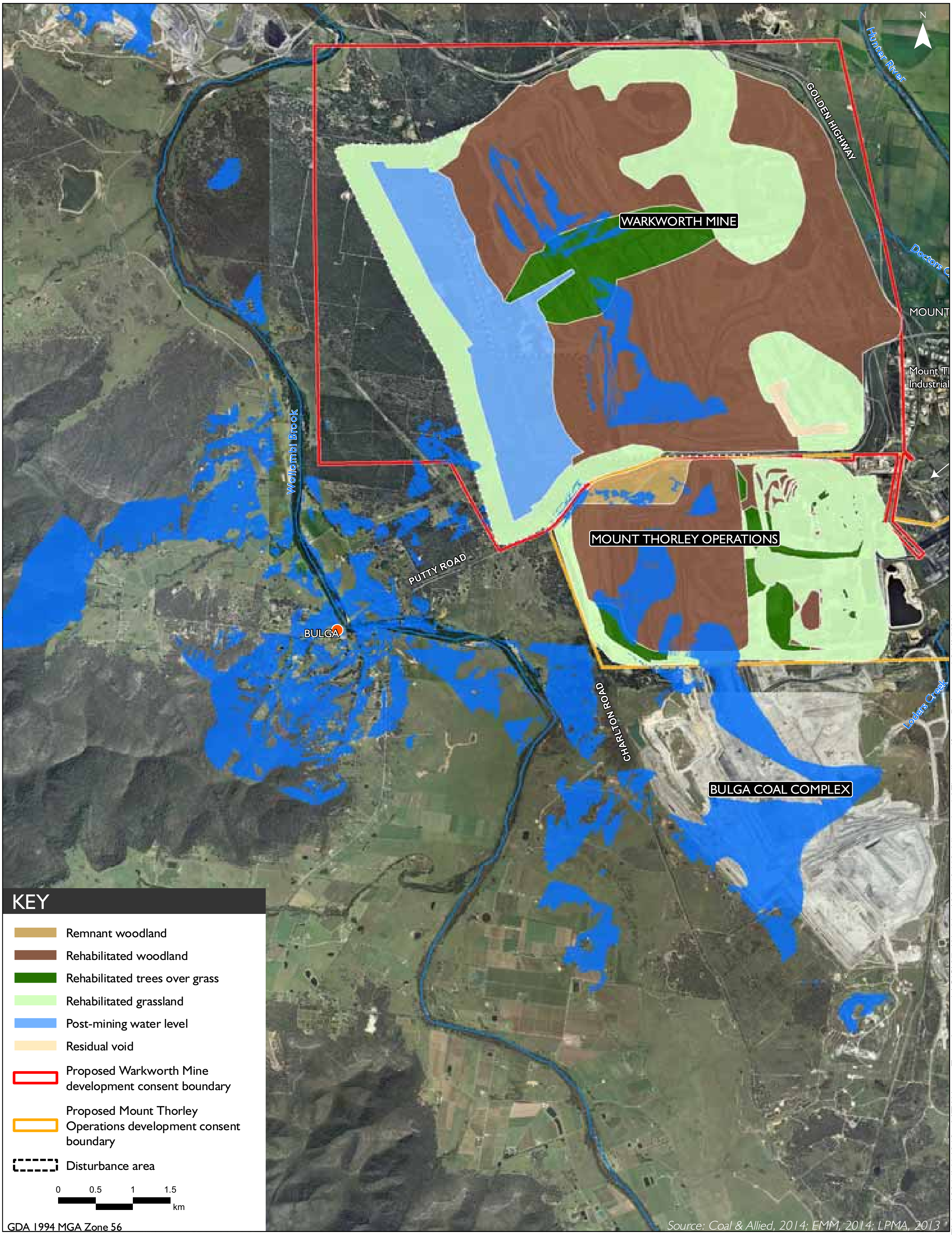

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Figure 5.5 Viewshed Analysis Bulga Village (Indicative Final Landform)

Figure 5.6 Putty Road North Photo Montages (VIAS 2010)

Figure 5.7 Putty Road South Photo Montages (VIAS 2010)

Figure 5.8 Bulga Hotel Photo Montages (VIAS 2010)

Figure 5.9 Turnbull Inlet Road Photo Montages (VIAS 2010)

Figure 5.10 Wambo Road Photo Montages (VIAS 2010)

6. Management and Mitigation

6.1 OBJECTIVES

The key elements of mitigation employed for the proposal will be the utilisation and management of existing native vegetation together with additional plantings and earthworks to achieve suitable visual screening.

The mitigation objectives include:

> Develop mitigation strategies to ameliorate adverse visual impacts;
> Provide details on the establishment of vegetation and bund screening for the purpose of maintaining satisfactory visual amenity; and
> Develop site specific mitigation strategies to ameliorate significant direct views from individual residences.

6.2 PROPOSED MITIGATION MEASURES

Potential visual impacts of will generally be moderate to low, as the impact on visual amenity will be limited and localised. The existing topography and vegetation will continue to provide screening to the mine to varying extents depending on view location and elevation. Some residences west of the proposal site may have potential to experience high impacts during the operations at MTO prior to the completion of rehabilitation i.e. during active mining.

A number of mitigation measures are currently in place for the approved operations at Warkworth Mine, these include:

> structure design to minimise visual impacts, consistent with engineering principles and practice, and any site constraints;
> direction of lighting away from offsite areas to the greatest degree possible, and the use of sensor lighting where permanent lighting unnecessary; and
> construction of small bunds, vegetated and built screens at appropriate locations along the Site boundary.

The additional strategies proposed to mitigate off-site visual impacts are detailed below.

> Examine in detail any high sensitivity viewing points and determine the opportunity for relevant screening treatments including site boundary treatments or mitigation measures to individual residences.
> Minimise the amount of pre-rehabilitation areas that are exposed to view by establishing grass cover to remove colour contrast; and
> Establish planting patterns of trees and grasses in rehabilitation areas to create a high level of visual integration with the surrounding landscape.

In order to determine the appropriate screening treatments for any high sensitivity viewing point a SSVA will be undertaken. In the case of individual residences, the landowner of an effected property may request a SSVA, which may result in mitigation measures at the affected property or between the property and the source. A conceptual process for implementing SSVAs is documented in the Draft VIMP.

Constraints currently exist to the implementation of any mitigation measures on public land and, therefore, such measures have not been proposed. In addition mitigation on private land is expected to be more effective for the visual impacts identified. Should the existing constraints be overcome and specific works be identified to mitigate high impacts measures on public land may be considered in the future.

The Draft VIMP will be developed and will detail the management of the visual mitigation measures for MTO. The following represents the elements of the VIMP as they will apply to the proposal.

6.3 ON-SITE MITIGATION MEASURES

Specific controls that will be adopted on-site to manage the visual impacts of the existing operations, as well as the proposal, are detailed below.

6.3.1 STRUCTURES

Whilst no new buildings are proposed, if any are required, they will be designed to minimise the visual impacts on the surrounding environment, consistent with engineering principles and practice and any site constraints. Any design of buildings and infrastructure will include consideration of:

> The location, form and height of buildings and structures;
> The use of nonreflective and textured building materials to avoid glare;
> The use of colours that will complement the surrounding environment. Muted greens or beige are favoured, except where bright colours are necessary for safety purposes;
> Where practical, the design and construction of trafficable haul roads shall be such that they occur below or above the natural surface level; and
> Infrastructure will be maintained in good order.

In general buildings will be constructed of a steel frame with metal roofs and wall cladding which would typically be Colorbond or a similar approved equivalent. As illustrated in Figure 6.1

Figure 6.1
Typical Structures and Equipment

6.3.2 MANAGEMENT OF OFF-SITE LIGHTING IMPACTS

Under the proposal, MTO will continue to operate 24 hours a day. Lighting can impact properties either directly or through reflection off a low cloud base. The potential light sources include lighting plants, lights on mine infrastructure and the use of lights on vehicles. The MTO aims to provide enough light to safely undertake its operations whilst minimising visual disturbance to residences and public roads.

The impact of off-site lighting is minimised by directing lights away from off-site areas to the greatest degree possible, directing lights down onto work areas, using sensor lights where permanent lighting is unnecessary. Regular checks will be undertaken to observe the effects of lighting on public roads and neighbouring properties. Equipment lighting is fitted with shields where practical and is checked and adjusted to minimise the effects on adjacent areas.

Significant portions of MTO are concealed by existing vegetation and bunds that provide screening from lighting effects at night and provide visual screening during the day. The areas where this screening is less effective include those areas where vegetation screening filters views alone and when activities are being undertaken on areas which are higher than the surroundings, such as on elevated overburden emplacement areas.

6.3.3 SITE AND BOUNDARY AREAS

Site boundary mitigation measures provide reasonable and feasible measures to minimise potential visual impacts of MTO from the public domain and roads around the site.

The visual impacts of MTO will be controlled in most cases through landscape designed to integrate with the rehabilitation strategy outlined in the MOP. Typically, this will involve constructed bunds, vegetation screens, or built screens as appropriate to the location. In some cases effective screening may not be reasonable or feasible.

In most areas around the MTO boundary there is some level of existing bunding or vegetation and as such additional screening will be achieved through infill planting in areas where gaps allow views of MTO rather than new broad scale vegetation screens. The first preference for visual mitigation will be to retain existing vegetation where possible. Where necessary the existing vegetation will be augmented with additional planting to enhance the screening effects.

Bunding at the view source has many positive visual effects including its immediate screening effect, complete screening in narrow depth areas where vegetation would be inadequate to filter views and screening of vehicles and access roads.

Bunding is typically utilised in areas where views require a more prompt mitigation or where a combination of bunding and vegetation is determined to provide more appropriate visual mitigation.

Where physical or operational constraints preclude the use of vegetation or bunding on-site, structures will be considered as an alternate means to screen views from sensitive assessment locations. A number of constraints exist within the areas directly adjacent to MTO's boundaries including power line easements and Roads and Maritime Services (RMS) owned road reserves in which the opportunities for mitigation measures are limited. Movable built screens may offer a practical mitigation in these areas.

Bunding may be removed when visual impacts associated with the location have lessened following rehabilitation or other removal of the impact source. This allows progressive landscape normalisation ahead of closure rather than having a period of significant activity in the period prior to and across closure.

Areas likely to require mitigation measures to be implemented include, but are not limited to, Putty Road, which is specifically addressed below.

6.3.4 PUTTY ROAD

Impacts will occur to the views along Putty Road as a result of the existing approvals, in particular where it passes between MTO and Warkworth Mine. Bunding has been constructed in the key viewsheds and in general the area available for additional screening is limited. As such, the form of any screening will be determined as part of the detailed mine planning process.

Plantings will be undertaken to enhance the existing established vegetation which will be retained where possible. In particular, understory shrub plantings will be introduced to provide low level screening for passing motorists. Fast growing screen species will be selected, using endemic species in line with the principles of MTW's MOP.

The MTO overburden emplacement area will have a significant impact from the west. As such, a bund has been constructed along the western site boundary adjacent Charlton Road, extending around the northwest corner of the site and along Putty Road. This bund has been revegetated and tree and shrub vegetation is becoming established on the external face. The bund and associated vegetation reduces the visual impact of the overburden emplacement.

6.3.5 PLANTING FOR VEGETATION SCREENING

Visual screen plantings will include trees and shrubs of varying heights and be of sufficient width to provide sustainable and good visual screening. It is proposed that, in new screen planting areas with sufficient width, trees be planted a minimum of four rows deep (where practical), with approximately five metres between the rows with rows offset to provide improved screening from all view angles. Trees and understory planting will be tubestock with shrubs infilling between trees every metre with an additional row of shrubs between each row of trees as shown in Figures 6.2 and 6.3. A mix of shrubs will alternate with taller trees to ensure that the screening is achieved rapidly. The arrangement of native plants will be random, and unevenly distributed to create a natural character.

Where screen planting is augmenting existing vegetation to infill open areas, the same principle will be followed. However, planting will be added to create this matrix in areas where the existing vegetation is sparse. The number of rows of trees will be suitable for the area to be in filled. A typical example of this matrix is illustrated in Figure 6.4.

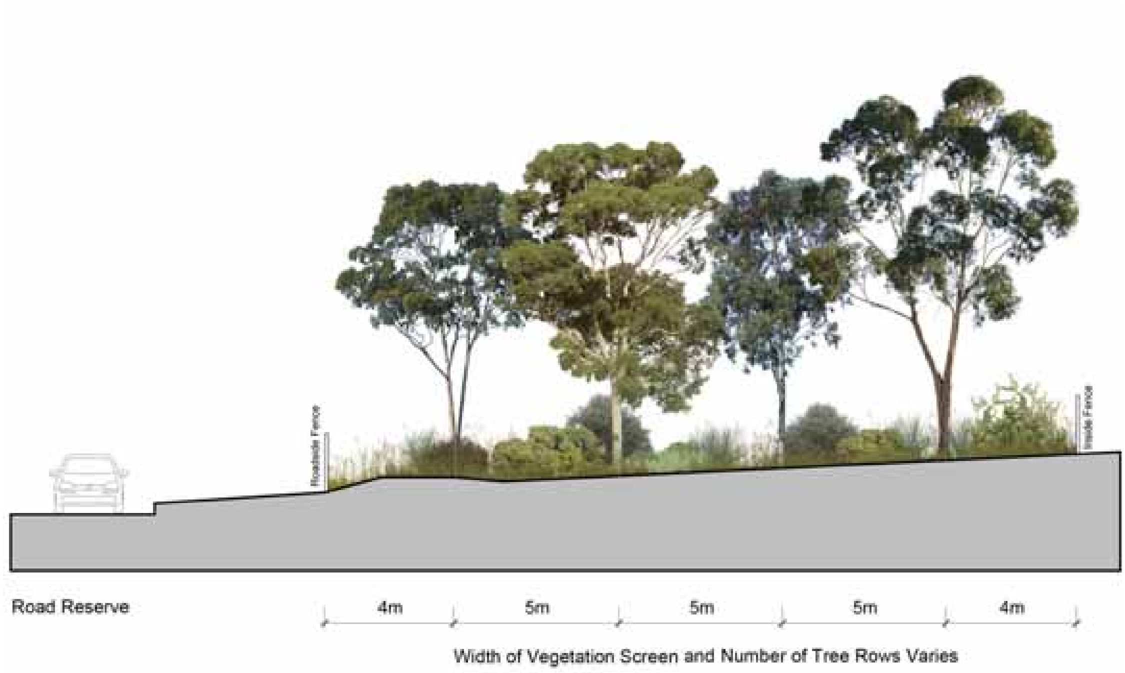
An indicative species list of locally endemic species is provided in the Draft VIMP Whilst preference will be given to species which are locally endemic, it is recognised that endemic species may not be commercially available in the numbers required to undertake the visual landscape screening. In this case, other appropriate native species which have performed well in the local area will be used.

6.3.6 PLANTING FOR BUND SCREENING

Visual bunds will require a program of planting to achieve a good level of vegetation cover. This program will aim for an initial cover crop followed by seeding of native grass / shrub and tree species. If the base soil conditions are suitable these phases may be undertaken as a single process.

For areas of high sensitivity augmentation plantings with advanced stock may also be undertaken. Large shrubs and small trees will be planted on the lower areas of the bund to screen at low levels with tall trees planted to the top of the bund to maximise its screening height. A typical screening bund is illustrated in Figure 6.5.

Figure 6.2
Typical Vegetation Screen Section



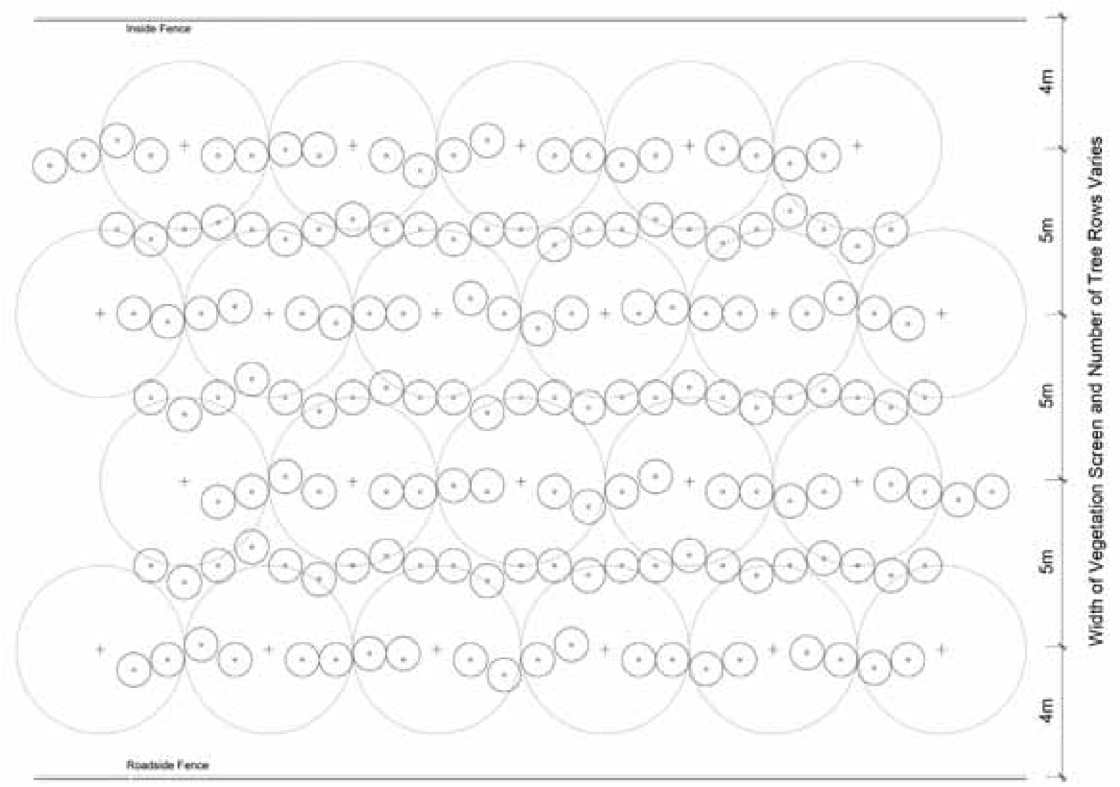


Figure 6.3
Typical Planting Matrix – New Screen Planting

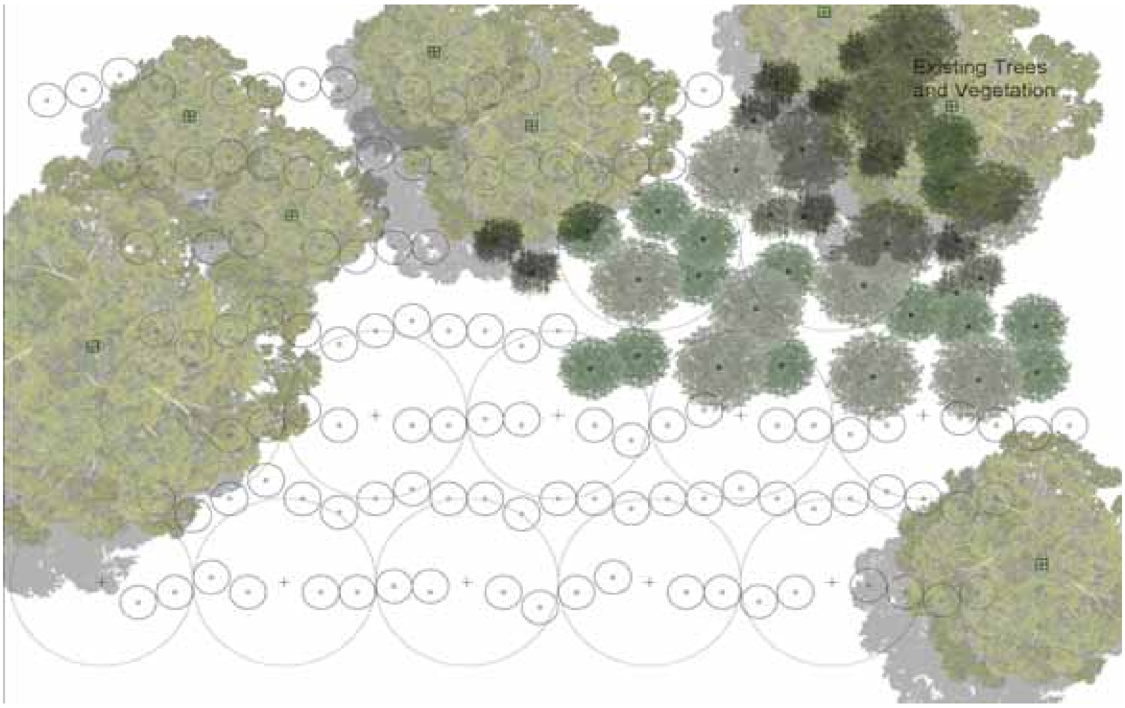
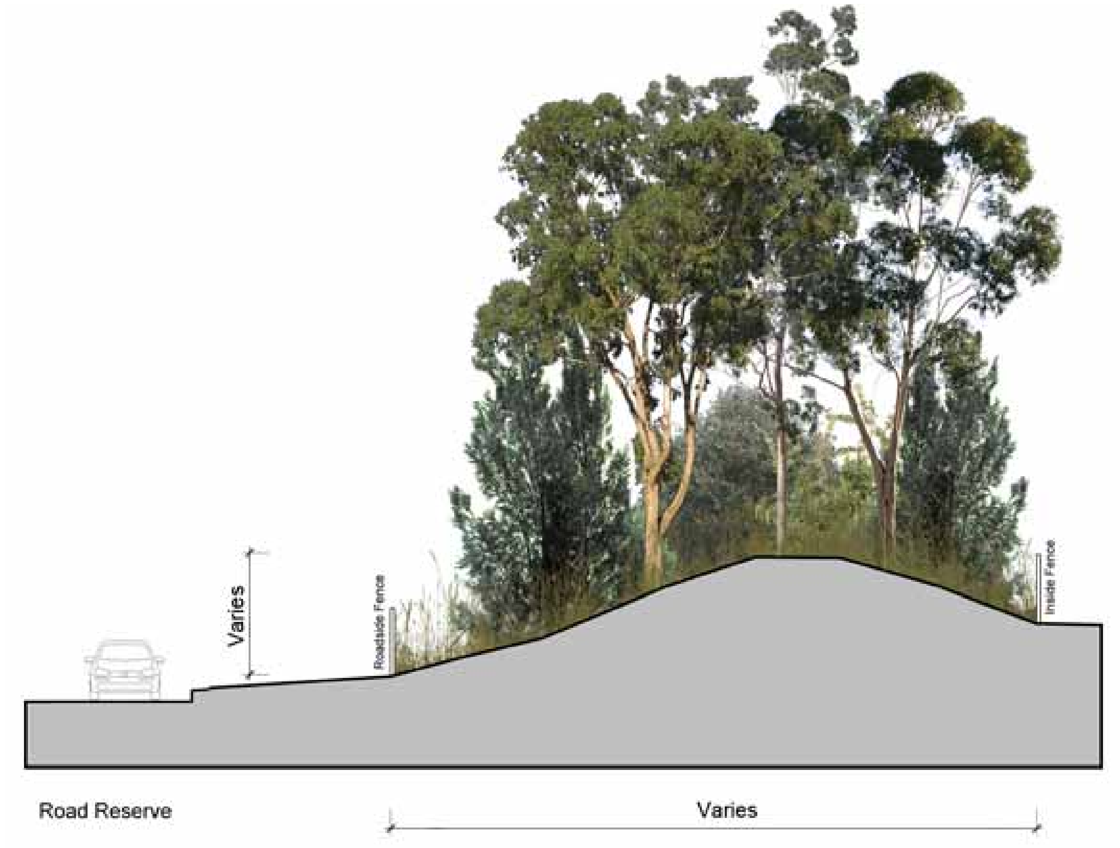


Figure 6.4
Typical Planting Matrix – Infill Screen Planting

Figure 6.5
Typical Bund Screen Section



6.3.7 LANDSCAPE PROCEDURES

The general planting procedures will be as described below, though these may change based on experience and site suitability.

> Where practical and available, topsoil will be translocated from mine advance areas with minimal stockpiling to utilise the native seed bank;
> The method of seeding will be in accordance with site practice and may include aerial seeding, direct seeding, hand broadcasting, brush-matting or hydromulching; and
> Best practice establishment procedures will be used as appropriate to planting sites including but not limited to consideration of: provenance and quality of seed and/or tubestock; ground preparation, planting practices, protection of plantings, and initial and ongoing maintenance.

6.4 OFF-SITE MITIGATION MEASURES

6.4.1 SCOPE

The mitigation measures described in this section apply to existing residences on existing residential allotments.

Visual mitigation of future subdivisions for the purpose of residential allotments are expected to be the responsibility of the developer or thereafter the resident.

6.4.2 SITE SPECIFIC VISUAL ASSESSMENT

Some individual residences within the PVC are likely to have significant direct views of MTO with a high visual impact at some stage during the operations.

Due to existing vegetation within the properties and the surrounding areas many of the residences within areas with potentially high visual impacts may not experience this level of impact. As the extent of existing screening is specific to each residence due to its elevation, orientation and layout, it is not possible to determine with any certainty the extent of impact on any individual residence without undertaking a SSVA. Where requested for properties in Bulga village, Coal & Allied will undertake a SSVA to determine the level of significance of the visual impact and the potential suitable mitigation measures to reduce the impact on the view. A conceptual methodology for this assessment and the process through which mitigation measures will be agreed with the land owner is outlined in the Draft VIMP.

Where possible within the permissions of effected landholders vegetation screening will be implemented as early as practicable during the development so as to allow a period for establishment of an effective screen prior to impact occurrence.

6.4.3 VISUAL MITIGATION TREATMENTS

Vegetation screening may be implemented to screen views related to the proposal from significantly impacted residences. Vegetation screening has various screening capacity depending on the significance of the impact. Coal & Allied will be guided by the recommended extent of mitigation based on the SSVA and any associated discussions and agreement with property owners. No work will occur without the owner's consent.

The design including species selection will be undertaken in consultation with the property owner. Designs will be in keeping with the character and design of the residence. All designs will be agreed and signed-off by the landowner prior to implementation.

Plant species will be selected for their suitability for the local area as well as their aesthetic properties. An indicative species list is provided in the Draft VIMP.

Landscape maintenance of planting undertaken on private land will be the responsibility of the landowner from the time of installation, although Coal & Allied will undertake fair and reasonable maintenance replanting of failed stock during the initial screen establishment period of approximately 12 months.

Figure 6.7
Example of Filtered On-Site Planting

Figure 6.8
Example of Dense On-Site Planting

The photomontages presented in Figures 6.9 through 6.14 illustrate the typical outcomes which can be expected from the proposed mitigation.

Figures 6.9 and 6.12 are photographs of the existing views taken from residences on Inlet Road in the Bulga area. Figures 6.10 and 6.13 illustrate the impacts without mitigation measures based on the indicative year nine view and 6.11 and 6.14 illustrate the views with mitigation measures in place.

Example Site 1 is located at 95 Inlet Road and Figure 6.11 illustrates filtered screen planting using tree and shrub species in keeping with the properties garden planting.

Figure 6.9
Site 1: Photograph of Existing View

Figure 6.10
Site 1: Photomontage Prior to Mitigation Measures (Indicative Year 9)

Figure 6.11
Site 1: Photomontage Post Mitigation Measures

Example Site 2 is located at 29 Inlet Road and Figure 6.14 illustrates dense screen planting. Given the current boundary planting on the property the mitigation planting would include augmenting the existing shrub beds with tree and shrub species in keeping with those already used.

Figure 6.12
Site 2: Photograph of Existing View

Figure 6.13
Site 2: Photomontage Prior to Mitigation Measures (Indicative Year 9)

Figure 6.14
Site 2: Photomontage Post Mitigation Measures

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7. Conclusion

The current approved operations at MTO would generate a range of visual effects that are in keeping with those that would typically be expected from the development of an open cut coal mine. The other existing mining activities in the area including Warkworth Mine, Hunter Valley Operations and Bulga Coal Complex have already created a change in the pre mining visual landscape.

The approved operations will generate an incremental change to the existing conditions and the proposal will have a low level of change in comparison to the current approved operations. The main variation will be the period of time over which these impacts will be experienced.

The visual impacts would for the most part be low; however, some sensitive assessment locations may experience higher impacts. The highest impacts occur from the west, in particular, from a limited number of residential properties in the area around Bulga Village. Impacts are partially limited by the intervening vegetation and topography; however, properties on elevated slopes are likely to require site specific mitigation measures.

The proposed mitigation measures aim to reduce potential visual impacts on the public domain through vegetation and bund screening along the site boundaries. In addition to these, specific foreground treatment measures at individual assessment locations determined to have significant impacts will also be implemented.

The progressive rehabilitation of MTO will reduce visual impacts over time with the revegetated final landform having a high level of integration into the natural rural landscape of the surrounding area.

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4. Coal & Allied Operations Pty Ltd, Mount Thorley Warkworth Mining Operations Plan, Amendment A (Warkworth Modification 6 to DA 300-09-2002), 30 January 2014.

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Appendix I

Groundwater study

Appendix I — Groundwater study

Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

MOUNT THORLEY OPERATIONS 2014 GROUNDWATER ASSESSMENT

Prepared for

EMGA Mitchell McLennan

Project No. G1468F   May 2014

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TABLE OF CONTENTS

Page No.

List of Tables

List of Figures

List of Appendices

REPORT ON

MOUNT THORLEY OPERATIONS 2014
GROUNDWATER ASSESSMENT

1 INTRODUCTION

Mount Thorley Operations (MTO) is an open cut coal mine approximately 10.5 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). The site currently operates under Development Consent No. DA 34/95 (the development consent) issued by the then Minister for Planning on 22 June 1996 under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Immediately to the north is Warkworth Mine. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for all the operations. Equipment, personnel, water, rejects and coal preparation are all shared between the mines. The MTW operations involve an existing operation of approximately 1,300 persons, which includes full-time personnel and a small number of short-term contractors. Ownership of the two mines remains separate.

Mining activities approved under DA 34/95 have mostly been completed with the exception of Loders Pit and Abbey Green North Pit (AGN) with rehabilitation well-progressed on the east of the site. Run-of-mine (ROM) coal from MTO is transported to either the MTO or Warkworth Mine coal preparation plant (CPP) for processing. Extraction of coal from other pits has been completed and overburden emplacement is ongoing. Product coal from the CPPs is transported via conveyor to the Mount Thorley Coal Loader (MTCL). Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The MTO 2014 (the proposal) seeks an approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

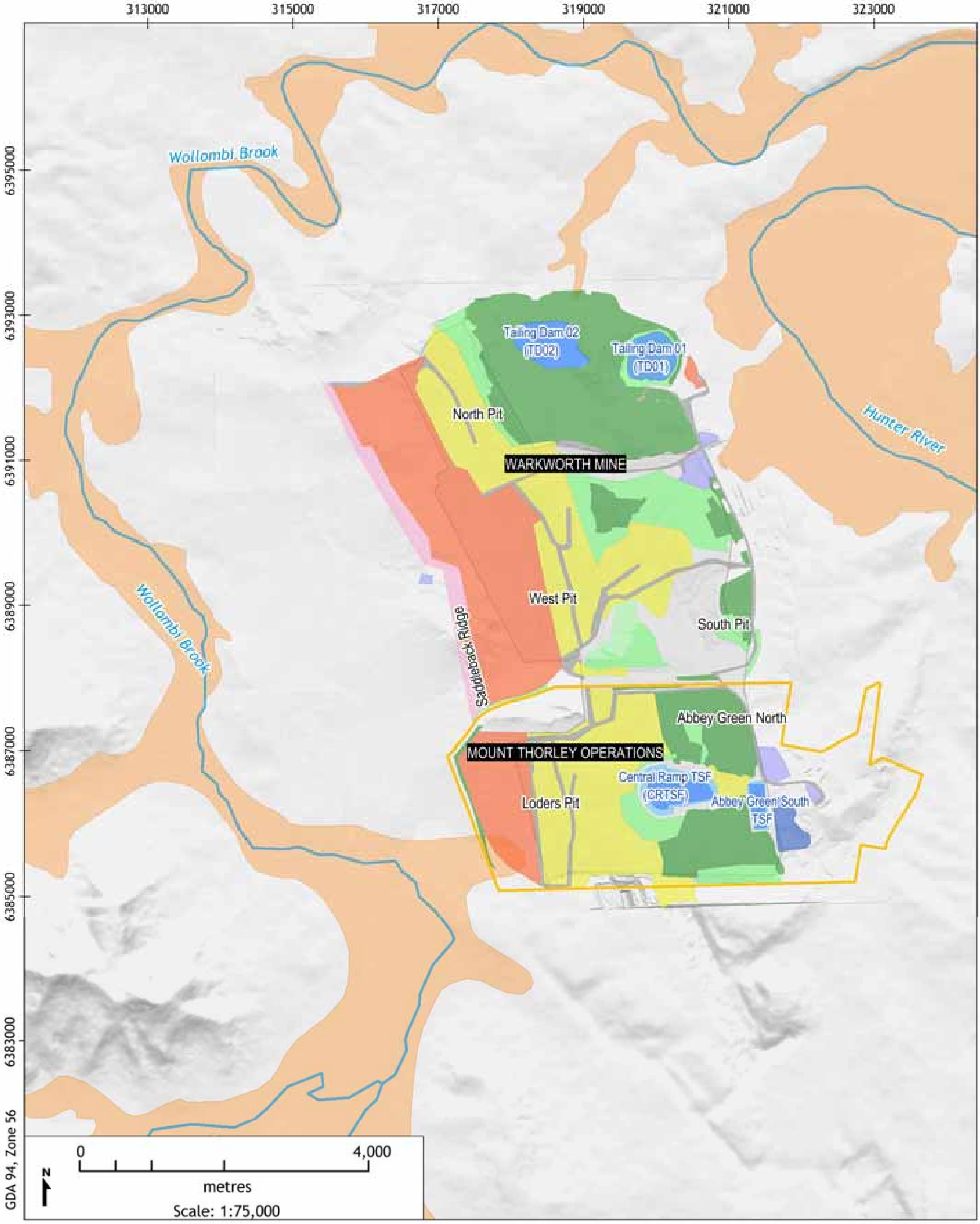
1.1. Project Description

MTO has approval to mine until 22 June 2017 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in 2015, operations at MTO are forecast to continue to the end of 2035, an 18 year extension over the current approval. The proposal seeks a continuation of all aspects of MTO as it presently operates and extends or alters them, including:

- mining in Loders Pit and AGN Pit. Mining in Loders Pit is expected to be completed in approximately 2020. Mining in AGN Pit is yet to commence; however, it is anticipated to take approximately two years and be completed before 2022;

- transfer of overburden between MTO and Warkworth Mine to assist in rehabilitation and development of the final landform;
- maintain existing extraction rate of 10 million tonnes per year (Mtpa) of ROM coal; and
- maintain and upgrade to the integrated MTW water management system (WMS), including:
    - upgrade to the approved discharge point and rate of discharge into Loders Creek from 100 Ml/d to 300 Ml/d via the Hunter River Salinity Trading Scheme (HRSTS);
    - ability to transfer and accept mine water from neighbouring operations (ie Bulga Coal Complex, Wambo Mine, Warkworth Mine and Hunter Valley Operations); and
    - increase in the storage capacity of the southern out-of-pit (SOOP) dam from 1.6 giga litres (GL) to 2.2 GL;
- maintain and upgrade to the integrated MTW tailings management:
    - including use of the northern part of Loders Pit as a TSF after completion of mining; and
    - Wall lift to Centre Ramp Tailings Storage Facility to approximately RL 150;
- upgrade to the MTO CPP to facilitate an increase in maximum throughput to 18 Mtpa with the ability to receive this coal from Warkworth Mine;
- acknowledge all approved interactions with Bulga Coal Complex (see Section 1.4.1); and
- continuation of coal transfer between Warkworth Mine and MTO and transportation of coal via the MTCL to Port of Newcastle.

All activities, including coal extraction will be within disturbance areas approved under the existing development consent. The proposal is shown in Figure 1.1 to Figure 1.3.



LEGEND:

- Proposed MTO development consent boundary
- Watercourse
- Quaternary alluvium (100k)

Indicative 2017 mine plan

- Pre-strip clearing
- Mining
- Emplacement
- Stockpile
- Indicative haul roads
- Rehabilitation to final landform
- Rehabilitation
- Temporary rehabilitation
- Out-of-pit water storage
- Tailings storage facility

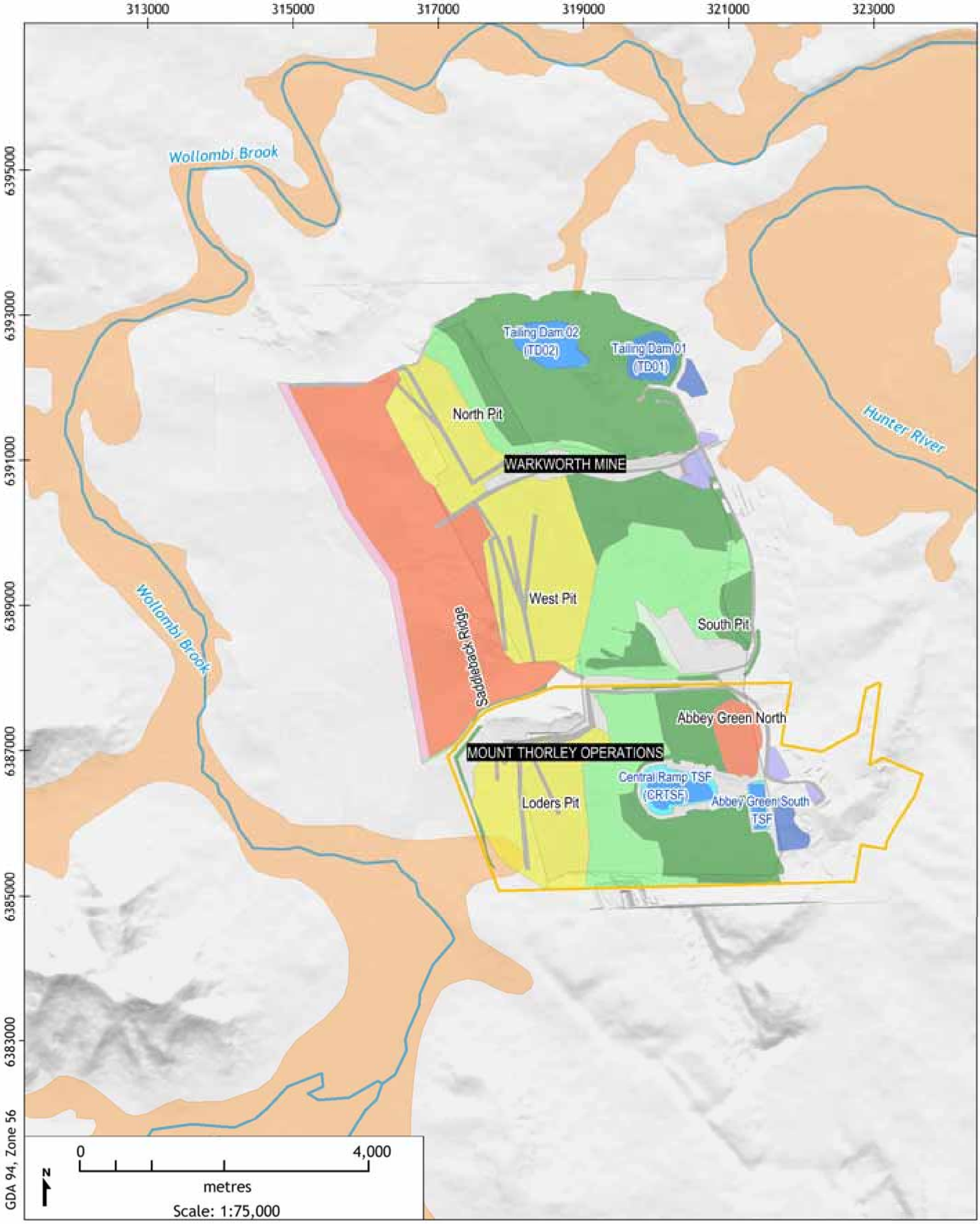
Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Indicative Year 3 mine plan

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 14/5/2014

FIGURE No: **1.1**



LEGEND:

- Proposed MTO development consent boundary
- Watercourse
- Quaternary alluvium (100k)

Indicative 2023 mine plan

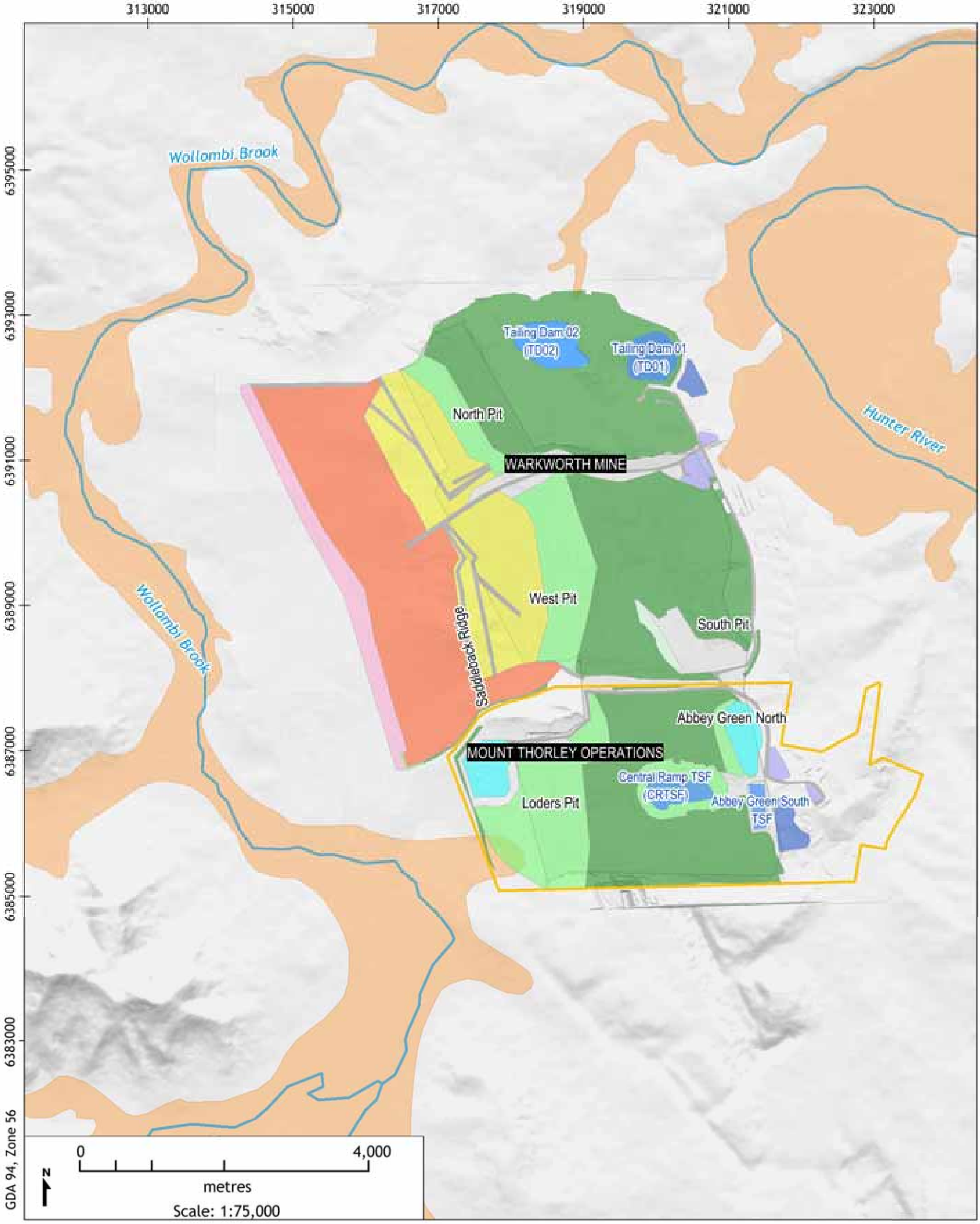
- Pre-strip clearing
- Mining
- Emplacement
- Stockpile
- Indicative haul roads
- Rehabilitation to final landform
- Rehabilitation
- Temporary rehabilitation
- Out-of-pit water storage
- Tailings storage facility

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Indicative Year 9 mine plan

DATE: 14/5/2014

FIGURE No: **1.2**



LEGEND:

- Proposed MTO development consent boundary
- Watercourse
- Quaternary alluvium (100k)

Indicative 2028 mine plan

- Pre-strip clearing
- Mining
- Emplacement
- Stockpile
- Indicative haul roads
- Rehabilitation to final landform
- Rehabilitation
- Temporary rehabilitation
- Out-of-pit water storage
- Tailings storage facility

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Indicative Year 14 mine plan

DATE: 14/5/2014

FIGURE No: **1.3**

2 OBJECTIVES AND SCOPE OF WORK

The objective of the groundwater study was to assess the impact of the proposal on the groundwater regime, and also comply with the requirements of the NSW and Federal governments that include:

- the NSW Aquifer Interference Policy (AIP);
- Water licensing requirements under the *Water Act 1912; and*
- *Water Management Act 2000 including the Water Sharing Plan for the Hunter Unregulated and Alluviual Water Sources.*

The legislative requirements are discussed further in Section 6. Requirements under the EPBC Act are not necessary for this proposal, as they have already be met for the existing MTW mine plan.

The scope of work to address requirements included:

- describing the existing environment;
- simulating the existing hydrogeological regime with a numerical groundwater model; and
- assessing the impact of the proposal on the groundwater environment, using the model including:
  - Groundwater take due to mine inflow from the Permian Coal Measures (*Water Act 1912);*
  - Groundwater take from the Wollombi Brook and Hunter River alluvial aquifers (*Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources);*
  - Changes to groundwater levels and salinity in private landholder bores (AIP);
  - Changes of more than 1% increase in groundwater salinity (AIP); and
- develop measures to mitigate and monitor potential impacts.

As required under section 78A of the EP&A Act, this EIS has been prepared in accordance with the DGRs and matters raised during stakeholder engagement; however, it also addresses matters raised in the L&E Court judgement. It is noted that the technical study, was progressed on the basis of contemporary DGRs for open cut mining projects in the Hunter Valley, DGRs issued for the Warkworth Extension 2010 and contemporary government policies. Prior to finalisation, the EIS, inclusive of technical studies, was considered against the proposal specific DGRs.

3 SURROUNDING MINES AND CURRENTLY APPROVED MTW OPERATIONS

The groundwater regime in the study area is influenced by historical and current mining operations at Warkworth and other surrounding mines. The latter comprise Wambo to the west, South Lemington in the north and north-west and Bulga in the south. Figure 3.1 shows the locality of the mining operations in the vicinity of MTW.

Because the groundwater regime has already been disturbed this report assesses the existing cumulative impacts from the historical and approved mining activities and the net impact of the proposal.

Mining at MTO and Warkworth Mines (MTW) commenced in the early 1980s with mining progressing west (down-dip) from sub-cropping coal seams of the Jerrys Plains Sub-Group. Most Warkworth sub-pits have been mined down to the Mt Arthur Seam with the exception of the North Pit which extracts to the shallower Warkworth Seam. The MTO pits are mined down to the shallower Woodlands Hill Seam. Mining at Warkworth is approved to continue until 2021, and at MTO until 2017.

Directly south of MTO is the Bulga Coal Complex, which comprises open cut and underground mines. Open cut mining commenced west of Broke Road in the early 1990s extending to the Whybrow Seam and down to the deeper Woodlands Hill Seam since 1999. The Saxonvale Colliery was developed south of Broke Road in in the early 1980s with mining targeting the Vaux Seam in the 1990s. Longwall mining of the Whybrow and Blakefield Seams under the open cut pits was approved to commence from 2010.

The former South Lemington Mine, which is part of Hunter Valley Operations (HVO) South, is located to the north of Warkworth Mine. South Lemington Underground was a bord-and-pillar operation that mined the Bowfield Seam and ceased operating in the early 1990s. The underground footprint underlies Wollombi Brook. The South Lemington Open Pit is part of the HVO South approval and is currently used as a dam to store and transfer water between Coal & Allied's MTO and HVO.

The Wambo Mine is located to the north-west of MTW. It includes both open cut and underground longwall operations. Mining commenced at Wambo in the late 1960s to early 1970s. Open cut operations have extended down to the Whynot Seam. Currently approved underground mining at Wambo includes longwall panels in the Whybrow, Wambo, Arrowfield and Bowfield Seams.

Table 3.1 summarises the coal seams mined at MTW, Bulga Coal Complex and Wambo.

Table 3.1:SUMMARY OF MINING OPERATIONS																						
Stratigraphic Column			**Coal Seam**	**Bulga Coal Complex**						**Wambo Mine**						**MTW**						
				Bulga Pit OC	Whybrow Pit OC	Saxonvale/ Vaux Pit OC	Beltana No1 Mine UG	Blakefield North UG	Blakefield South UG	Wambo OC	Arrowfield UG	Bowfield UG	North Wambo UG	Whybrow UG	United Collieries UG	Homestead/Wollemi UG	North Pit	South Pit	West Pit	Loders /Mount Thorley Pit	Abbey Green North	Lemington Underground
Regolith/ alluvium																						
Wittingham Coal Measures	Jerrys Plains Subgroup	*Mt Leonard*	Whybrow	x	x	x	x		x	x				x		x	x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Althorpe Fm		(tuff)																		
Wittingham Coal Measures	Jerrys Plains Subgroup	Malabar Fm.	Redbank Creek							x							x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Malabar Fm.	Wambo	x						x			x				x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Malabar Fm.	Whynot							x							x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Malabar Fm.	Blakefield	x				x	x								x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Mt. Ogilvie Fm.	Glen Munro	x				o	o								x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Mt. Ogilvie Fm.	Woodlands Hill	x				o	o						x		x		x	x		
Wittingham Coal Measures	Jerrys Plains Subgroup	Milbrodale Fm.		(tuff)																		
Wittingham Coal Measures	Jerrys Plains Subgroup	Mt. Thorley Fm.	Arrowfield								x				x		x		x			
Wittingham Coal Measures	Jerrys Plains Subgroup	Mt. Thorley Fm.	Bowfield									x					x	x	x		x	
Wittingham Coal Measures	Jerrys Plains Subgroup	Mt. Thorley Fm.	Warkworth														x	x	x		x	
Wittingham Coal Measures	Jerrys Plains Subgroup	Fairford Fm.		(tuff)																		
Wittingham Coal Measures	Jerrys Plains Subgroup	Burnamwood Fm.	Mt. Arthur															x	x		x	x
Wittingham Coal Measures	Jerrys Plains Subgroup	Burnamwood Fm.	Piercefield																			
Wittingham Coal Measures	Jerrys Plains Subgroup	Burnamwood Fm.	Vaux														o	o	o	o		
Wittingham Coal Measures	Jerrys Plains Subgroup	Burnamwood Fm.	Broonie																			
Wittingham Coal Measures	Jerrys Plains Subgroup	Burnamwood Fm.	Bayswater														o	o	o			

Note:

x Currently approved or historically mined

LEGEND:
- NOW stream gauge station
- Major watercourse
- Proposed MTO development consent boundary

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Local Context

DATE: 14/5/2014

FIGURE No: **3.1**

4 CLIMATE AND SURFACE WATER

4.1. Climate

The climate in the vicinity of MTO is mostly temperate and is characterised by hot summers with regular thunderstorms and mild dry winters. Table 4.1 summarises the average monthly temperature, rainfall and evaporation rates for the area. This table shows that rainfall recorded at MTW (since 2012) has generally been below the long-term average (1889-2013) for Jerrys Plains, and that evaporation exceeds rainfall on a monthly basis. The average annual rainfall at MTW is 591 mm, with February being the wettest month.

Table 4.1: CLIMATE AVERAGES JERRYS PLAINS (STATION 061086) and MTW

Statistic	Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Mean max temp (ºC)	SILO[1]	31	30	28	25	21	18	17	19	23	26	29	31	25
Mean evaporation (mm)	SILO	211	166	148	108	75	55	64	87	117	156	181	213	1579
Mean rainfall (mm)	SILO	77	73	61	44	41	49	42	36	42	53	63	67	648
Warkworth Mine mean rainfall	MTW[2]	78	151	87	25	13	48	21	10	26	9	79	26	591
Evaporation minus MTW rainfall	**-**	**133**	**16**	**61**	**83**	**62**	**7**	**43**	**77**	**90**	**147**	**102**	**187**	**989**

1. SILO Patched Point Data (PPD) from Department of Science, Information Technology, Innovation and the Arts (DSITIA) for Jerrys Plains Station. The PPD includes daily climate readings from the Bureau of Meteorology (BoM) as well as interpolated data where readings are not available. The SILO dataset includes long-term daily rainfall, temperature and evaporation readings from 1889 to present.
2. Rainfall recorded by Warkworth Mine from 2012.

Monthly rainfall records were used to calculate the Cumulative Rainfall Departure (CRD – also known as rainfall residual mass) for the Jerrys Plains Station. Figure 4.1 shows the calculated CRD.

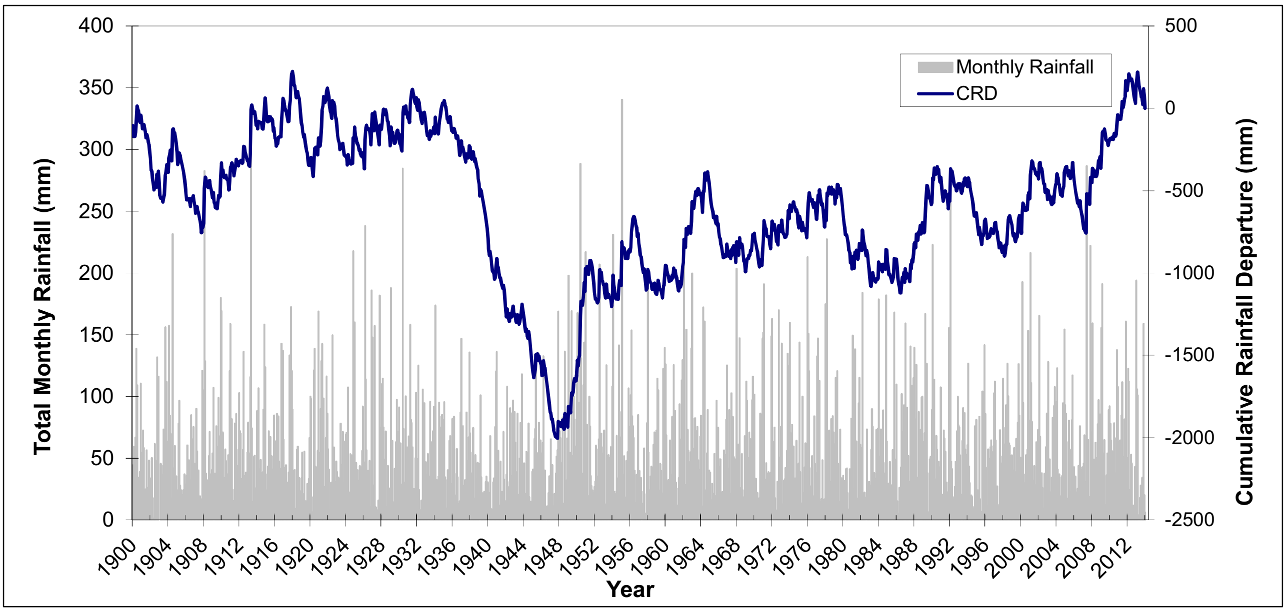


Figure 4.1: Cumulative Rainfall Departure – Jerrys Plains

The CRD shows trends in rainfall relative to the long term average and provides a historical record of relatively wet periods and droughts. A rising trend in slope in the CRD plot indicates periods of above average rainfall, whilst a declining slope indicates periods when rainfall is below average.

The CRD in Figure 4.1 indicates that the district experienced above average rainfall between 2007 and 2012, followed by a general decline in rainfall to the present day.

4.2. Surface Water

The main watercourse in the study area is Wollombi Brook, which is located to the west of MTO. The ephemeral Wollombi Brook is a tributary of the Hunter River and flows in a north to north-easterly direction past Warkworth Mine. The NSW Office of Water (NOW) collects real time stream flow data via the Hunter Integrated Telemetry System (HITS). Figure 3.1 shows the two NOW gauging stations on Wollombi Brook in close proximity to MTW, which are:

- Station 210004 (Wollombi Brook at Warkworth) north of Warkworth Mine (47.8 mRL at zero gauge and 48.4 mRL cease to flow); and
- Station 210028 (Wollombi Brook at Bulga) west of MTO (56.50 mRL at zero gauge and 57.4 mRL cease to flow).

Data on the HITS database indicates Wollombi Brook at Bulga (Station 210028), the closest gauging station west of MTW, flows at a median rate of around 41 ML/day. The median flow rate between April and December 2013 is approximately 8.4 ML/day due to below average rainfall.

Figure 4.2 shows stream flow levels recorded at the two stations, compared against daily rainfall and evaporation from 2010 to present.

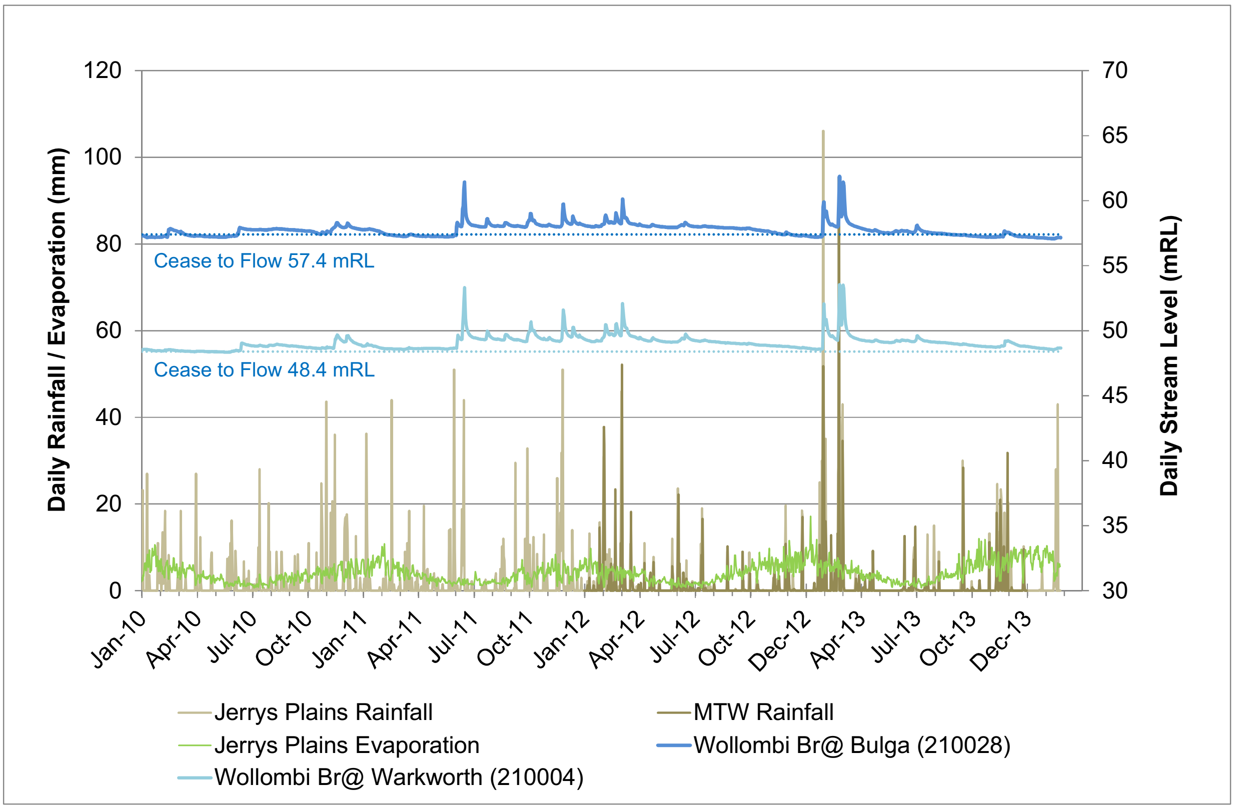


Figure 4.2: Wollombi Brook stream levels and climatic conditions

The graph shows that daily evaporation generally exceeds daily rainfall, and that peaks in stream flow in Wollombi Brook are in response to peak rainfall events. Between peak rainfall events the stream flow shows a steady recession. The graph also shows that stream flow has been maintained in the Wollombi Brook (at Warkworth Station) since 2010, but not at the Bulga Station. In early 2010, and prior to that date, the full record shows that the Wollombi Brook at both Bulga and Warkworth have had extended periods of no flow. In addition, flow volumes were higher downstream of the mine site (Warkworth) than upstream (Bulga). This indicates that there is surface and/or groundwater input to Wollombi Brook between these stations.

5 HYDROGEOLOGICAL REGIME

5.1. Groundwater Occurrence

Figure 5.1 shows the outcropping geology units and aquifer systems in the region. The geologic strata at MTW can be categorised into the following hydrogeological units:

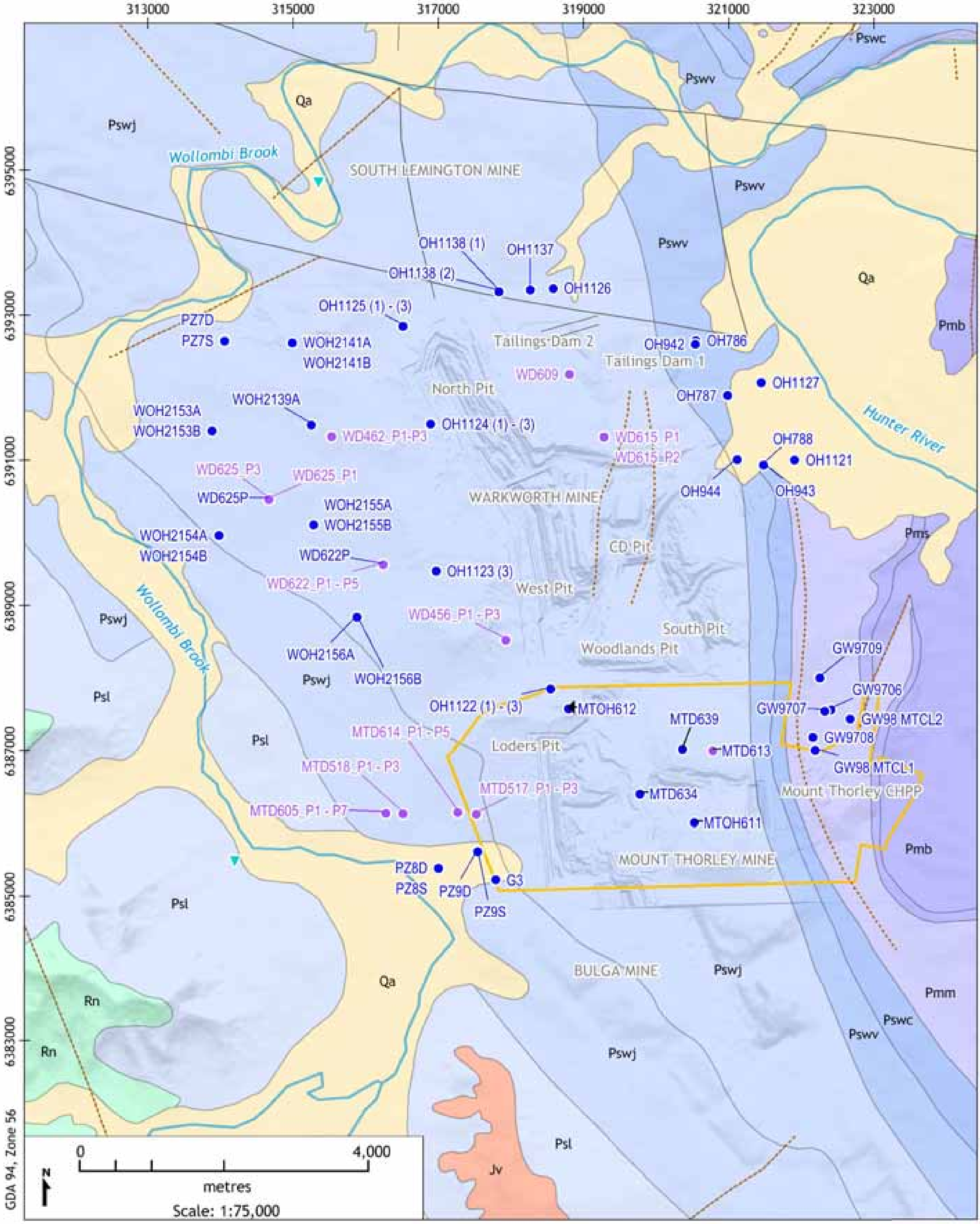
- alluvium along Wollombi Brook and the Hunter River that can form a productive aquifer system, although salinity can limit use of the water;
- aeolian sands associated with the Warkworth Sands Woodland to the north-west of Warkworth Pit that forms a thin perched groundwater system of limited extent;
- shallow weathered bedrock (regolith) near ground surface that is mainly present in the more elevated mining areas and is largely dry;
- hydrogeologically “tight” and very low yielding sandstone, siltstone and conglomerate that comprise the majority of the Permian interburden / overburden and is considered an aquitard; and
- low to moderately permeable coal seams that range in thickness from 1 m to 6 m and are the prime water bearing strata within the Permian sequence.

The Wollombi Brook alluvial aquifer and associated flood plain is largely restricted to the main channel of Wollombi Brook and only extends a short distance up the associated tributaries. Whilst Figure 5.1 shows the alluvium extending into the MTO mining area, this is based on 1:100,000 scale mapping, and work within the approved mining area shows the Loders Pit will not intersect alluvium. The alluvium is typically less than 20 m thick, with many of the private bores intersecting between 10 m and 15 m of sediment.

Groundwater entitlements for the Lower Wollombi Brook Water Source total 5,071 ML/year with approximately 55% used for irrigation and approximately 44% used for industrial purposes. This entitlement is distributed across 38 groundwater licences (DWE, 2009). This distribution is considered current, with an updated search of the NSW Government 2013 version of PINEENA groundwater database showing no new bores within the study area since 2010.

The Wollombi Brook alluvium to the west of MTW, and the Hunter River alluvium to the east of MTW can support higher yielding irrigation bores in some areas and could be considered a ‘highly productive aquifer’ according to the Aquifer Interference Policy (AIP) criteria.

Aeolian sands overlie the Permian coal measures to the north-west of the Warkworth Mine (extent shown in Figure 5.3). The sands ability to store and slowly release water supports woodland known as the Warkworth Sands Woodland. The fine grained sands are approximately 3 m thick and overlie a low permeability base of residual clay associated with the underlying strata. The low permeability clays reduce vertical flow of groundwater and result in the formation of a thin perched water table at the base of the sand mass. Cumberland Ecology (2014) noted species indicative of a persistent water table can be found in dune swales suggesting some groundwater permanence. The Warkworth Sands aquifer is considered to be perched above, and not directly connect to the regional water table.



LEGEND:

Monitoring Bores
- Standpipe
- VWP
- NOW Stream Gauge Station
- Fault
- Fold
- Watercourse
- Proposed MTO development consent boundary

Hunter Coalfields 100k Geology
- Qa - Quaternary Alluvium
- Jv - Jurassic Volcanics
- Rn - Hawkesbury Sandstone, Narrabeen G.
- Psl - Wollombi Coal Measures
- Pswj - Denman Fmt, Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pms - Muree Sandstone
- Pmb - Braxton Formation

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Geology and Monitoring Bores

AGE GROUNDWATER & ENVIRONMENT

DATE: 14/5/2014

FIGURE No: **5.1**

The Permian deposits occur as a regular layered westerly dipping sedimentary sequence. Coal seams currently mined at MTW include the Redbank Creek, Wambo, Whynot, Blakefield, Glen Munro, Woodlands Hill, Arrowfield, Bowfield, Warkworth and Mt Arthur Seams (Figure 5.2). Currently approved mining at MTO targets seams down to the Woodlands Hill. These seams vary in thickness from 0.3 m to more than 6 m. Groundwater usage from the Permian strata is limited by the generally brackish to saline nature of the groundwater and the low and variable yields.

Figure 5.3 shows an east to west schematic cross-section from the Hunter River through MTO and west to Wollombi Brook. The coal seams outcrop west of the Hunter river and dip steeply along the Mt Thorley Monocline that is located close to the outcrop area. The dip of the seams becomes more gentle within the mining area. The section shows the coal seams are more than 200 metres below the ground surface to the west where the alluvial sediments associated with Wollombi Brook occur.

The prime users of groundwater from the Permian strata are the underground mines in the area. MTW does not report any significant seepage into the pits due to a combination of low permeability formations, and because the evaporation rate generally exceeds the rate of seepage from the mine face. The hydrostratigraphic units of the Permian coal measures typically yield less than 5 L/s, and are therefore classified as 'less productive aquifers' according to the criteria set out in the Aquifer Interference Policy (AIP).

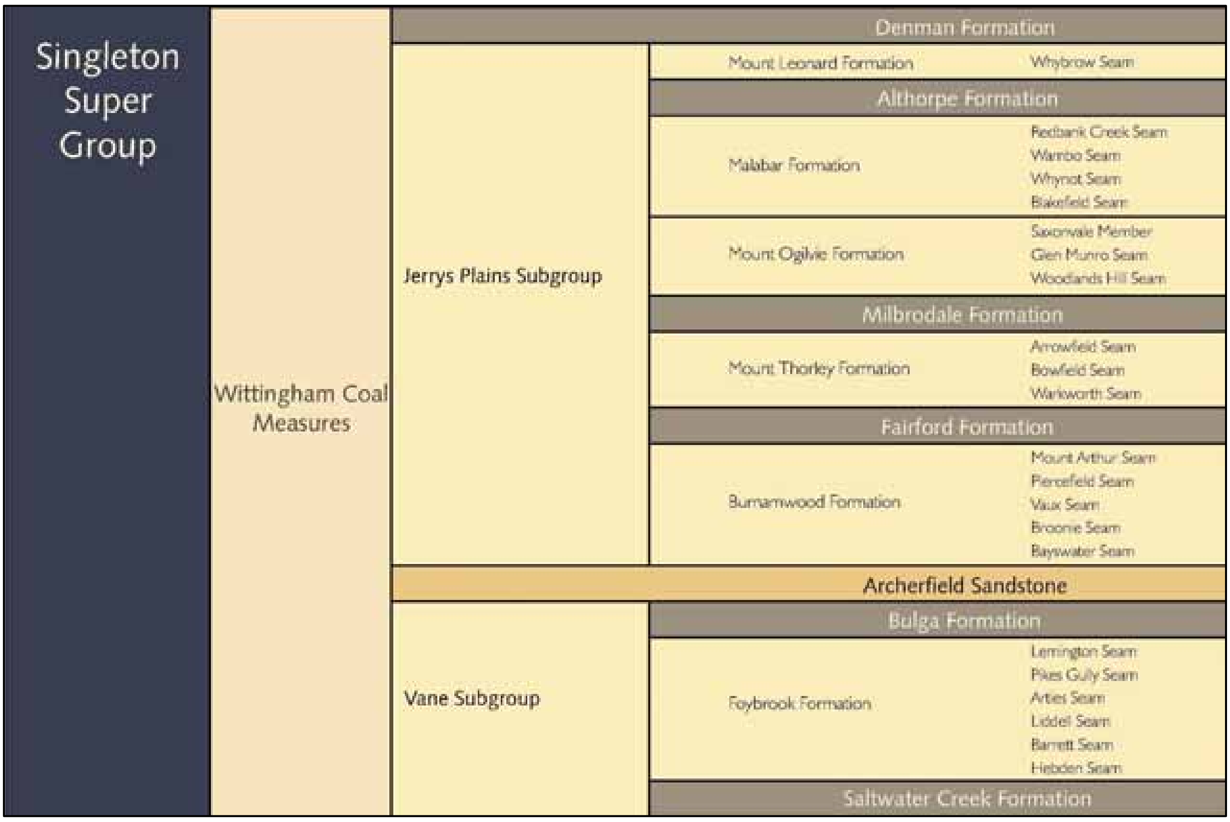
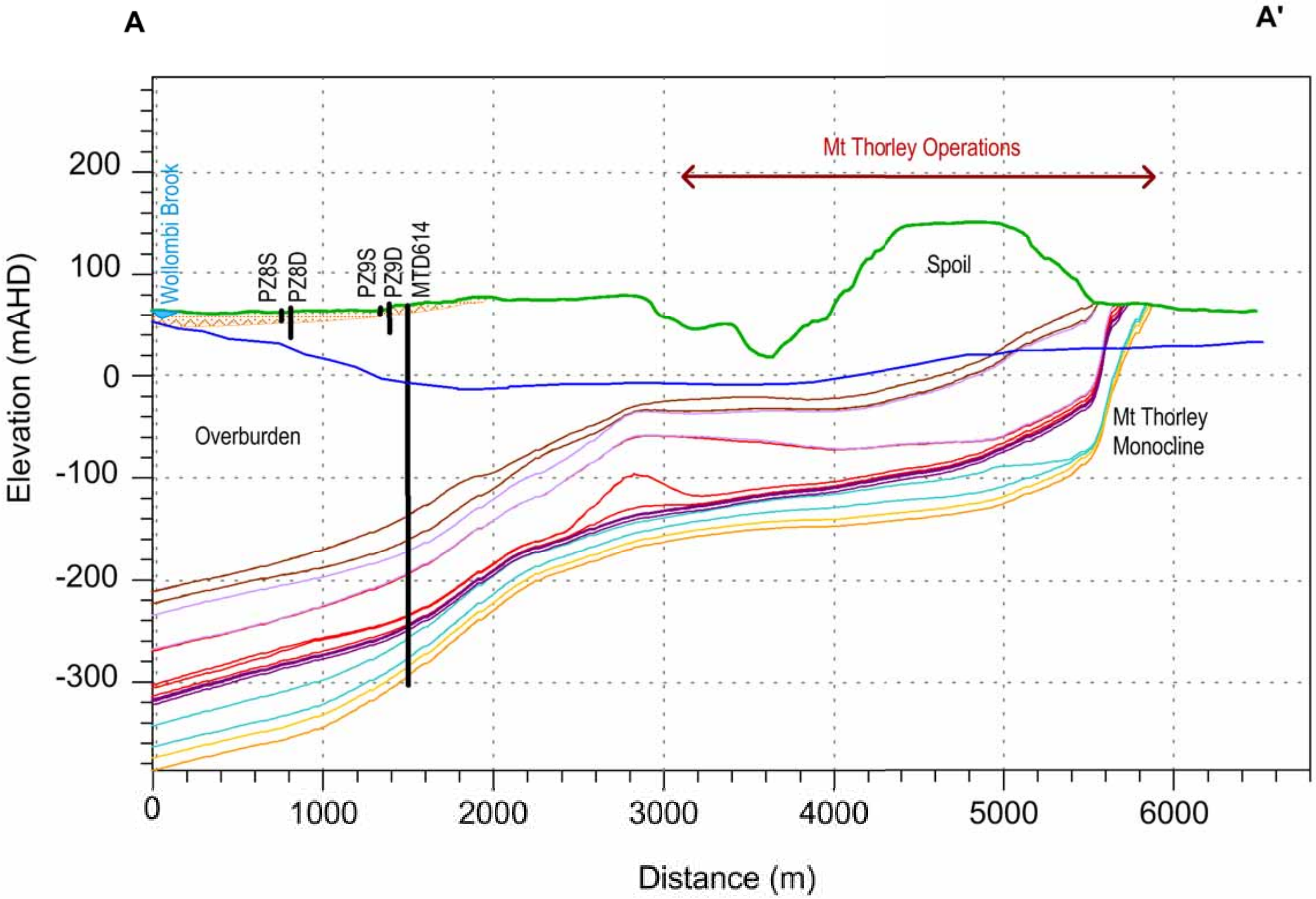
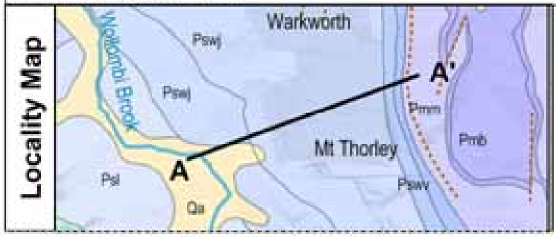


Figure 5.2: Stratigraphic column



(Vertical Exaggeration 1:6)



LEGEND:

- Inferred Permian Potentiometric Surface
- Alluvium
- Surface topography
- Arrowfield Seams
- Bowfield Seams
- Warkworth Seams
- Mt Arthur Seams
- Piercefield Seams
- Vaux Seams

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Hydrogeological Cross-Section
Mt Thorley (A-A')

DATE:
14/5/2014

FIGURE No:
5.3

5.2. Groundwater Monitoring

Water levels are routinely measured in a network of monitoring bores at MTW. Figure 5.4 shows the location of monitoring bores relative to an aerial photograph. The monitoring network comprises standpipe style PVC monitoring bores, and vibrating wire piezometers (VWPs). Temporal groundwater level data has been gathered via manual dipping of bores and via data loggers since 2003. Some sites have both monitoring bores and VWPs, which allows the study of hydraulic gradients between the alluvium and the Permian sequence, and also within the layered Permian strata and spoil.

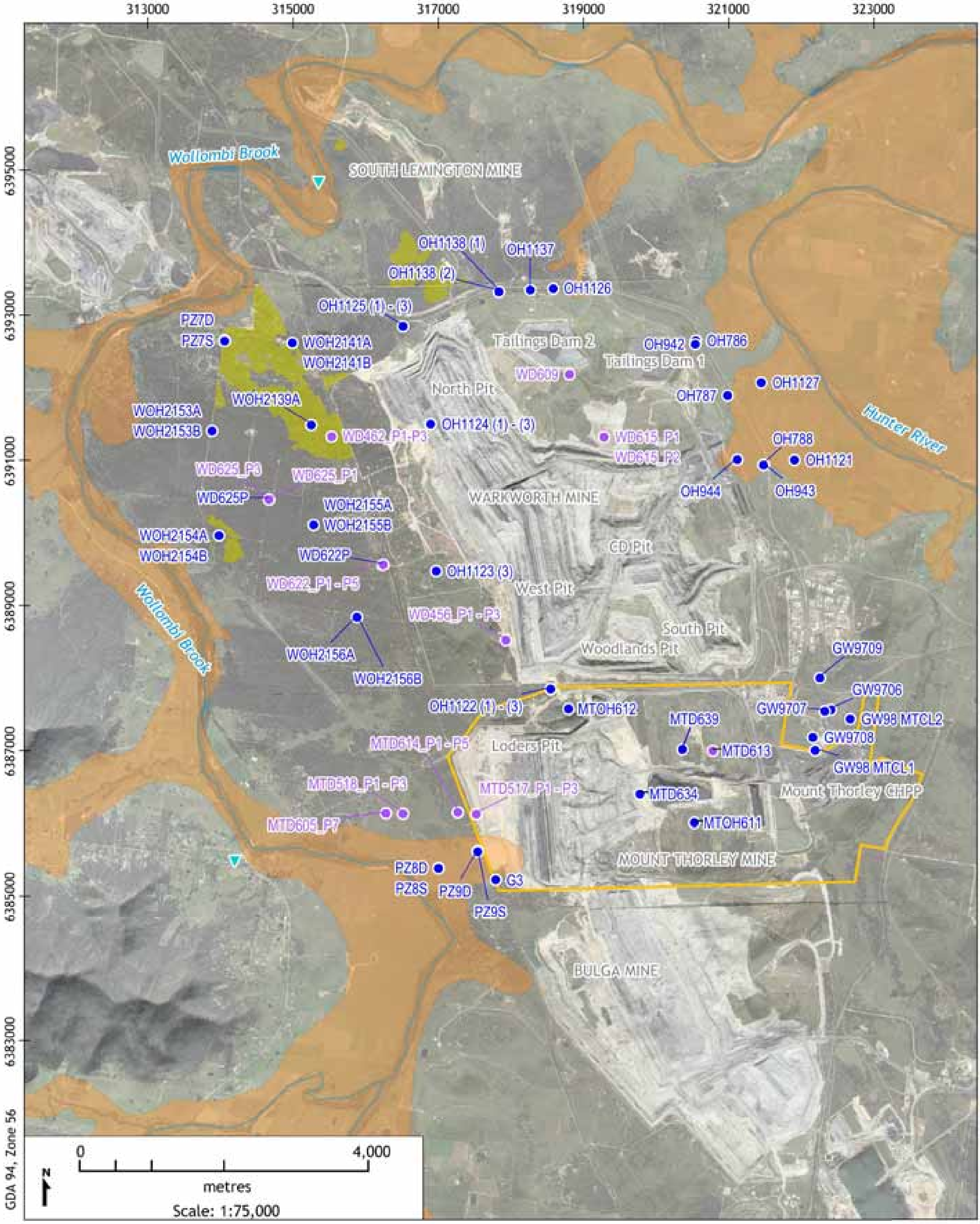
Monitoring bore construction details and recent groundwater levels are detailed under Appendix A.

5.3. Groundwater Levels

Monitoring from the network of bores surrounding the MTW open cut pits show mining is depressurising the coal seams to the west of the active face, resulting in declining water levels. Monitoring shows the water levels within the alluvium to date are unaffected by mining. Figure 5.5 shows the drawdown in the potentiometric surface within the Permian sequence in late 2013. The cumulative impact of mining is made evident by the flow of groundwater towards the active mine area. This outlines the importance of simulating the existing effects of mining at MTW and regionally appropriately in this study, to compare effects from this proposal.

Figure 5.5 includes an inset with estimated groundwater levels within the Loders Pit mine spoil. There is limited water level data for the spoils, and therefore data from geophysical logging (Neutron Log) of exploration holes were used to estimate the zone of saturation. The interpreted water levels indicate the spoils are saturated at the base and drain across the historical pit floor towards the open void in the west.

Figure 5.5 highlights the changes to the groundwater regime induced by mining. Prior to mining groundwater levels would have been expected to have been a subtle reflection of the topography, with gradients towards the west and Wollombi Brook. To the west of the MTO high-wall a series of nested monitoring bores and VWPs are present, which monitor both the multi-layered Permian strata and the Wollombi Brook alluvium. The monitoring network shows depressurisation is most significant in the Permian strata in close proximity to the active high-wall and decreases with distance to the west. The cumulative impacts of historical mining are addressed further throughout this report.



LEGEND:

Monitoring Bores

- Standpipe
- VWP
- NOW stream gauge station
- Alluvium (100k)
- Warkworth Sands Woodland
- Major watercourse
- Proposed MTO development consent boundary

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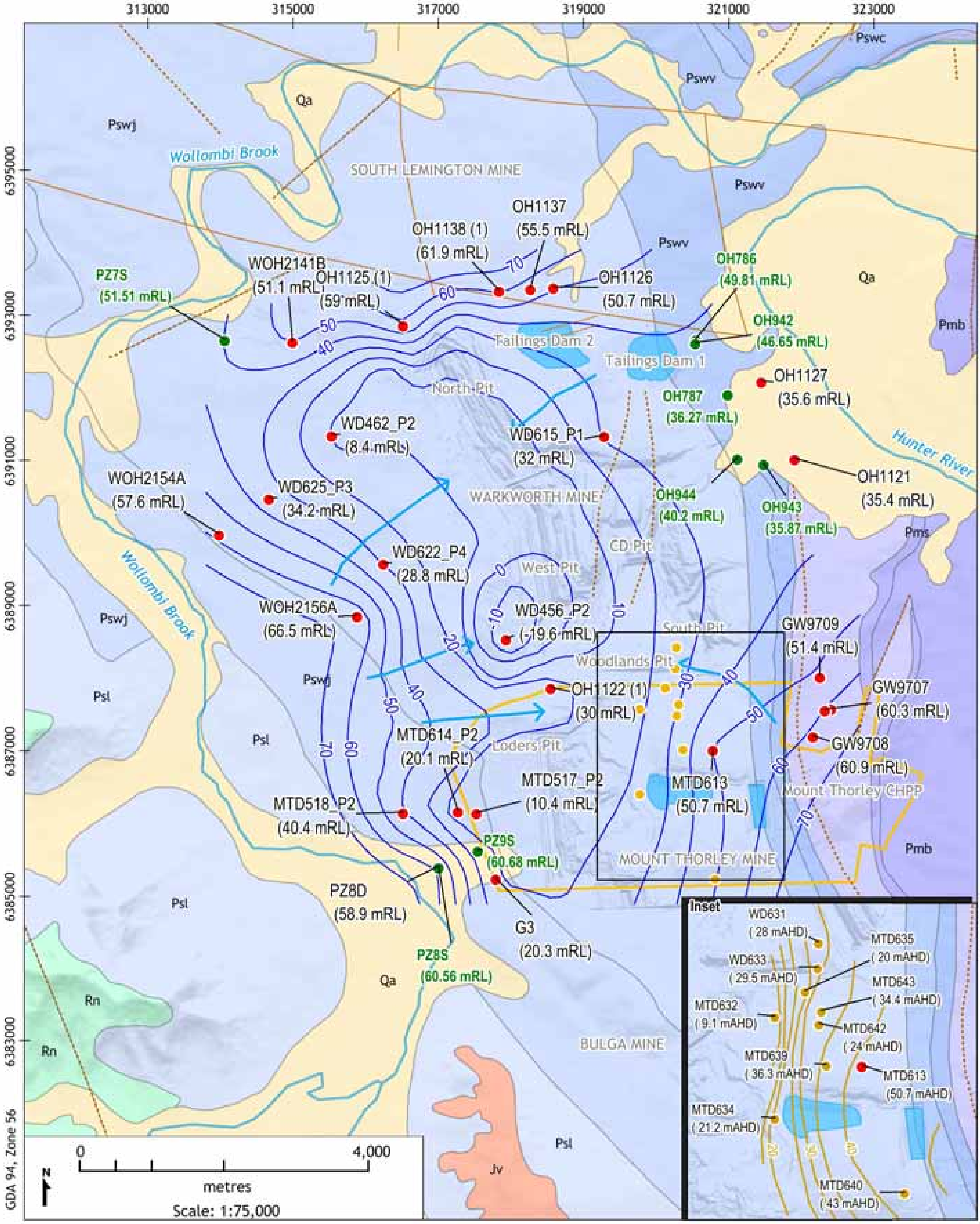
Air Photograph & Monitoring Bores

AGE GROUNDWATER & ENVIRONMENT

DATE: 14/5/2014

FIGURE No: 5.4



LEGEND:

- Proposed MTO development consent bounary
- Monitoring bore (alluvium - SWL mRL)
- Monitoring bore (Permian - SWL mRL)
- Monitoring/Exploration hole (spoil - SWL mRL)
- 10m Inferred Permian Groundwater Contour (RL - Sep/Oct 2013)
- Inferred groundwater flow direction
- 5m inferred spoil groundwater contours (mRL)
- Tailings storage facility
- Fault
- Fold

Hunter Coalfields 100k Geology

- Qa - Quaternary alluvium
- Jv - Jurassic Volcanics
- Rn - Hawkesbury Sandstone, Narrabeen G.
- Psl - Wollombi Coal Measures
- Pswj - Denman Fmt, Jerrys Plains Subgroup
- Pswv - Archerfield Ss., Vane Subgroup
- Pswc - Saltwater Creek Formation
- Pmm - Mulbring Siltstone
- Pms - Muree Sandstone
- Pmb - Braxton Formation

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Groundwater Contours and Groundwater Flow Directions

AGE
GROUNDWATER & ENVIRONMENTAL

DATE: 14/5/2014

FIGURE No: 5.5

The multi-level VWPs at site MTD517 monitor the Wambo Seam (P3), Woodlands Hill Seam (P2) and the Mt Arthur Seam (P1) directly west of the current Loders Pit at MTO. Site G3 monitors Wambo Seam to the south-west of Loders Pit. Piezometric levels for these sites are shown in Figure 5.6. The Woodlands Hills Seam is the base of open cut operations in the Loders Pit and Bulga Coal Complex, with the Warkworth pits mined to the lower Mt Arthur Seam. The downward trend in each of the three VWPs and the monitoring bore indicates depressurisation of the coal seams due to mining.

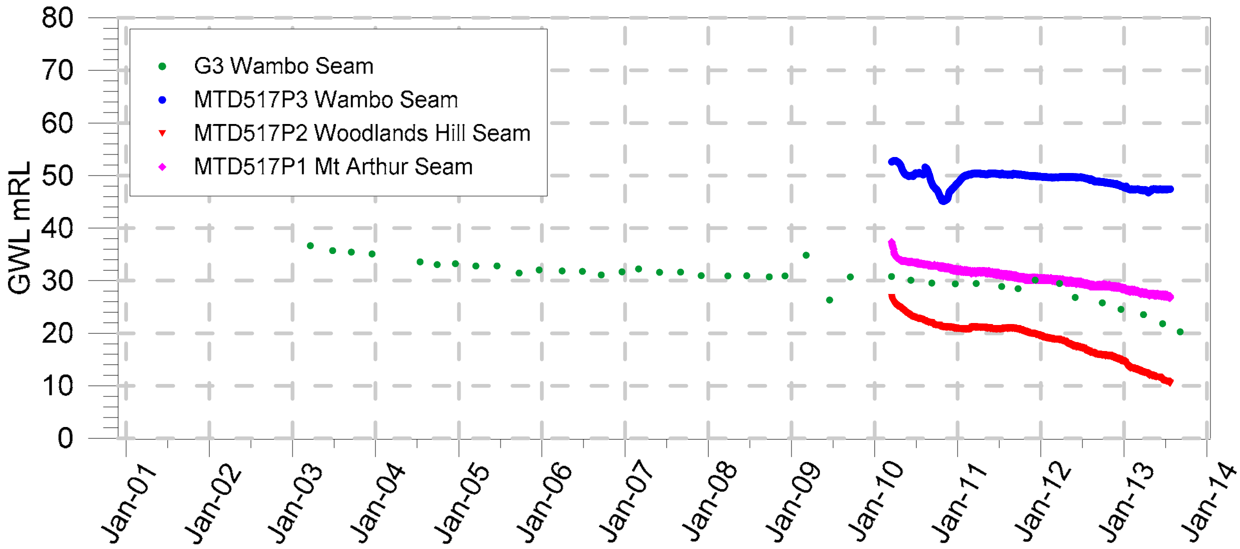


Figure 5.6: Groundwater levels within the Permian coal seams directly west of MTO

Other nested monitoring bores and VWPs within the Permian sequence located west of the proposal show similar downwards dewatering trends. The dewatering effects of mining reduce with distance westwards from the mined area. The low permeability of the Permian strata means the zone of depressurisation remains in relatively close proximity to the mining areas.

Figure 5.7 shows groundwater level data for nested monitoring bores within the Wollombi Alluvium (PZ9S) and underlying Permian overburden (PZ9D) west of MTO that were constructed in 2009.

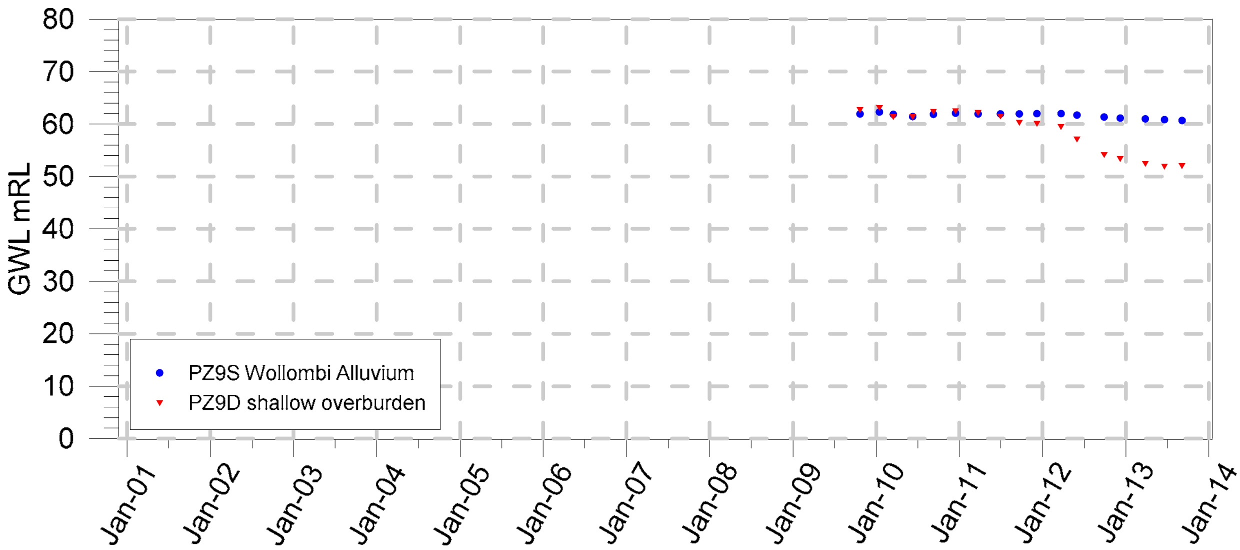


Figure 5.7: Groundwater levels within Wollombi Brook alluvium and overburden west of Loders Pit

The alluvial bore PZ9S shows relatively stable conditions with no impact of mine dewatering evident. The deeper bore PZ9D within overburden does show that drawdown associated with currently approved mining has increased the downward gradient within the overburden, resulting in a decline in groundwater levels. This drawdown in overburden was previously predicted under current approvals for MTO (Mackie Environmental Research, 2002).

Monitoring shows groundwater levels to the east of MTO are unaffected by depressurisation of the coal measures. The sub-crop of coal seams, and exposure of underlying low permeability sediments at surface between MTO and the Hunter River alluvium, prevents drawdown with the coal measures reaching the alluvium. Water levels in all the alluvial monitoring locations east of MTO recorded stable water levels fluctuating only in response to climatic conditions.

In summary, a long history of previous mining at MTO and Bulga Complex to the south have led to localised dewatering of the Permian strata down-dip (west) of the mine site. No drawdown to date has been detected in the Wollombi Brook alluvium. Drawdown to the east in the Hunter River is constrained by sub-crop of geological formations impeding depressurisation in an easterly direction.

5.4. Groundwater Gradients

Figure 5.5 shows the groundwater contours and generalised[1] flow directions of the Permian groundwater, which generally flow towards the active mine area.

Alluvial groundwater contours could not be interpolated due to the limited number of bores within these sediments. The alluvial groundwater levels however indicate a relatively flat groundwater gradient from the edge of the alluvium towards the main watercourse (i.e. Wollombi Brook and Hunter River). In addition, groundwater levels between the alluvium and Permian units appear to be similar beyond a certain distance away from mining activity. Also, alluvial groundwater levels are notably higher in elevation compared to Permian levels closer to the mine (e.g. PZ9S and G3). As discussed in Section 5.3, these results indicate that the current influence of mining on the potentiometric surface is localised in the Permian strata, with no detectable drawdown in the alluvium.

A number of nested monitoring bores and multi-level VWPs surrounding MTO permit the analysis of vertical hydraulic gradients between coal seams being mined and in some cases the underlying unmined coal seams.

West of the Loders Pit most of these sites show a downward gradient to the Woodlands Hill seam which is the base of current open cut operations. Downward gradients comprised of up to 40 m in head difference are noted. Heads from coal seams below the Woodlands Hill Seam tend to show upward gradients, inferring that unmined lower coal seams have not been depressurised extensively from current mining. The majority of the measured vertical hydraulic gradients are presumed to be caused from mining activities, although with no pre-mining data this cannot be confirmed.

5.5. Strata Permeability And Storage

Permeability has been investigated in several site specific studies at MTW and the neighbouring Bulga mine. AGC (1984) and Amoco Australia (1995a and 1995b) are two studies with permeability measurements for coal seams at the site. These studies and one by Mackie (2009) refer to a reduction of coal seam permeability with depth.

[1] The groundwater levels presented in this image are combined for the Permian sequence, where there was more than one coal seam monitored at a given location the lowest value was used to generate the groundwater level surface. Hence this surface presents the 2013 generalised hydraulic gradient in the Permian.

In addition, as documented by AGE (2010), a monitoring bore drill program was undertaken to construct monitoring bores at three sites in the Wollombi Brook alluvial plain. At each site separate monitoring bores were constructed in the alluvial sediments (PZ7S, PZ8S and PZ9S) and underlying coal measures and overburden (PZ7D, PZ8D and PZ9D). As a part of the investigation permeability tests were conducted, with the results summarised in Table 5.1.

Table 5.1: FALLING HEAD TEST RESULTS			
Bore ID	**Strata**	**Hydraulic Conductivity**	
		m/sec	**m/day**
PZ7S	Alluvium	3.4×10^{-6}	0.3
PZ8S		1.9×10^{-5}	1.6
PZ9S		2.8×10^{-6}	0.2
PZ7D	Bedrock	1.2×10^{-6}	0.1
PZ8D		-	-
PZ9D		1.1×10^{-6}	0.1

The results show that the hydraulic conductivity within the alluvium is highly heterogeneous, due to the depositional environment. The hydraulic conductivity measured in the Permian stratigraphy was anomalously high, and may have been due to the shallow nature of these boreholes and weathering in the Permian strata.

In addition to the AGE (2010) field investigation, a recent field investigation by Golder (2013) near the study area has provided a number of new results from borehole hydraulic (packer) testing.

Figure 5.8 presents the available data for Permian coal seam hydraulic conductivity versus depth from previous groundwater assessments mentioned in this section.

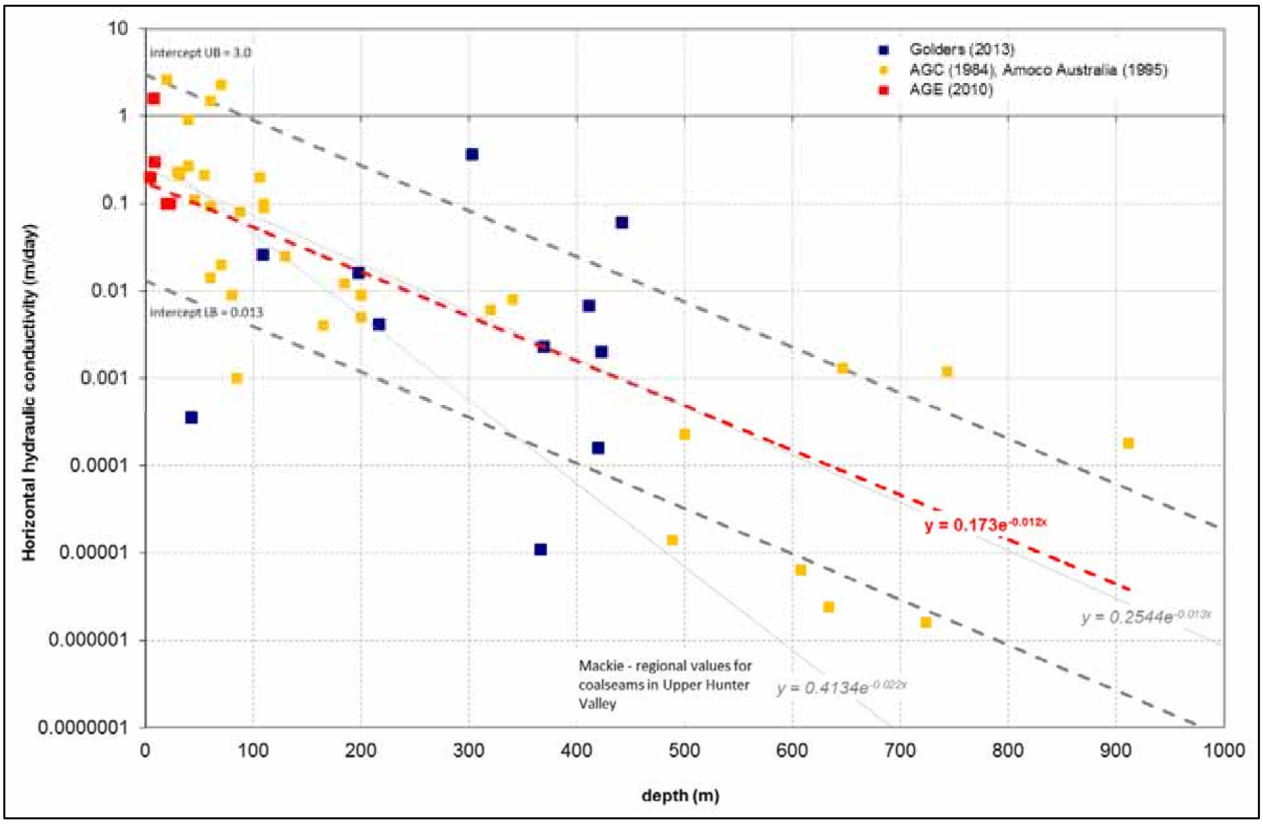


Figure 5.8: Change of hydraulic conductivity with depth in coal seams

Figure 5.8, shows a correlation between depth and declining hydraulic conductivity. The red dotted line shows the best fit through this data, and is similar to that presented by AGE (2010).

Data for hydraulic conductivity of the interburden and overburden is limited. The horizontal hydraulic conductivity of interburden is generally considered at least one, and sometimes several orders of magnitude less permeable than the coal seams.

No site specific data is available for storage properties of local stratigraphy. Mackie (2009) estimated specific storage for the Hunter Region using Young's modulus, and results ranged between 1×10^{-4} and 3×10^{-6} (1/m). These results are based on similar stratigraphy to the proposal area, and are therefore considered applicable to this study.

5.6. Recharge

Recharge to the Permian coal measures can occur where coal seams outcrop or sub-crop close to the surface. Recharge to the alluvium occurs via rainfall infiltration through the unsaturated zone, hill slope runoff and leakage from rivers and streams when and where the surface water levels are above the water table in the alluvium.

Experience in similar studies at MTW (AGE 2010) and within the Hunter Valley suggest recharge to the Permian coal measures is low, typically below 1% of annual rainfall. Recharge to alluvium is around 10% of rainfall, however, this varies based on alluvial composition.

5.7. Discharge

5.7.1. Discharge Processes

Natural discharge processes in the system are via groundwater flow into water courses as baseflow when the water table in the adjacent groundwater system is higher than either the stream bed or the water levels in the stream channel. It also includes groundwater inflow into mining zones, disposal and/or evaporation., groundwater use by private landholders and evapotranspiration where the water table is within the root zone of plants and trees.

5.7.2. Baseflow

As detailed in Section 4.2, a review of surface water flows and climatic conditions indicates groundwater may contribute to baseflow in Wollombi Brook. The proportion of groundwater in steam flow would tend to increase during times of low flow. Figure 5.9 below compares Wollombi Brook levels to rainfall and groundwater levels within the associated alluvium (PZ7S, PZ8S and PZ9S) and the underlying Permian stratigraphy (PZ8D and PZ9D).

It can be seen in Figure 5.9 that groundwater trends within the alluvium do not respond to rapid changes in stream levels. Water levels suggest the alluvium discharges to the stream predominantly, rather than the stream recharging the alluvium. A rapid decline in groundwater levels in June 2013 is visible for PZ8D, which is believed to relate to groundwater sampling. The bore was likely purged during the round of sampling, and the low hydraulic conductivity resulted in a slow rate of groundwater level recovery.

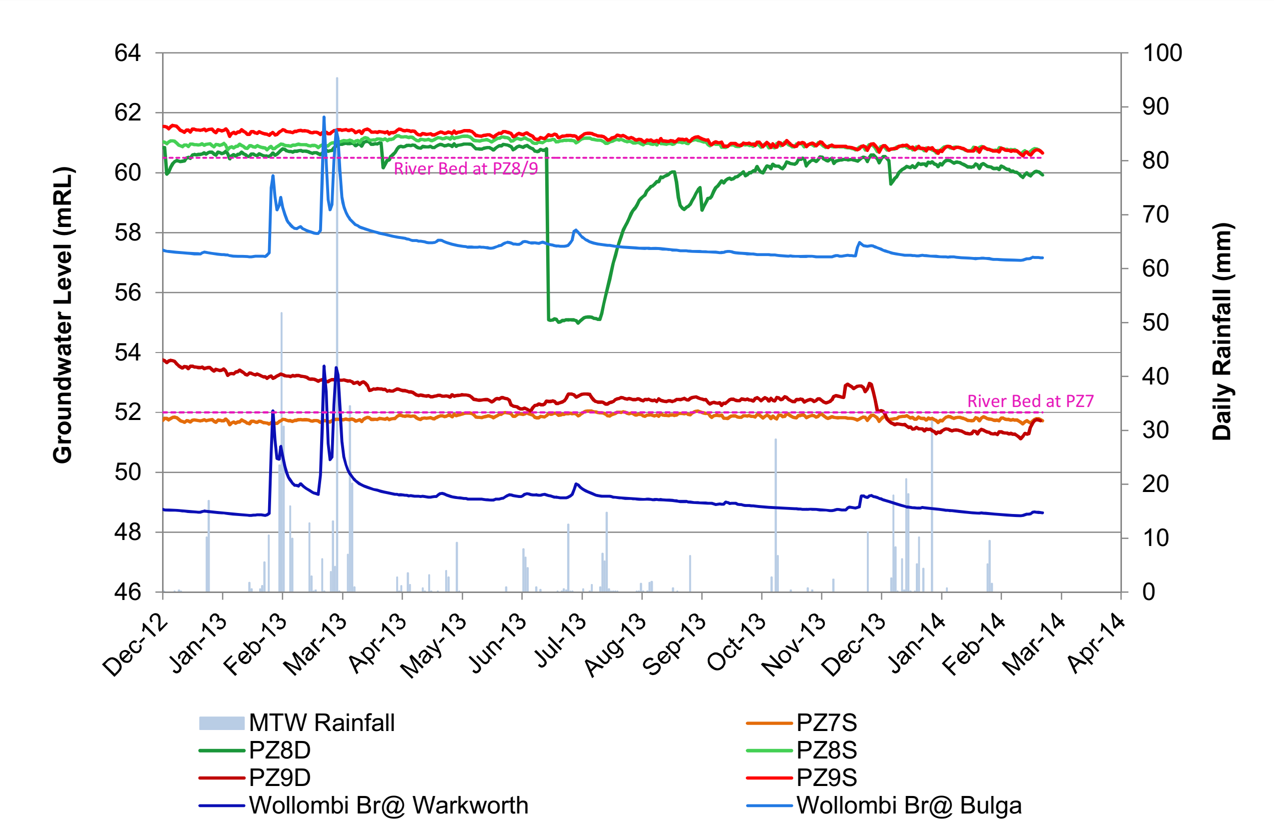


Figure 5.9: Baseflow Assessment for Wollombi Brook

As bores PZ8 and PZ9 (S and D) are located approximately 2.5 km upstream of Station 210028 (Bulga), and bore PZ7S is located over 3 km upstream of Station 210004 (Warkworth), the river bed elevations next to the bore sites were estimated using LIDAR data. Within the PZ8/PZ9 area the river bed level is approximately 60.5 mRL, and within the PZ7 area the river bed level is approximately 52 mRL. Based on these river bed elevations, Wollombi Brook within the PZ8/9 area appears to be a gaining system. However, at the downstream PZ7 site the groundwater levels are close to or slightly below river levels, indicating a slightly losing stream system where the alluvium is potentially recharged by Wollombi Brook. This is supported by water quality results, with brackish water quality within the alluvium at PZ7S, compared to the naturally saline water quality at PZ8S and PZ9S (see Section 5.8).

5.8. Water Quality

Groundwater quality has been measured at MTW since 1993. Appendix B summaries the water quality data and includes the median, 5th percentile and 95th percentile for each bore for the following parameters:

- pH - laboratory data from 1993 to 2002 and field data from 2002 to 2013;
- electrical conductivity (EC) - laboratory data from 1993 to 2002 and field data from 2002 to 2013; and
- major ions (calcium, magnesium, potassium, sulphate, phosphate and sodium).

The results show a degree of variability within and between each stratigraphic unit. The alluvium records from both the Hunter River and Wollombi Brook alluvium show relatively saline water quality, while the underlying Redbank Creek Seam generally records moderately saline groundwater. The deeper coal seams (i.e. Blakefield, Woodlands Hill, Bowfield, Warkworth, Vaux and Bayswater seams) also record saline groundwater. Results for the Wollombi Brook, presented by WRM (2014a), show slightly brackish water quality.

Figure 5.10 shows a Schoeller plot for the alluvium and Permian stratigraphy, based on historic (1993 – 2013) water quality data collected at MTW. Figure 5.10 also shows Wollombi Brook median water quality data (collected by WRM, 2014a) and recent (20/2/2014) spoil water quality data collected by AGE from bore MTO634[2].

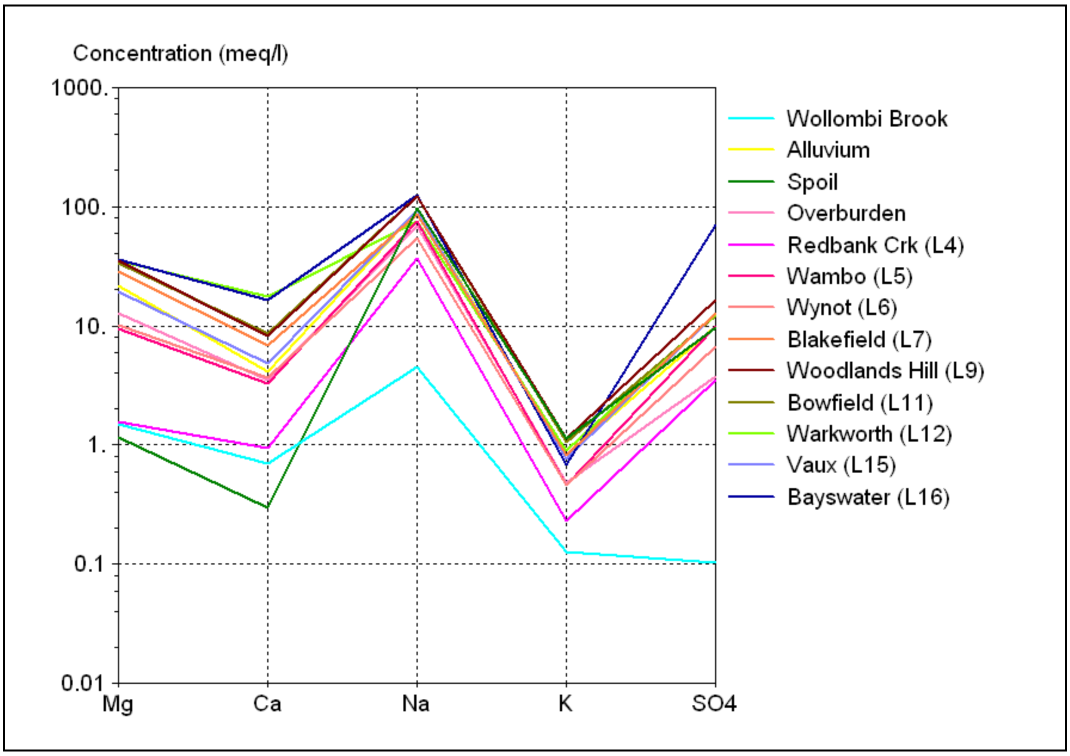


Figure 5.10: Schoeller plot of typical alluvium or seam chemistry

The Schoeller diagram compares chemistry from different samples; similar shaped lines from multiple samples indicate a similarity in origin and vertical displacement of similar lines indicates dilution with fresh water (resulting in downward shift in the line) or concentration/evaporation (resulting in an upward shift).

Figure 5.10 shows that, as expected, the Wollombi Brook has the lowest ion concentrations whilst the deeper Permian coal seams have the highest. The Permian samples have a similar signature indicating similar groundwater provenance. The samples from the spoil show lower concentrations of Mg and Ca compared to the Permian units, indicating potential dilution from rainfall recharge through the more porous spoil material.

5.9. Groundwater Users

AGE (2010) assessed groundwater usage from the groundwater systems by reviewing data held on the NSW Government groundwater database, and by conducting a bore census on private landholdings to the west of the mine. It was also identified during the bore census that bore GW44529 (shown in Figure 5.11) is abandoned, bores GW017462 and GW066590 are located on land owned by MTW, and bore GW080964 is a NOW groundwater monitoring bore.

[2] MTO634 was completed in late 2013 directly downgradient of the CRTSF in MTO, the bore was sampled in early 2014.

During the bore census ten bores were visited to the north of the village of Bulga, locations of the bores are shown in Figure 5.11 and findings are detailed in Table 5.2. The census found that nine of the 10 sites were relatively shallow, at about 14 m or less in depth, indicating that these bores are likely to be constructed in the alluvial sediments. Three bores with a depth greater than 60 m are probably constructed in the underlying bedrock. Comparison of the registered bore details and the bore census findings indicates that two of the registered bores were not identified in the field and may be abandoned or destroyed. Four additional bores were also identified, which are likely not registered.

An updated search of the NSW Government 2013 version of PINEENA groundwater database outlined no new bores within the study area since 2010.

Table 5.2: AGE (2010) LANDHOLDER SURVEY FINDINGS

Registered Number	AGE (2010) census ID	Depth (mbgl)	Easting	Northing	Owner
GW047667	112-W	9.25	313729	6386469	Laurie & Rhonda Caban
GW078782	128-B	12.15	313408	6386512	Laurie & Rhonda Caban
GW078806	140-W	2.84	313439	6386593	Greg Caban
GW065097	177-W	11.85	313073	6386604	Greg Banks
GW078031	248-B	11.65	313298	6387553	Paul Dunn & Susan Irwin
GW078029	89-B	23.62	313446	6386014	Ian & Annette Bartholomew
Not identified in the field survey					
GW066607	-	6.7†	313269‡	6386399‡	-
GW071569	-	14.6†	313169‡	6387568‡	-
No identifiable registration number					
	138-W	11.82	312996	6386427	Greg Banks
-	217-B	100	313234	6387612	George & Honor Lianos
-	217-W	60	313228	6387595	George & Honor Lianos
-	129-W	100	313233	6386442	Damien & Danielle Hanson

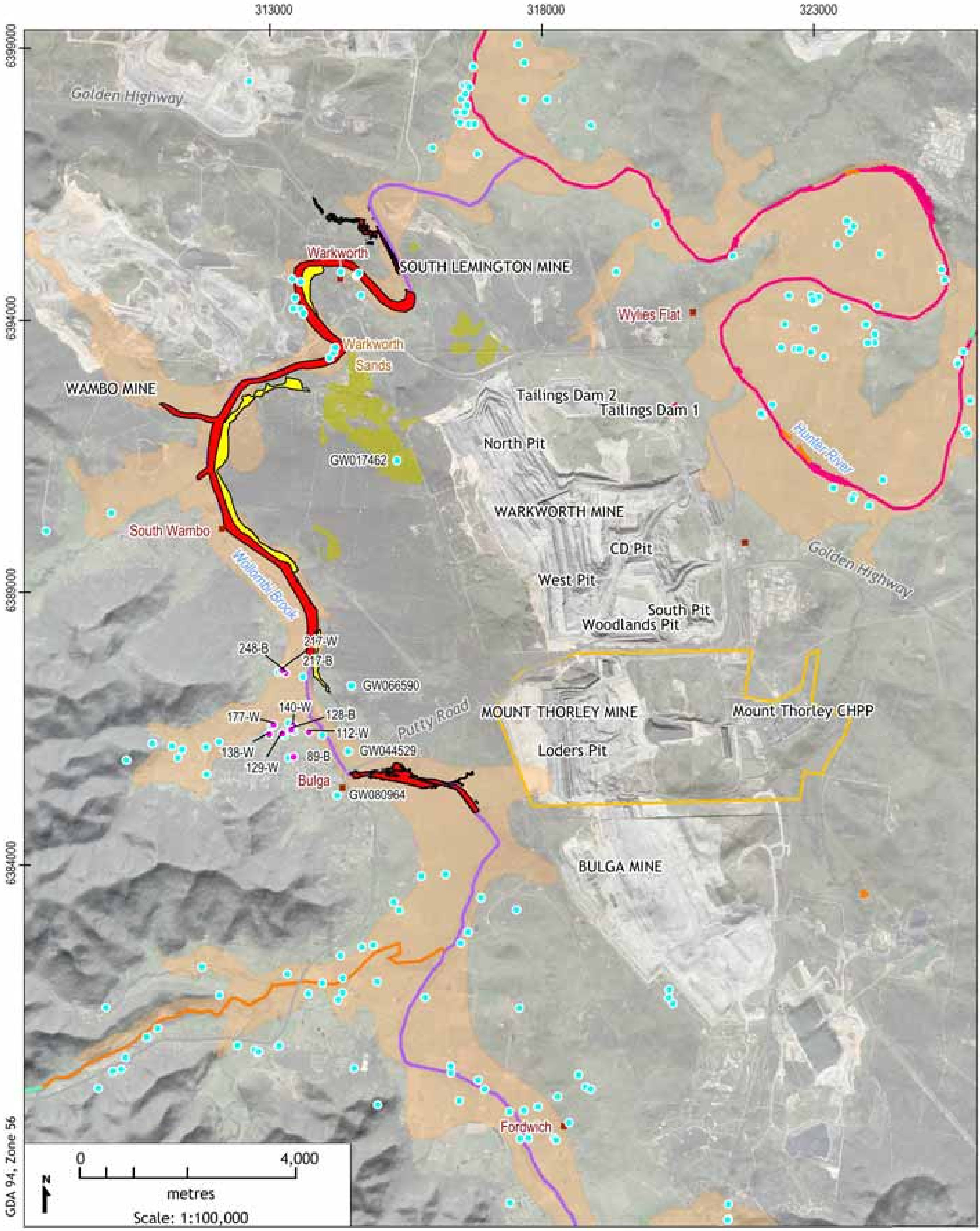
Note: *Coordinates in MGA 94 Zone 56 (field data collected from handheld GPS)*
† Depth from groundwater database (PINEENA)
‡ Coordinates from groundwater database (PINEENA)

5.10. Groundwater Dependent Ecosystems

Aquatic or specifically Groundwater Dependent Ecosystems (GDEs) are defined as *“communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater”*. The Project area has historically been partially cleared of vegetation and used for grazing; however, the southern portion of the Project area remains largely vegetated.

The Federal Government has established the National Atlas of GDEs (GDE Atlas), based on the current knowledge of GDEs across Australia. The atlas shows known GDEs and ecosystems that potentially use groundwater, and is considered the most comprehensive inventory of the location and characteristics of GDEs in Australia. The GDE Atlas (Figure 5.11) shows that are known GDEs identified by previous fieldwork along Wollombi Brook. There are also areas identified as having a moderate to high potential for groundwater interaction.

Cumberland Ecology (2010) identified two potentially groundwater dependent vegetation communities along Wollombi Brook. These were the Hunter Valley River Oak Forest and the River Red Gum Floodplain Woodland which are in a thin riparian zone along Wollombi Brook about 4 km from the mining areas, as shown in Figure 5.11.



LEGEND:

- Proposed MTO development consent boundary
- Private Bore (Pineena 2013)
- Bore Census (AGE 2010)
- Road
- Warkworth Sands Woodland
- Alluvium
- Place Name

GDE Atlas - Surface Expression

- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction
- Identified in previous study: fieldwork

Potential Groundwater Dependent Ecosystems

- Hunter Valley River Oak Forest
- River Red Gum Floodplain Woodland

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Groundwater Users and GDEs

DATE: 14/5/2014

FIGURE No: 5.11

6 POLICY AND LICENSING REQUIREMENTS

Groundwater associated with coal measures is governed under the (NSW) *Water Act 1912* (Water Act), while the NSW *Water Management Act 2000* (WM Act) regulates the use and interference with surface water and alluvial groundwater in the region.

6.1. Water Act 1912

The Water Act governs water licences from water sources including rivers, lakes and groundwater aquifers in NSW. It also manages the trade of water licences and allocations. The Water Act is progressively being replaced by the WM Act, with water sharing plans in place, except for Permian groundwater sources.

6.2. Water Management Act 2000

The objectives of the WM Act include the sustainable and integrated management of the State's water for the benefit of both present and future generations. The WM Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for three types of approvals:

- *Management works approvals:*
    - water supply work approval;
    - drainable work approval; and
    - flood work approval (Section 90 WM Act)
- *Water use approval – which authorises the use of water at a specified location for a particular purpose, for up to 10 years (Section 89 WM Act);*
- *Activity approvals comprising:*
    - controlled activity approval; and
    - aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer such as approval for activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years (Section 91 WM Act).

The proposal relates to an amendment to mine scheduling, and does not include any new disturbance areas. However, this groundwater assessment addresses the potential impact of a more prolonged mine schedule on the groundwater regime.

6.2.1. Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources

The main tool in the WM Act 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. The Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources (henceforth referred to as the Water Sharing Plan) commenced on 1 August 2009. The Water Sharing Plan includes the Hunter unregulated rivers and creeks, the highly connected alluvial groundwater above the tidal limit, and tidal pool areas. A licence holder's access to water is managed in the water sharing plan through the long-term average annual extraction limit which sets the total annual extraction rate through daily access rules.

The long term limit is a management tool against which total extraction will be monitored and managed over the 10-year life of the plan. The rules in the plan that determine when licence holders can and cannot pump on a daily basis are more specific. Basic landholder rights do not require a water access licence. However, water access licences are required for mining activities where these activities intercept an unregulated river or connected aquifer water.

6.3. Aquifer Interference Policy

In September 2012 NOW released the AIP, which covers water licensing and assessment processes for aquifer interference activities within NSW. The AIP addresses the 'incidental' take of groundwater from significant developments such as mines, which is not accounted for in the Water Act or WM Act. The AIP ensures that all take of groundwater is accounted for, to ensure Water Sharing Plans function effectively.

The AIP forms the basis for assessment of aquifer interference activities under the EP&A Act. It clarifies the need to hold water licences under the WM Act and Water Act and establishes whether 'minimal impact' occurs. The policy addresses any activity which involves any of the following:

- penetration of an aquifer;
- interference with water in an aquifer;
- obstruction of the flow of water in an aquifer;
- taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and
- disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

The AIP outlines highly productive and less productive groundwater sources, as well as high and minimal impact interference activities. The alluvial aquifers associated with Wollombi Brook and the Hunter River are both potentially highly productive aquifers, while low permeability units and saline groundwater within the Permian coal measures are classed as a less productive groundwater source. Section 7 addresses the key groundwater related requirements of the AIP processes.

7 MODELLING APPROACH

A numerical groundwater flow model was used to assess the potential influences of the proposal on the groundwater regime. The impacts of the proposed mining are described in this section, with the technical details on the modelling included in Appendix C.

In summary, the potential influences were assessed by:

- developing a numerical model using the available information on the hydrogeological regime (refer Section 0);
- calibrating the model using available historical mine stresses at MTW, Bulga and Wambo (1980 to 2013), groundwater levels and stream flows recorded in the area (refer Appendix C);
- assessing the uncertainty and variability in the calibration by running multiple models with randomly generated parameters held within measured and realistic bounds (refer Appendix D);
- simulating the drawdown and water take of the proposed mining from 2015 to the end of 2035;
- assessing the uncertainty and variance in the predictions (refer Appendix D); and
- simulating recovery of the groundwater system after mine decommissioning for an additional 1000 years.

The impacts of the proposal were simulated by running the following two modelling scenarios:

1. The first model included all the mining associated with the proposal, being continued mining of Loders and Abbey Green North Pits, and all other mining activities within the model domain; and
2. The second model included all surrounding mining (Warkworth, Bulga and Wambo mines), but excluded the mining operations associated with the proposal.

The model addresses the requirements of the NSW AIP by estimating the:

- volume of water inflow from the Permian strata and coal seams;
- drawdown induced in the Permian strata and coal seams;
- potential for drawdown and groundwater extracted from alluvial aquifers;
- potential for changes in baseflow to Wollombi Brook and the Hunter River;
- potential drawdown of groundwater levels in surrounding private landholder bores; and
- changes in groundwater salinity.

Recent water level data has been collected from the MTW groundwater monitoring network, as well as from new bores installed since the original model by AGE (2010). This data was utilised to gain a good understanding of the groundwater regime within the proposal area, which is detailed under Section 5. The numerical model has been refined based on this newly collected data, and from peer and independent reviews, creating a robust representation of the local groundwater regime.

As the groundwater regime has been highly modified by mining activities, the model was first used to simulate the approved and historical mining. This then provided the appropriate antecedent conditions prior to the assessment of the current proposal.

Dr Frans Kalf reviewed the modelling work a key stages during the project, and reported on the applicability of the modelling.

7.1. Numerical Model Development

A numerical model using the MODFLOW SURFACT software was developed to assess the impact of the proposed mining on the groundwater regime. The model developed by AGE (2010) formed the basis of the numerical model, but a number of changes were implemented to improve the predictive capability of the model including:

- representing the gradual development and recharge process through the spoil piles;
- adding the existing and proposed tailings storage facilities;
- increasing the number of layers to better represent the coal seams and interburden units; and
- conducting a transient calibration using water level data from the monitoring bore/VWP network.

The 16 layer model simulates the key features in the local groundwater regime including the alluvium associated with Wollombi Brook and the Hunter River, the layered interburden and coal seams of the Permian coal measures, as well as the underlying and unmined Permian coal seams. The active model domain, shown in Figure 7.2, covers an area of approximately 344 km^2 and is approximately 19 km (from west to east) and 24 km (from north to south). The model domain encompasses MTW, as well as the Bulga and Wambo mines. Further details regarding the model construction and design are included in Appendix C.

7.2. Numerical Model Calibration

Appendix C describes the calibration of the model in detail. The appendix provides sufficient information to assess the model performance against the Australian Modelling Guidelines (Barnett *et al* 2012). The model was first calibrated manually by adjusting model parameters and then using software to optimise the calibration. Parameters adjusted during the calibration were intentionally constrained within logical bounds, which in some cases came at the expense of a better statistical fit between model and observed groundwater level data.

The calibrated steady state model simulated as close as possible pre-mining water levels. The water levels generated by this model were then used as the initial conditions for a transient calibration. The transient model simulated the currently approved mining at MTW, Bulga and Wambo for the period 1981 to 2013. The model divided this baseline period into annual stress periods with mines advancing in annual blocks. Recharge to the model was applied as a percentage of annual measured rainfall distributed over zones representing the outcropping alluvium, Permian regolith and emplaced spoil areas. The model represented perennial rivers/streams (using the SURFACT ‘River’ package) with a constant head set in rivers and ephemeral streams as drains (also using the SURFACT ‘River’ package).

Appendix C describes in more detail the model set-up, set-up, calibration process and uncertainty analysis. Figure C-11 to Figure C-21 within Appendix C present modelled versus observed water levels for all monitoring bore/VWP sites. Several of the data points presented in these figures were excluded from the calibration process as they appeared in error compared to surrounding data and the conceptualisation. However, for completeness all data supplied by Coal & Allied for the study area has been included in these graphs. Appendix C further discusses the excluded datasets.

7.2.1. Steady State Calibration

The objective of the steady state model calibration was to simulate pre-mining groundwater levels, and to capture natural background conditions for the alluvial aquifer. The groundwater model was calibrated by adjusting aquifer parameters and stresses, within conceptual bounds, to produce the best match between the observed and simulated water levels and fluxes. Figure 7.1 shows the modelled-versus-observed scatter plot for the steady state run.

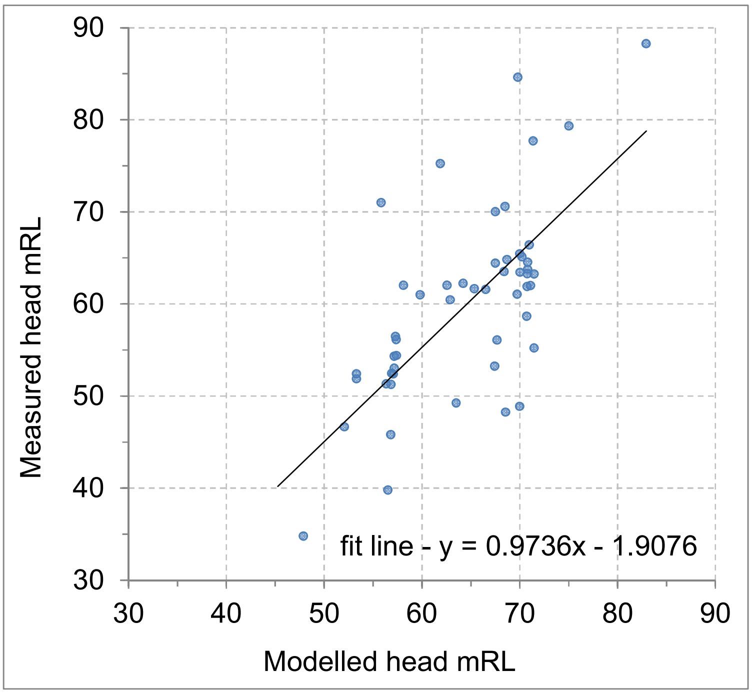


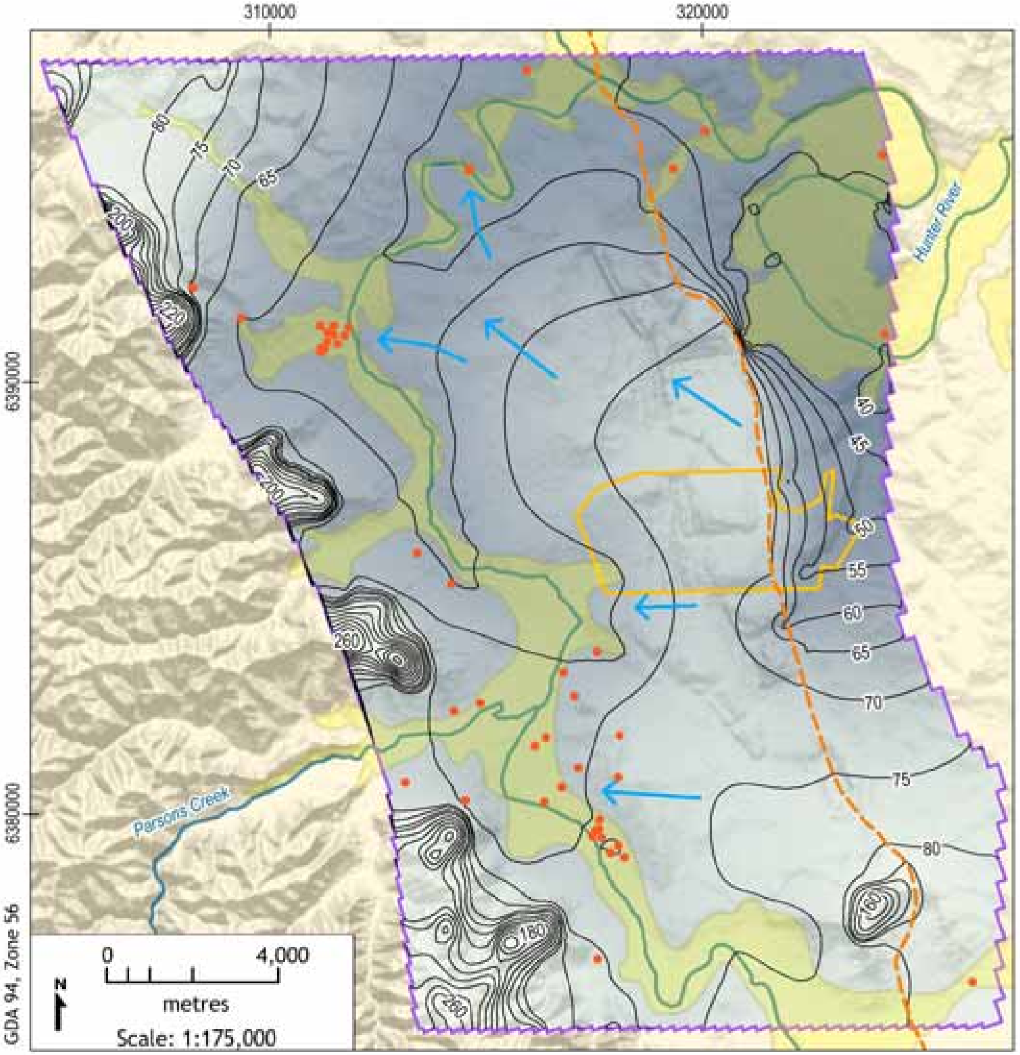
Figure 7.1: Steady state scatter diagram

Whilst the measured and simulated water levels do not correlate perfectly, it is important to note the steady state calibration was only used to setup a stable starting water level for the pre-mining period. The suitability of much of the data to adequately represent pre-mining conditions is not known. The calibration process therefore put limited weighting on fitting these points.

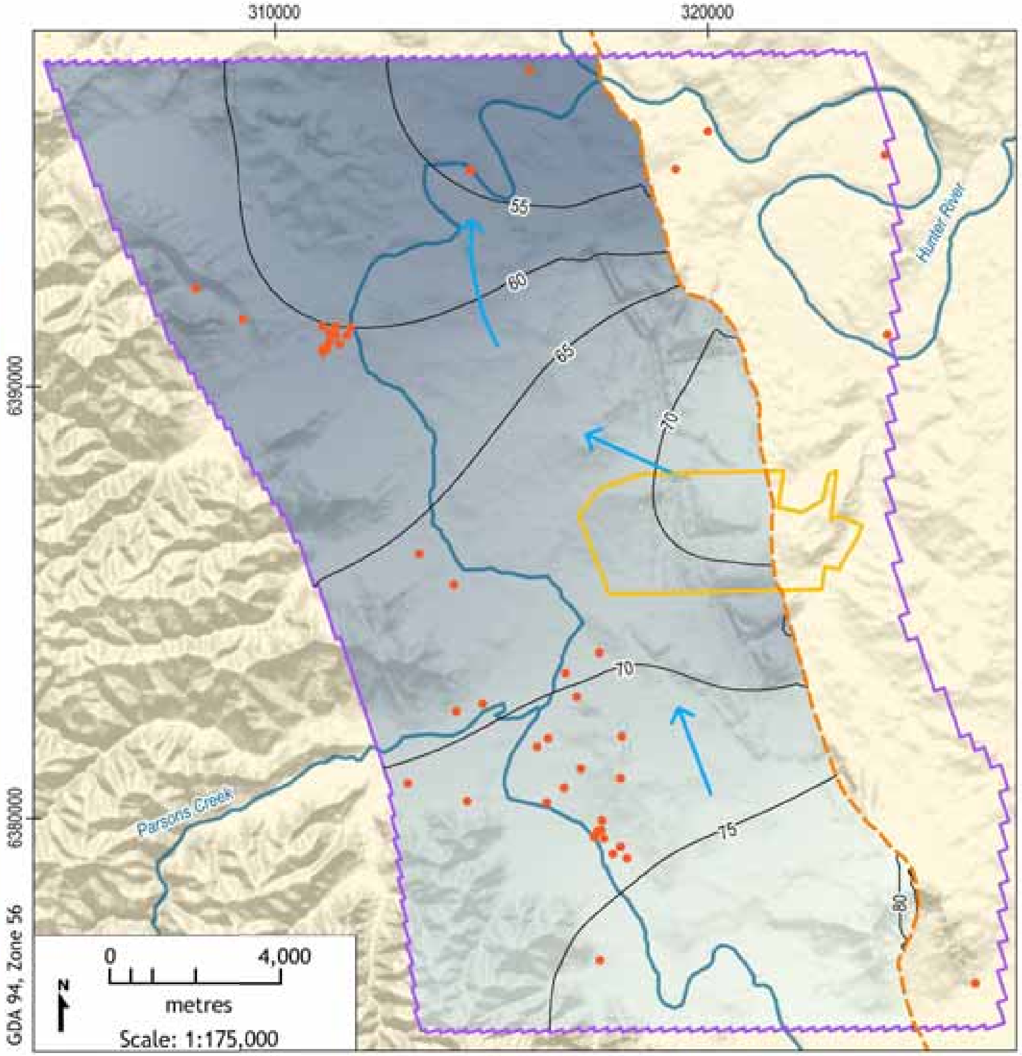
Figure 7.2 shows the simulated steady state pre-mining water levels in model Layer 1 and Layer 13. The Layer 1 water levels are a smoothed reflection of topography in the region. A topographic high between MTW and Wollombi Brook is present with water levels reaching 65 mRL. The potentiometric surface within the confined coal sequence shows that groundwater flow is in a generally northerly direction.

The root mean square (RMS) of the steady state model is 9.16 m while the scaled root mean square (SRMS) is 15.7%. This exceeds the 10% suggested by the Australian Modelling Guidelines (Barnett *et al* 2012). However, this steady state calibration is considered adequate given the lack of pre-mining groundwater level data, and an extensive history of mining within the region. The suitability of the model predictions is also further assessed through transient calibration, which provides further measure of the model predictions versus measured groundwater levels.

Steady State Heads - Layer 1 - Alluvium and Regolith



Steady State Heads - Layer 13 - Mount Arthur Seam



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Quaternary alluvium (100k)
- Subcrop of Jerrys Plains Formation
- Steady state observation bore
- Groundwater level contour
- Inferred groundwater flow direction
- Major watercourse

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Steady State Heads
Start of Transient Calibration
Layer 1 and Layer 13

DATE:
14/5/2014

FIGURE No:
7.2

7.2.2. Transient Calibration

The hydraulic heads and strata hydraulic properties from the manual steady state calibration provided the starting values for the transient calibration of the model. The steady state calibration was used to establish pre-mining groundwater conditions (to 1980), while the transient calibration was used to establish current groundwater conditions since mining commenced in 1981 until 2014.

Figure 7.3 shows a modelled versus observed transient scatter plot for the transient calibration. Figure 7.4 shows selected representative modelled versus observed hydrographs. Figure 7.5 shows the simulated groundwater levels in Layer 1 and Layer 13 for 2013 at the end of the transient calibrated model run.

The heads are also the starting point for simulating proposed future mining. The zone of depressurisation generated by mining is evident in both water level surfaces. The modelled versus observed transient hydrographs for all monitoring locations show variable fit, from good matches in key monitoring locations near to and beneath Wollombi Brook alluvium, to some significant over and under-prediction in some nested VWP data locations (see Appendix C).

Statistically the overall SRMS of the calibration of 15.1%,is greater than the upper limit of 10% in the Australian Groundwater Modelling Guidelines (Barnett et al 2012). During initial calibration the SRMS was skewed by the density of data from bores with automatic level recorders. Some bores for example have recorded levels every 15 minutes and this led to over representation of these bores within the statistical analysis. In contrast many other bores have only monthly or greater periods of manual dip data available. Bores with high resolution data were resampled to a weekly average prior to final calibration and reporting of statistics.

The SRMS shows statistically what is evident graphically in the hydrographs in Appendix C, that there are some predictions (particularly from VWPs in the Permian strata) significantly different than observed. In general, however, transient modelled head data reflects the zone of depressurisation that is being generated by the active mining. It should also be noted that roughly as many monitoring data points over-predict as under-predict, suggesting the calibration is in middle ground between under- and over-prediction. Figure 7.6 shows the average residual for each monitoring location with red dots showing where the model is over predicting heads and the blue dots are where the model is under predicting. Generally the model over predicts drawdown close to the current mine areas and under predicts effects further to the west. Critically, predictions are good in Layers 1 to 9 around the key assessment location of Wollombi Brook alluvium. Predictions near these key regional assessment location were considered to be more important than localised predictions near the active pit. Even though the model calibration is above the SRMS criteria stipulated in the Australian model guidelines it is still thought an accurate representation of the aquifer system and fit for purpose as a simulator for predictions in this study.

Appendix C discusses in more detail the simulated and measured groundwater levels. A key limiting factor in the calibration is the lack of information on the historical sequence of mining. This, in effect, inputs a further variable into the model that may prevent significant improvement in the current calibration.

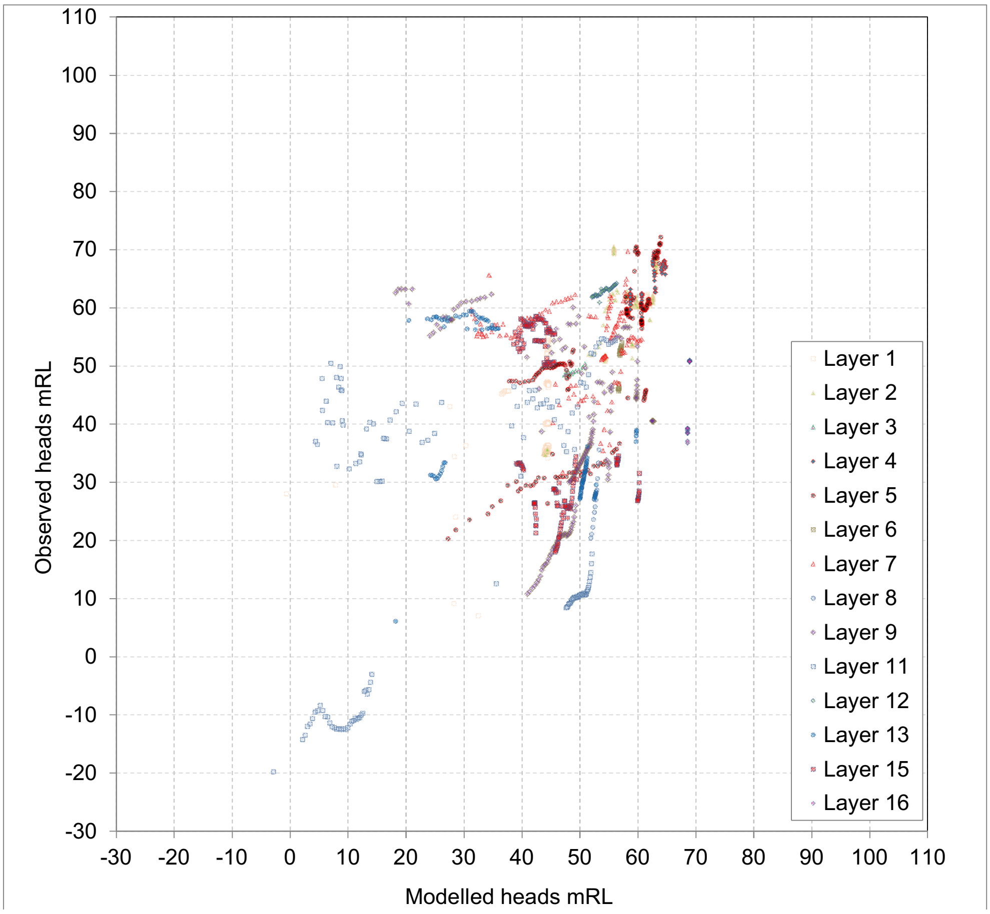


Figure 7.3: Transient scatter plot of modeller versus observed heads

Figure 7.4-A shows example modelled versus observed groundwater heads to the west of the Loders high-wall. The observed data from this site is from a multi-level VWP and shows a significant vertical hydraulic gradient between seams. The observed data in the figure also shows there is higher groundwater pressure in Layer 13 (Mt Arthur Seam) below the base of active mining in Loders Pit, which mines to the base of the Woodlands Hills Seam (Layer 9). The modelled data in Figure 7.4A shows a over-prediction of drawdown in the shallower Layer 5 with an under-prediction of drawdown in Layer 9. Appendix C Figures C-16 and C-17 shows data from other nested monitoring sites west of the Loders pit. Generally there is a under-prediction of drawdowns in deeper coal seams west of the Loders pit compared the monitoring installations west of the Warkworth Mine high-wall to the north.

Figure 7.4-B shows example modelled versus observed groundwater heads from shallow formations to the west of the Loders high-wall. The fit in these shallow alluvium (PZ9S), shallow overburden (PZ9D) and shallow coal seam (G3) is excellent. The fit in data for deeper coal seams monitored close to the Loders Pit high-wall was given less weighting in the calibration compared to these more distal sites close and within Wollombi Brook alluvium. Figure 7.4-B shows the model is predicting effects accurately close to the Wollombi Brook alluvium.

Figure 7.4-C shows example modelled versus observed groundwater heads from bore and geophysics picks of the water table within the Loders pit spoil surrounding CRTSF. See Section 5.3 for further background. The observed data shows groundwater level mounding in the spoil around CRTSF. The observed data was used during calibration to estimate spoil and TSF leakage parameters. The model estimates reasonable fits to water level data within the spoil for the end of the calibration period, no time series groundwater level data within the spoil was available for this study.

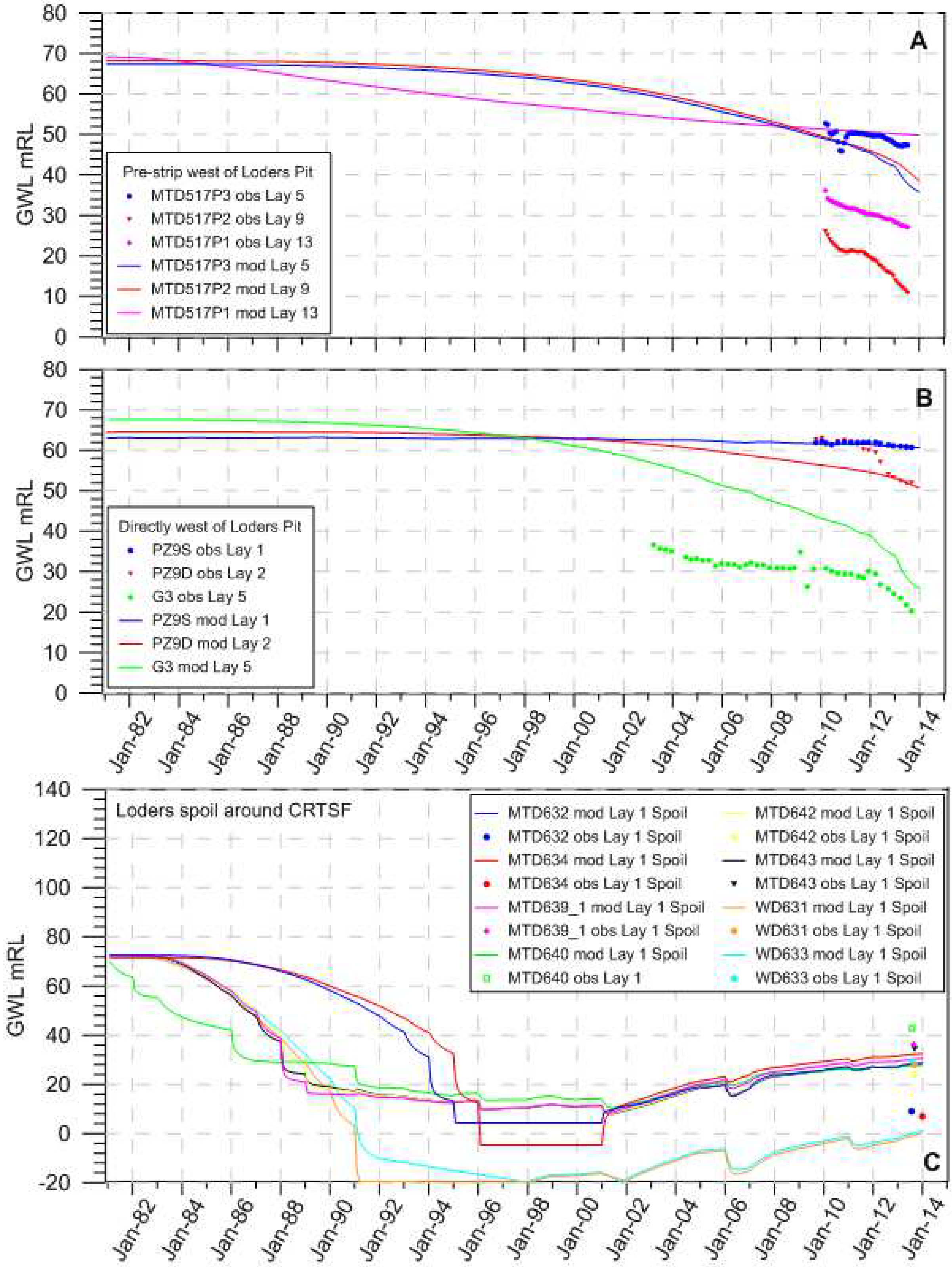
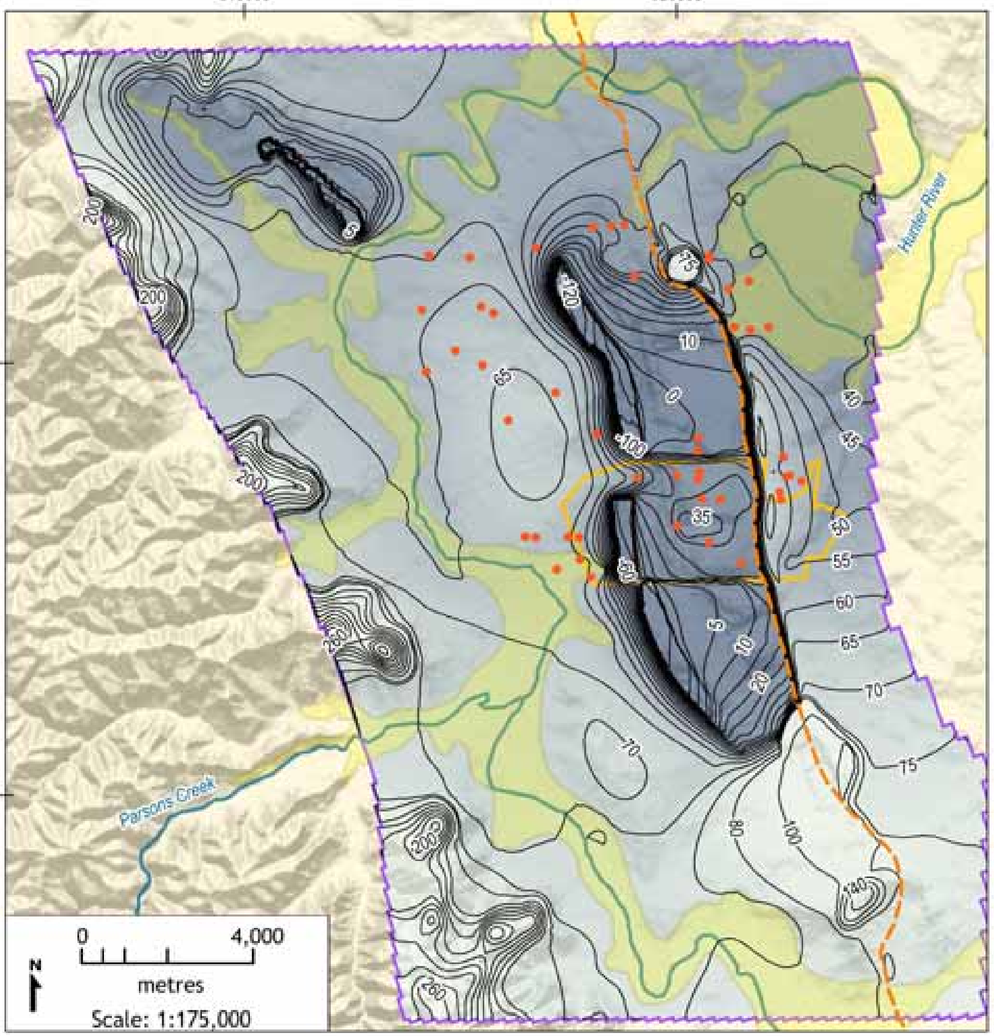
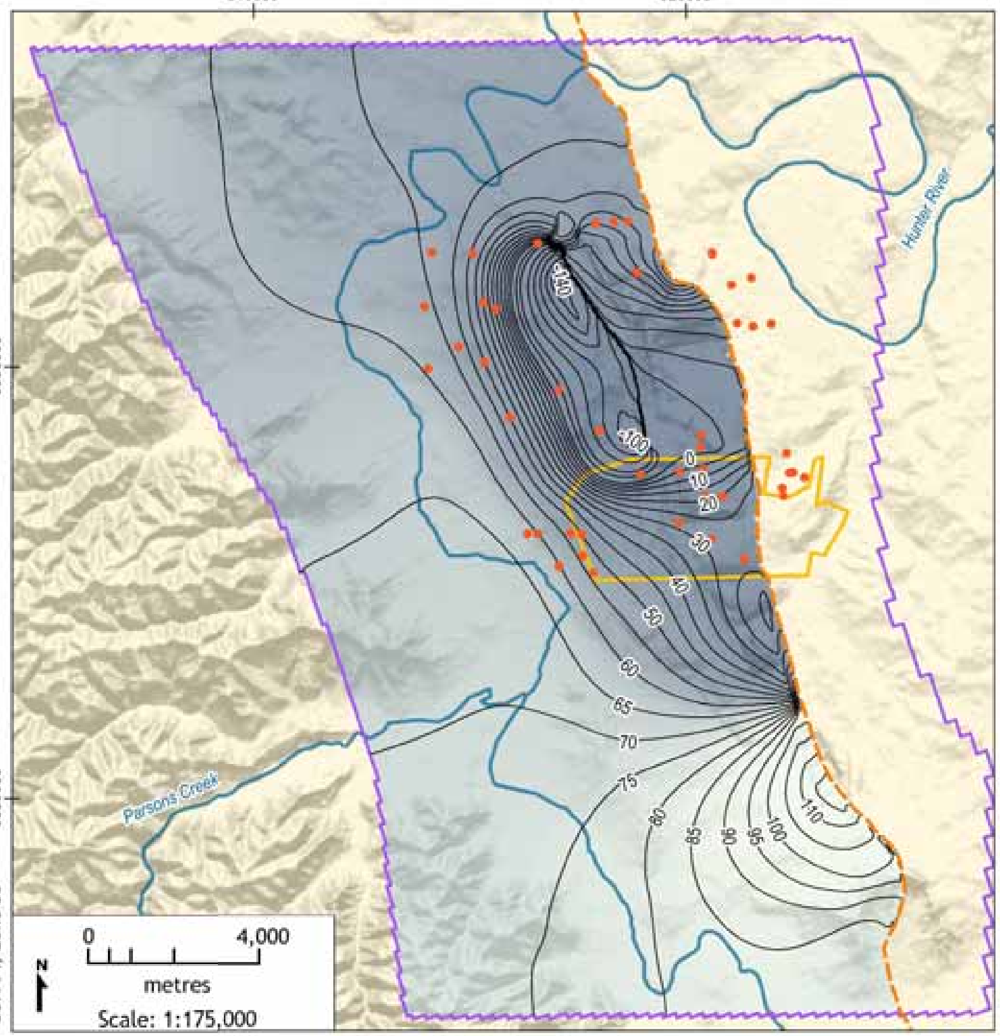


Figure 7.4: Representative transient modelled versus observed hydrographs

Heads - Layer 1 - Alluvium and Regolith



Heads - Layer 13 - Mount Arthur Seam



LEGEND:

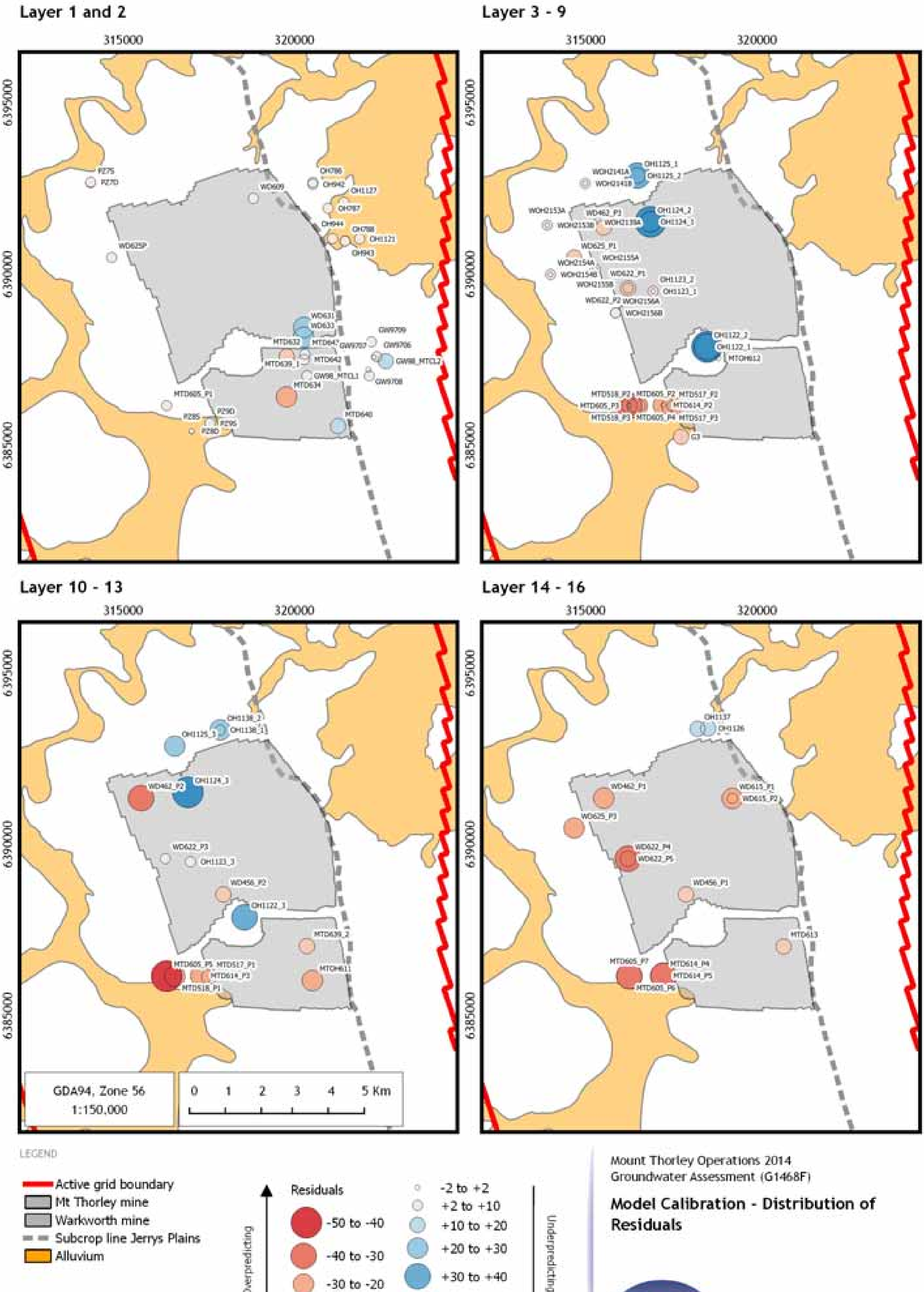
- Proposed MTO development consent boundary
- Active model boundary
- Quaternary alluvium (100k)
- Subcrop of Jerrys Plains Formation
- Transient observation bore
- Groundwater level contour
- Major watercourse

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Heads at the End of Calibration Run (Year 2013)

DATE: 14/5/2014

FIGURE No: **7.5**



Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Model Calibration - Distribution of Residuals

DATE 14/5/2014

FIGURE No: **7.6**

8 IMPACT ASSESSMENT

The impact of the proposal contribution to the cumulative impact was assessed as the difference between the predictive results for the two model scenarios, as described in Section 7.1. The impacts assessed from the model results include:

- drawdown associated with the proposal;
- magnitude of drawdown on private landholder bores ;
- magnitude of drawdown and water take from the alluvium of Wollombi Brook and Hunter River;
- changes to stream baseflow and salinity;
- negative influence on GDEs;
- inflow rates into the MTO Loders Pit;
- implications for groundwater licensing;
- post mining recovery, including final void water levels; and
- water quality and leachate migration from mine spoil and TSFs.

8.1. Results of the Predictive Model Run

8.1.1. Water Levels and Drawdown

Figure 8.1, Figure 8.2 and Figure 8.3 show simulated water levels and drawdown at the end of proposed mining for:

- Layer 1 - alluvium and shallow regolith;
- Layer 9 - Woodlands Hill coal seam - base of MTO; and
- Layer 13 - Mt. Arthur coal seam - base of Warkworth Mine.

Figure 8.1 shows the extent of the drawdown in the water table associated with the proposal. This represents the component of drawdown attributable to the proposal. 1 m drawdown contour can be seen to extend primarily within the Permian, although directly west of MTO it does enter the margins of the Wollombi Brook alluvium. The drawdown also extends into the Warkworth Mine to the north, and Bulga Mine to the south, which represents the projects portion of the cumulative impacts attributable to mining.

Figure 8.1 shows a groundwater level mound in Layer 1 at the end of mining in the region of the CRTSF and Loders Tailings Storage Facility (TSF). The groundwater model creates hydraulic gradients and groundwater flows towards the north to the Warkworth Mine but also westerly towards Wollombi Brook. The groundwater levels and gradients at the end of mining indicate a flux of groundwater from the MTO to Wollombi Brook alluvium.

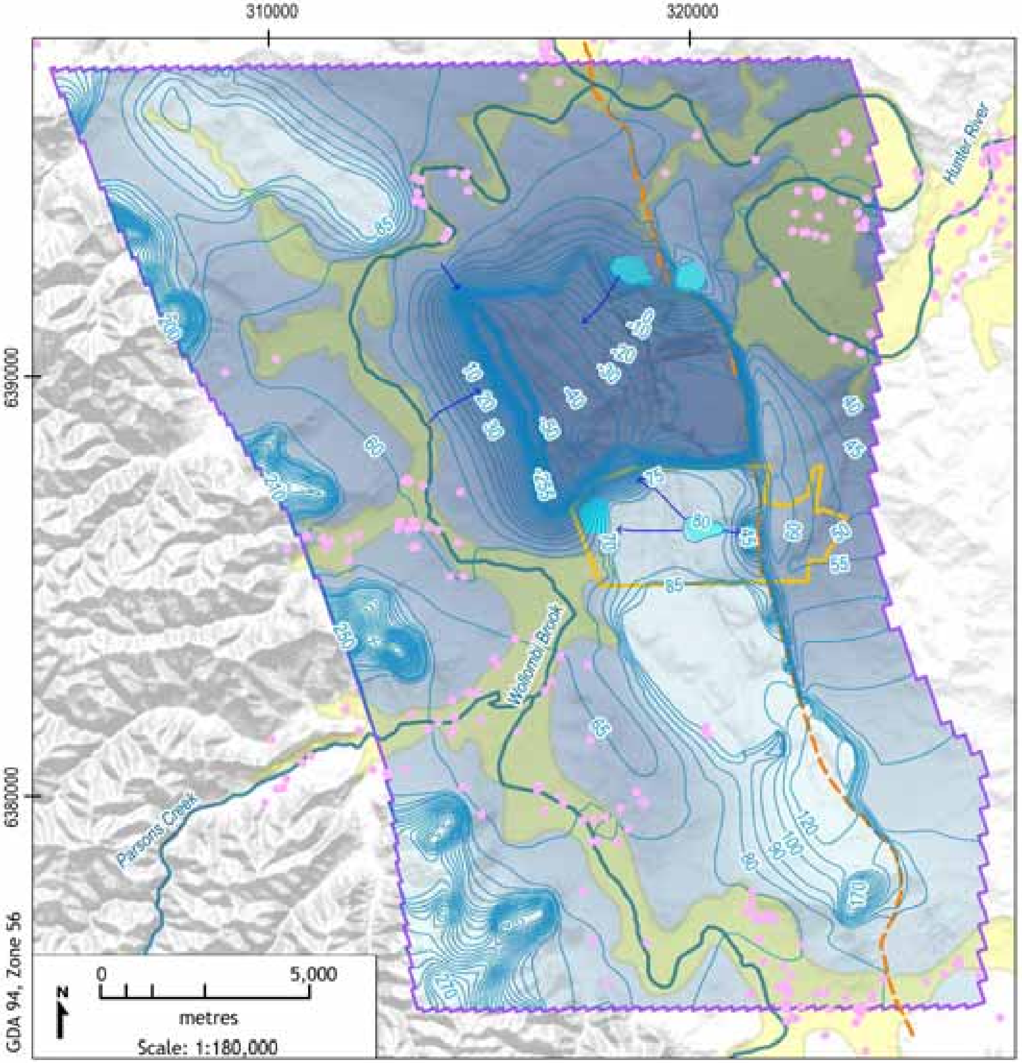
Figure 8.2 shows the drawdown in Layer 9 associated with the proposal representing the Woodlands Hill seam. Figure 8.3 shows the drawdown in Layer 13 associated with The Mt Arthur Seam. The drawdowns in both can be seen to extend west below Wollombi Brook alluvium.

Figure 8.4 shows a schematic cross section west to east at the end of mining (2035) through the Wollombi Brook to CRTSF. The water levels at the end of mining show the small groundwater mound associated with the CRTSF. Figure 8.5 shows a second south west to north east schematic cross section through the proposed Loders TSF.

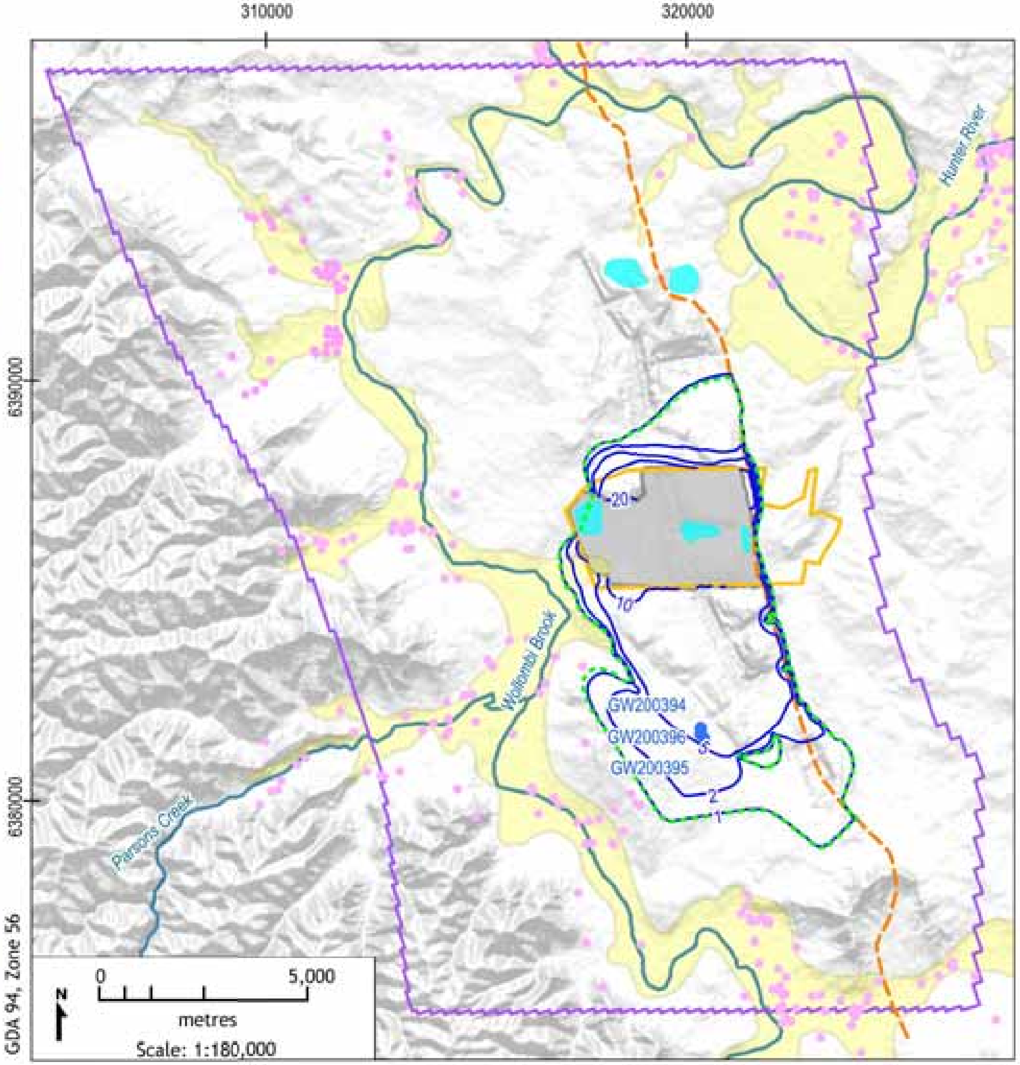
To test if the river boundary conditions used in the simulation buffers and retards the drawdown from moving beyond the simulated rivers a sensitivity model run was completed with no flow[3] set in Wollombi Brook for the 21 year predictive run. Figure 8.1 shows the 1m drawdown contours from this sensitivity simulation are very close to those of the calibrated model. This infers that the calibrated model river simulations do not buffer drawdowns during prediction.

[3] Zero river stage set in river boundaries to simulate the river as a ephemeral stream.

Groundwater Levels - Alluvium/ Regolith (Layer 1) Year 21 (2035)



Change in Groundwater Levels - Alluvium/ Regolith (Layer 1) Year 21 (2035)



LEGEND:

- 5m EOM Groundwater Contours (mAHD)
- Groundwater drawdown contours (m)
- Inferred groundwater flow direction
- 1m drawdown - sensitivity run
- Groundwater users (Pinneena 2013)
- Private groundwater user (predicted drawdown >1m)
- Active model boundary
- Quaternary alluvium (100k)
- Tailings storage facility
- Excavated mine area
- Proposed MTO deveopment consent boundary
- Subcrop of Jerrys Plains Formation
- Major watercourse

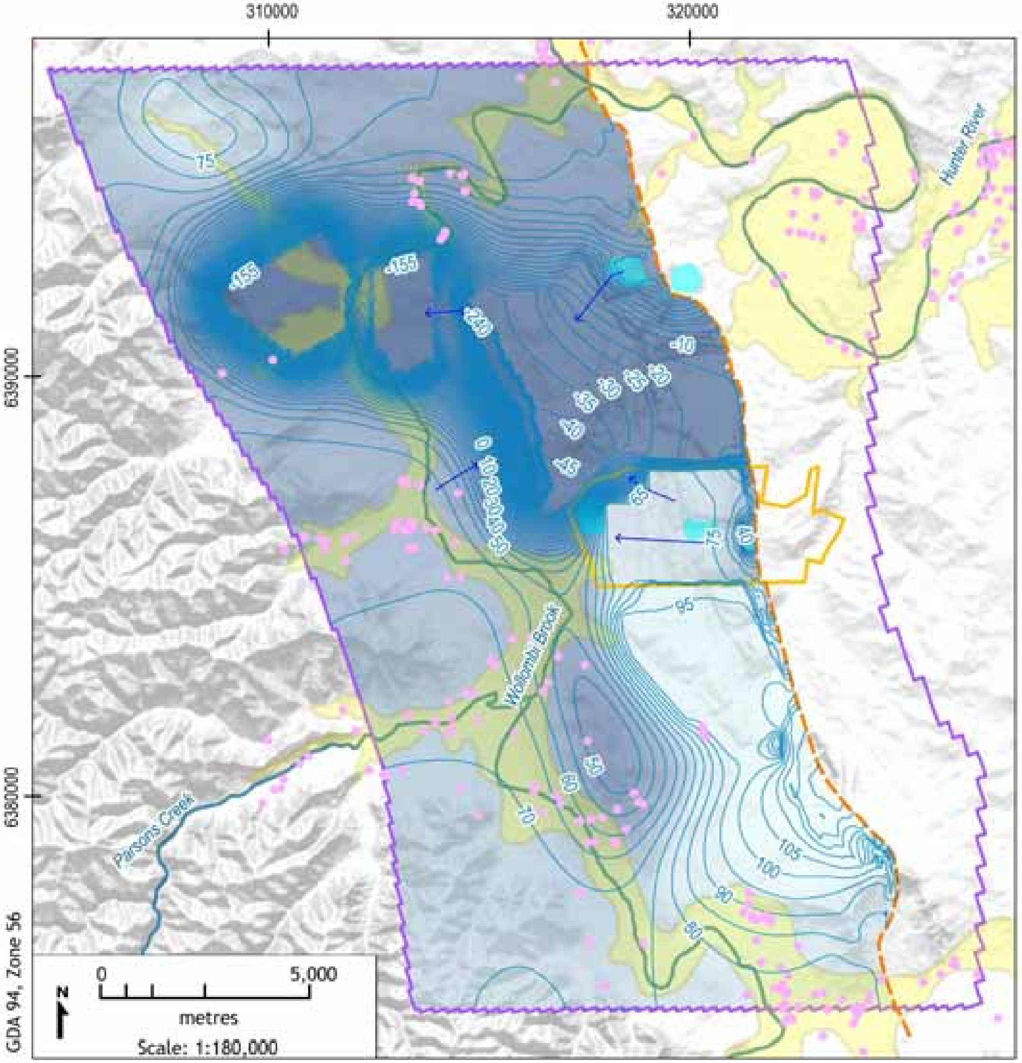
Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

End of Mining Groundwater Levels & Change in Groundwater Levels Layer 1

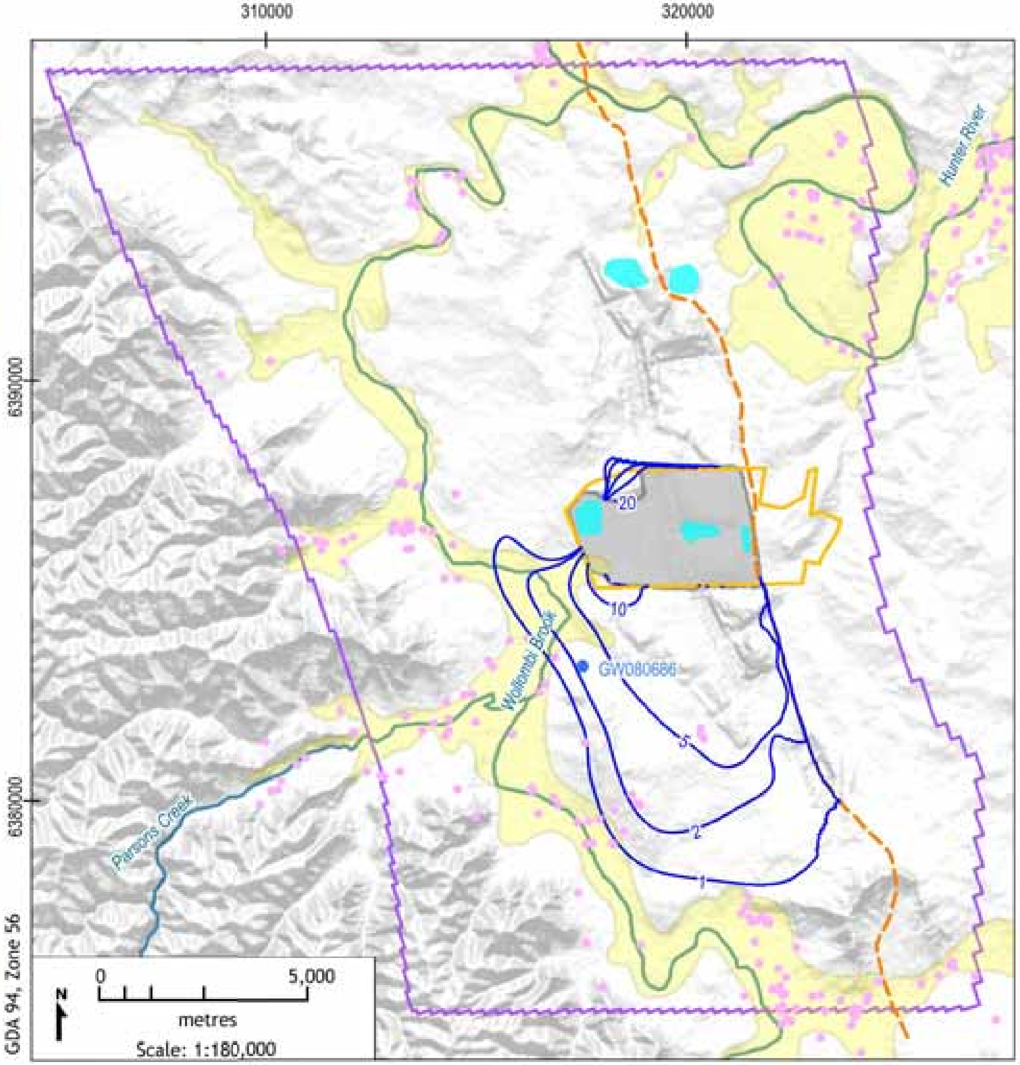
DATE:
14/5/2014

FIGURE No:
8.1

Groundwater Levels - (Layer 9) Year 21 (2035)



Change in Groundwater Levels - (Layer 9) Year 21 (2035)



LEGEND:

- 5m EOM Groundwater Contours (mAHD)
- Groundwater drawdown contours (m)
- Inferred groundwater flow direction
- Groundwater users (Pinneena 2013)
- Private groundwater user (predicted drawdown >1m)
- Proposed MTO deveopment consent boundary
- Active model boundary
- Quaternary alluvium (100k, Layer 1)
- Excavated mine area
- Tailings storage facility
- Major watercourse
- Subcrop of Jerrys Plains Formation

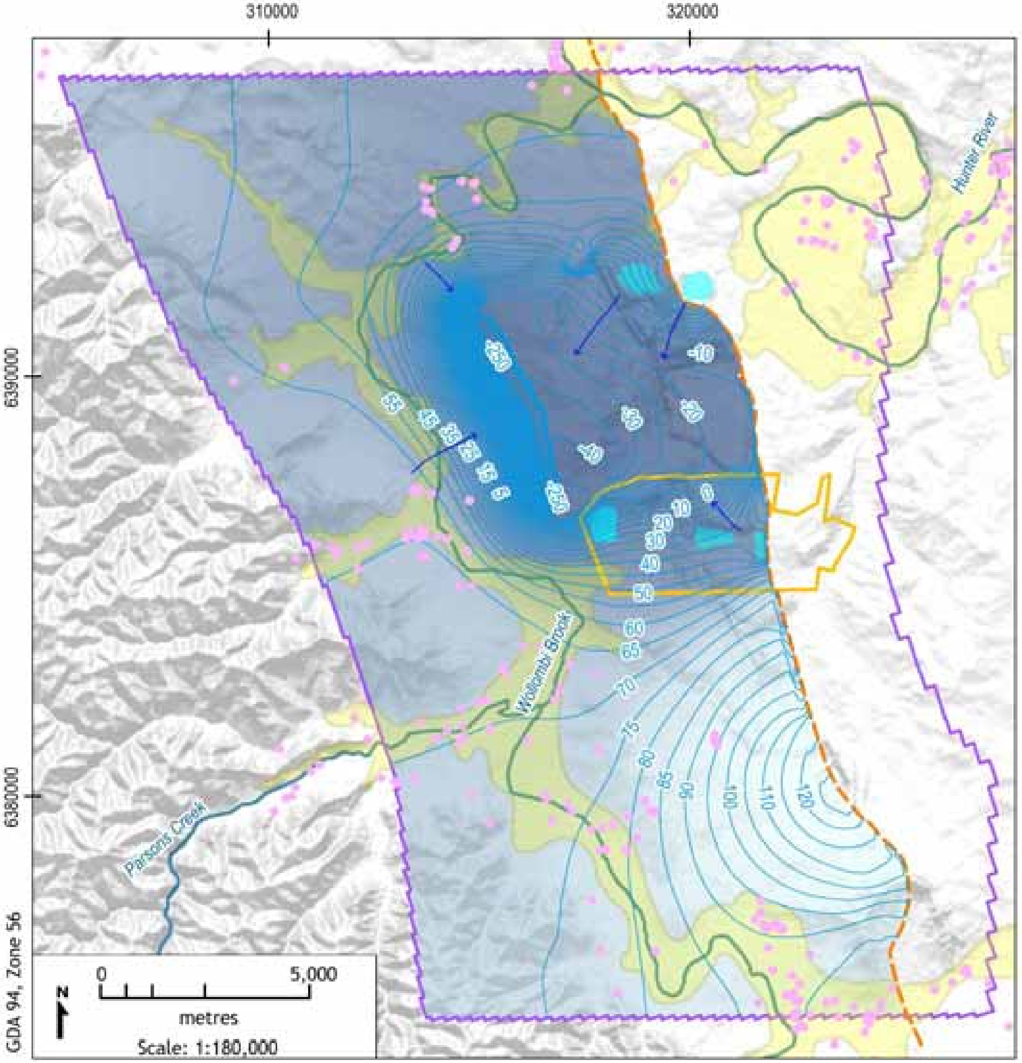
Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

End of Mining Groundwater Levels & Change in Groundwater Levels Layer 9

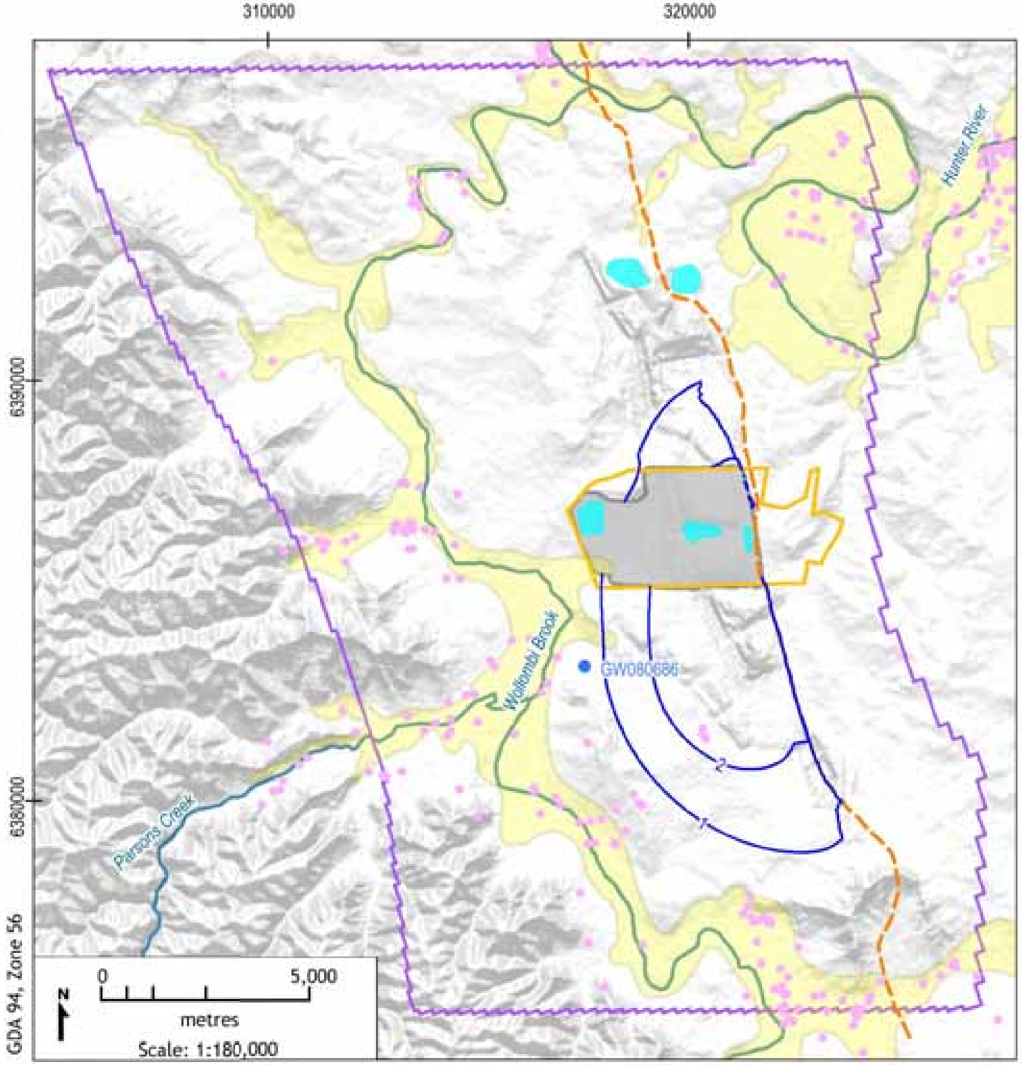
DATE:
14/5/2014

FIGURE No:
8.2

Groundwater Levels - Mt Arthur Seam (Layer 13) Year 21 (2035)



Change in Groundwater Levels - Mt Arthur Seam (Layer 13) Year 21 (2035)



LEGEND:

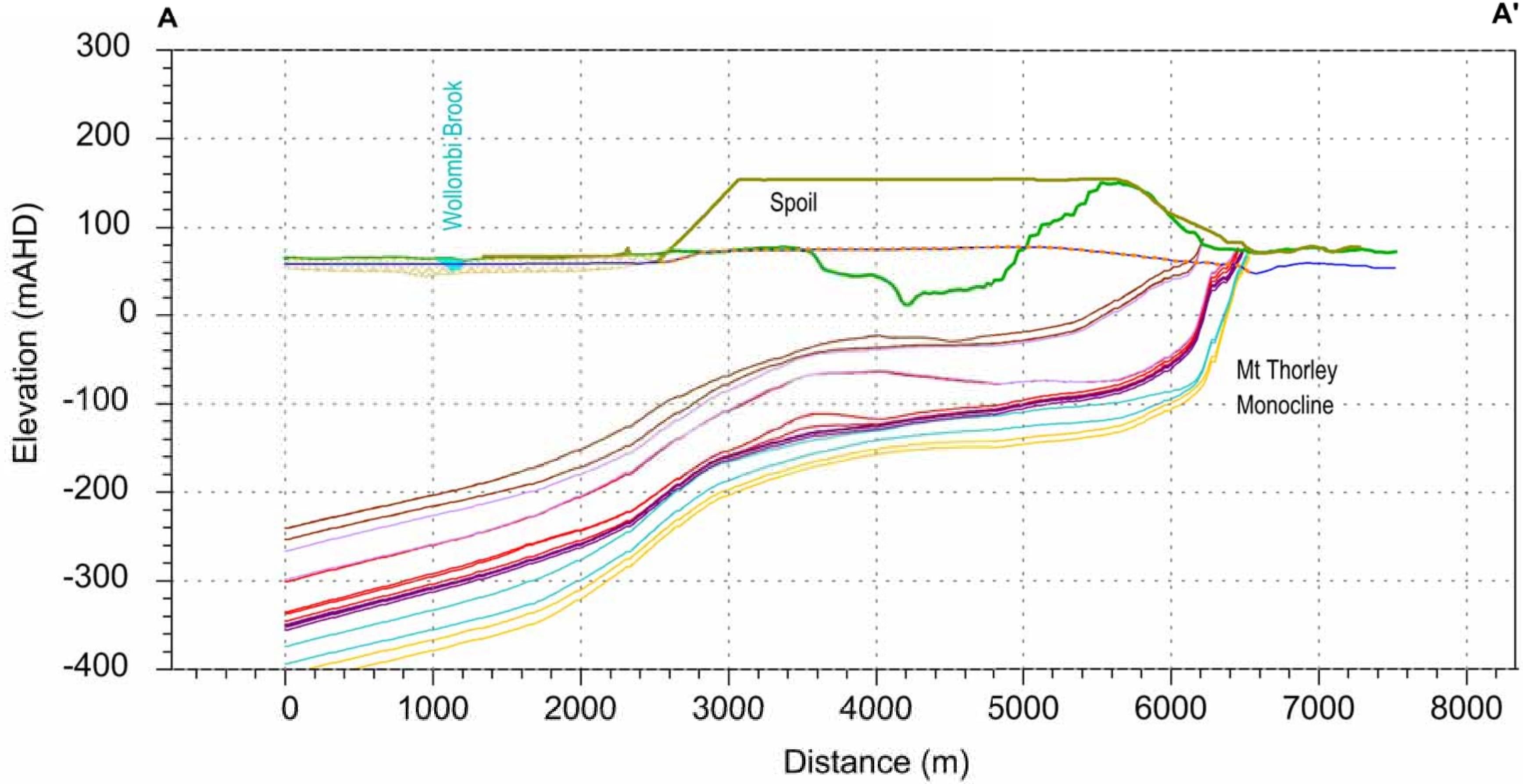
- 5m EOM Groundwater Contours (mAHD)
- Groundwater drawdown contours (m)
- Inferred groundwater flow direction
- Groundwater users (Pinneena 2013)
- Private groundwater user (predicted drawdown >1m)
- Proposed MTO deveopment consent boundary
- Active model boundary
- Quaternary alluvium (100k, Layer 1)
- Excavated mine area
- Tailings storage facility
- Major watercourse
- Subcrop of Jerrys Plains Formation

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

End of Mining Groundwater Levels & Change in Groundwater Levels Layer 13

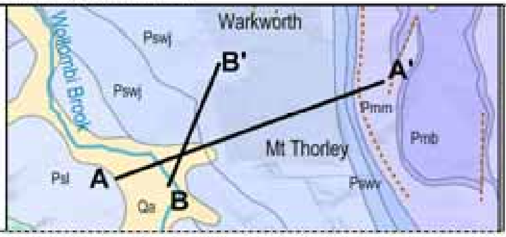
DATE:
14/5/2014

FIGURE No:
8.3



(Vertical Exaggeration 1:6)

Locality Map



LEGEND:

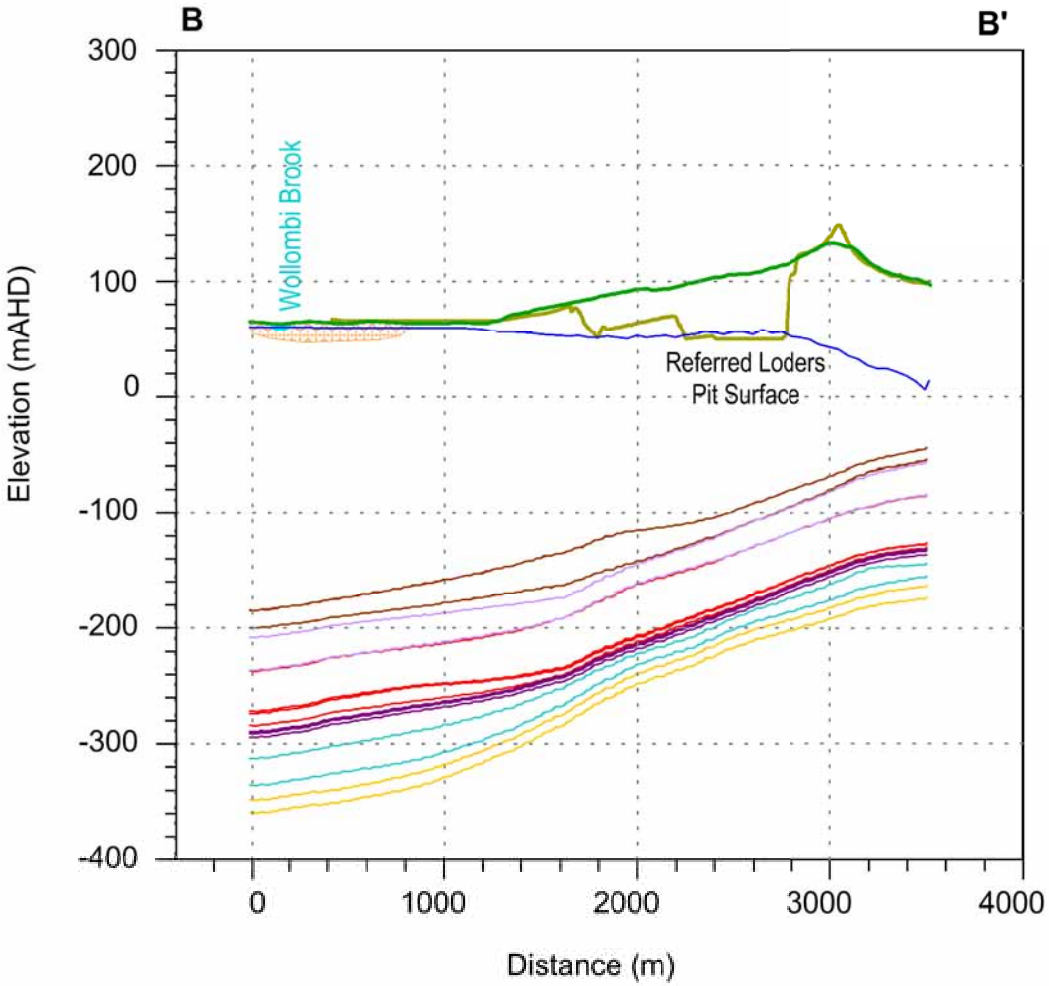
- Modelled EOM groundwater levels - Layer 1 (mAHD)
- Modelled EOM groundwater mound
- Proposed final landform
- Surface topography
- Arrowfield Seams
- Bowfield Seams
- Alluvium
- Warkworth Seams
- Mt Arthur Seams
- Piercefield Seams
- Vaux Seams

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Model End of Mining Groundwater Levels (Layer 1) Mt Thorley Cross-Section (A-A')

DATE:
14/5/2014

FIGURE No:
8.4



(Vertical Exaggeration 1:6)

Locality Map

LEGEND:

- Modelled EOM groundwater levels - Layer 1 (mRL)
- Alluvium
- Proposed final landform
- Surface topography
- Arrowfield Seams
- Bowfield Seams
- Warkworth Seams
- Mt Arthur Seams
- Piercefield Seams
- Vaux Seams

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Model End of Mining Groundwater Levels (Layer 1) Mt Thorley Cross-Section (B-B')

DATE: 14/5/2014

FIGURE No: **8.5**

8.1.2. Impact on Groundwater Users

The AIP stipulates that within highly productive groundwater sources (i.e. alluvial water sources) and less productive sources (i.e. porous and fractured rock) the maximum cumulative drawdown at any water supply bore should not be more than 2 m. Table 8.1 shows the predicted drawdown within the Permian sequence at registered bores where drawdown attributable to the project exceeds 1 m. Table 8.1 also shows the cumulative drawdown at these bores due to all mining projects in the region.

Table 8.1: IMPACTS OF THE MINING ACTIVITIES ON GROUNDWATER USERS

Bore ID	Easting	Northing	Depth	Formation	Owner	Drawdown	
						Proposal component	Total cumulative
GW200394	320338	6381740	20	Permian regolith	Bulga Mine	6.5	13.2
GW200396	320329	6381589	5	Permian regolith	Bulga Mine	5.9	9.8
GW200395	320406	6381484	20	Permian regolith	Bulga Mine	5.7	9.3
GW080686	317535	6383210	na	Permian	Bulga Mine	2.5	19.2

The NOW groundwater database shows a total of four water bores as being present in the Permian strata within the predicted zone where depressurisation attributed to the project exceeds 1 m. None of these bores are private bores used for water supply purposes and are owned by Bulga Mine. There are no bores within the alluvium with predicted drawdown impacts.

The modelling predicts water levels at most of the bores will reduce by less than 1 m due to the proposal. The majority of the private bores are screened in the Wollombi Brook alluvium, which experiences less drawdown than the Permian sequence due to the buffering effect of diffuse rainfall recharge and stream bed leakage. The pumping yield of private bores will not be affected by the proposal.

As detailed above, the AIP requires that aquifer interference activities do not induce a decline of more than 2 m in the water table or water pressure at any water supply work, (i.e. a bore or a well) in both highly and less productive groundwater sources. The modelling predicted no drawdown in any private bores within alluvium. Groundwater level declines of over 2 m in Permian units are predicted at four monitoring bores at Bulga Mine (see Table 8.2). However, as there are no predicted impacts on private water supply bores, this condition of the AIP is met.

8.1.3. Impact on Alluvium

In the early years of the calibration model, i.e. the 1980s, the model predicts there is a net upward flow entering the alluvium from the Permian formations across the whole model domain. As mining operations in the region expand over time, the Permian strata depressurises within the zone of influence, will decrease upward flow of groundwater from the Permian to the alluvium. As water quality within the Permian stratigraphy is brackish to saline, a reduction in upward flow will consequently reduce the salinity levels within the alluvium.

Two model runs were used to estimate the change in groundwater flow from the Permian to the alluvial aquifers. The first run was a simulation without mining at MTO, and therefore only included the surrounding mining zones, while the second run included mining under the proposal as well as the surrounding mining zones. The change in flow contribution from the Permian to the alluvial aquifer was then calculated by extracting alluvium zoned cell-by-cell flow data for each stress period from the “mine proposal” and “no mine” scenarios.

Figure 8.6 shows the predicted additional take from Wollombi Brook alluvium and Hunter River alluvium resulting from the proposal. The simulation shows a gradual increase in take from the Wollombi Brook alluvium to a peak calculated take of 532 m^3/day at year 2019 which corresponds to the final year of active mining simulated in Loders Pit. As spoil is placed in Loders Pit after 2019 a reduction in calculated take from the Wollombi alluvium occurs, with the long term rate of 320 m^3/day at year 2035. Take from the Hunter River alluvium is undetectable.

In summary the maximum additional take associated with the proposal from the Wollombi Brook alluvium (at year 2019) is estimated at 195 ML/yr (532m^3/day).

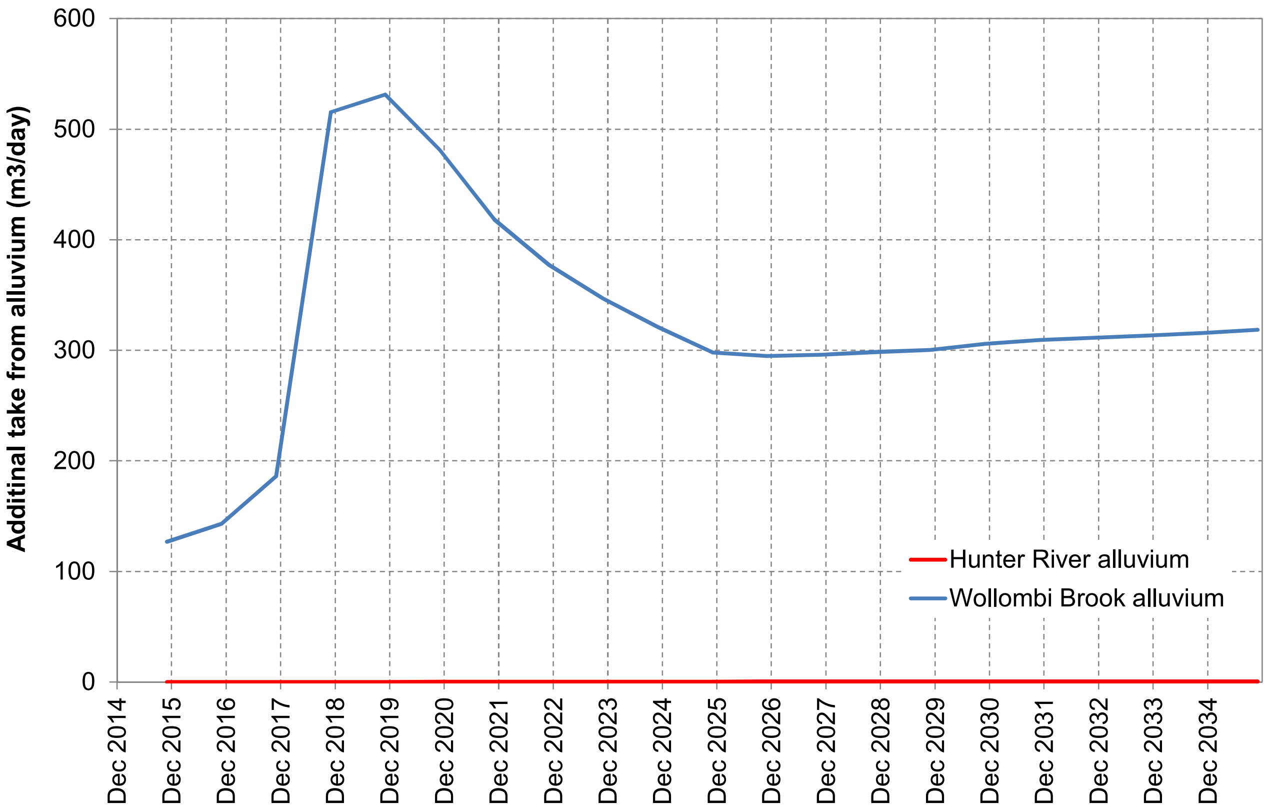


Figure 8.6: Change in groundwater seepage into Wollombi Brook alluvium from the Permian Coal Measures

8.1.4. Impact on Stream Baseflow

In the absence of mining, the river and creek network surrounding MTO is largely a gaining stream from groundwater discharge (baseflow). As mining expands in the region, the Permian strata depressurisation within the zone of influence will decrease upward groundwater flow from the Permian to the alluvium. The result is a slight lowering of groundwater levels in the Wollombi Brook alluvium, reducing the hydraulic gradient between the stream bed and alluvial aquifer and in turn decreasing baseflow.

Figure 8.7 presents the net change in the river/brook baseflows in response to mining. This was determined by subtracting the net river/creek flows in the predictive model from the scenario that removed mining of the proposal.

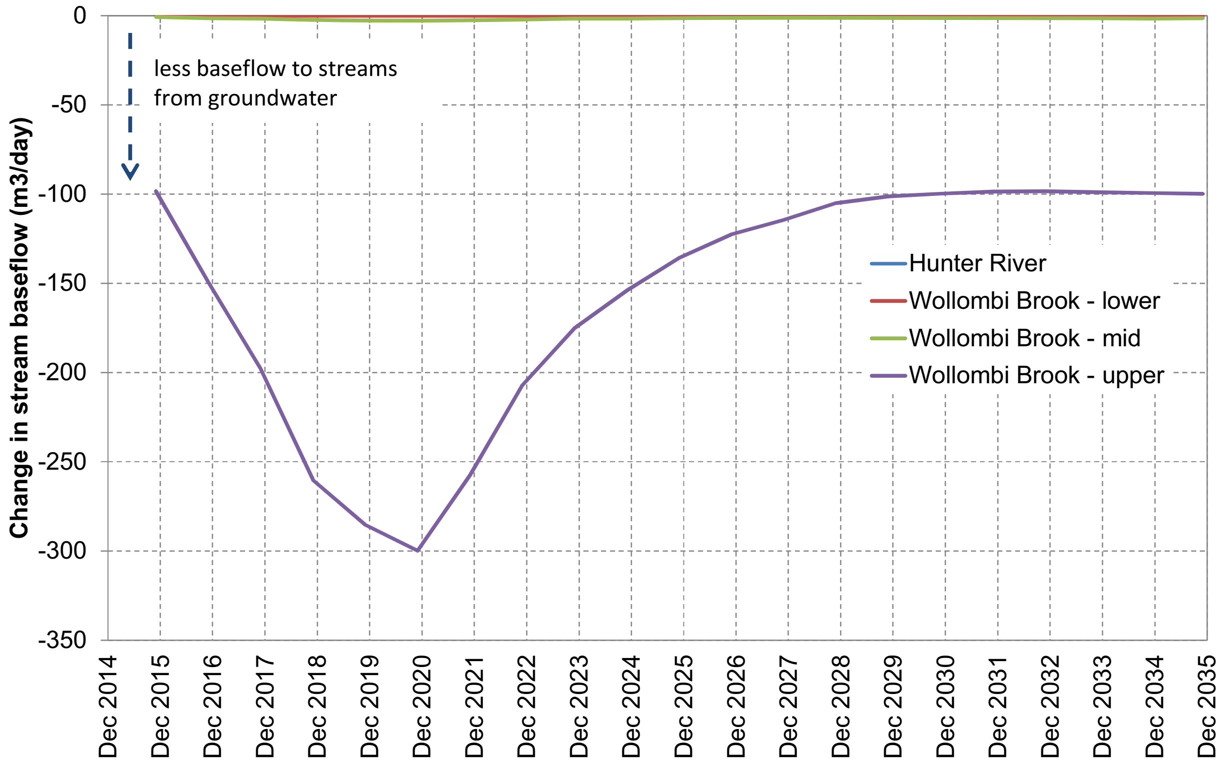


Figure 8.7: Net Change in surface water flow

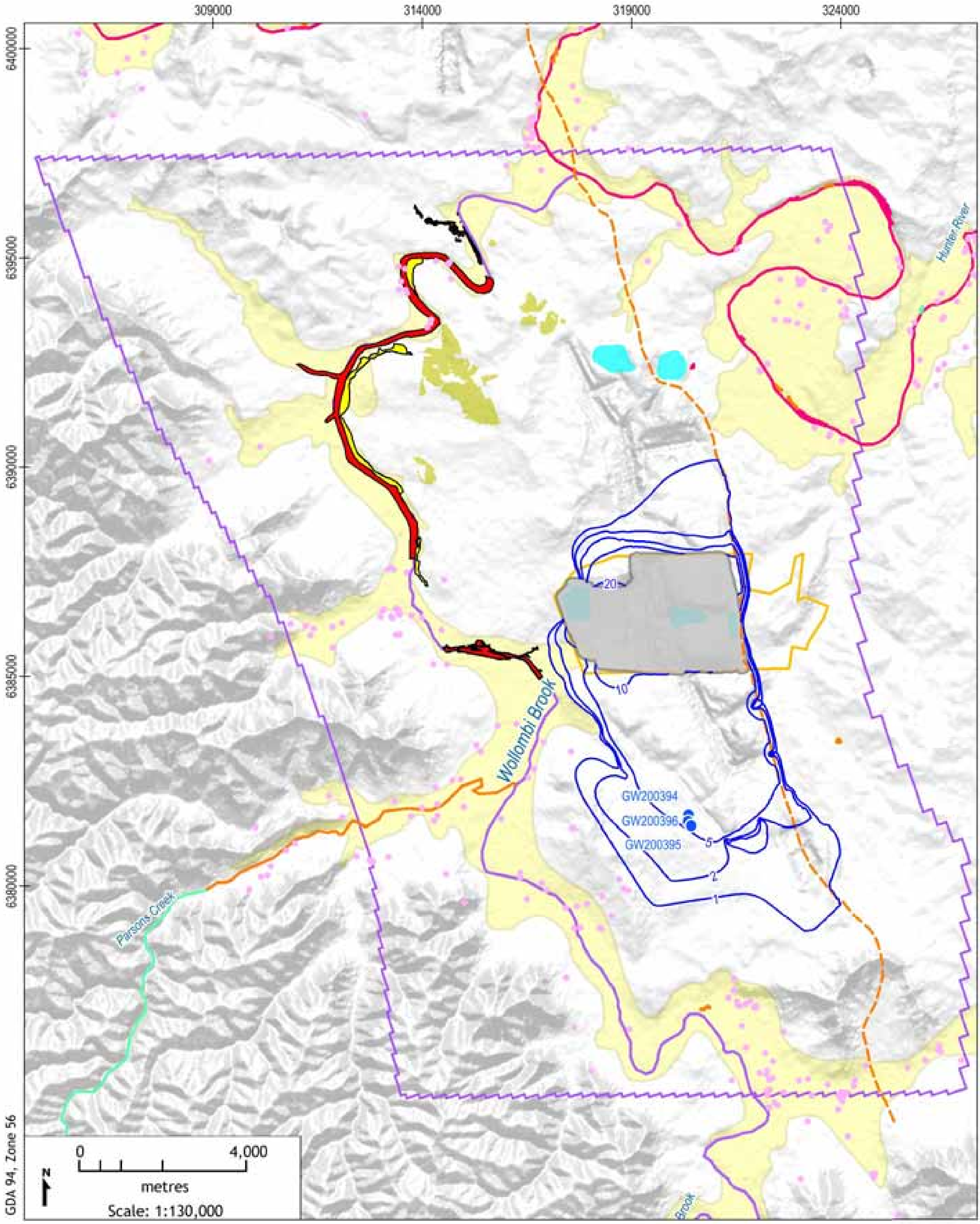
Figure 8.7 shows a reduction in baseflow to the Wollombi Brook for the proposal. The peak reduction in baseflow is in 2020 during the final stages of mining in Loders Pit. The majority of the loss in Wollombi Brook baseflow is in the upper reach above the stream gauge at Bulga (Station 210028), with only negligible loss in the mid reach to the stream gauge north of Warkworth Mine (Station 210004) and the lower reach to the confluence with the Hunter River. Baseflow reduction for Wollombi Brook (all reaches) is at a maximum of 300 m^3/day at 2020. Zero impact on baseflow is calculated for the Hunter River.

It is important to note from a water accounting point of view the reduction in baseflow is accounted for in the calculated reduced groundwater flow from the Permian to the alluvium. Of the calculated 532 m^3/day maximum take from the Wollombi Brook alluvium a maximum 300 m^3/day decrease in baseflow is expected.

8.1.5. Impact on Groundwater Dependent Ecosystems

Cumberland Ecology (2010) identified two potentially groundwater dependent vegetation communities along Wollombi Brook. These were the Hunter Valley River Oak Forest and the River Red Gum Floodplain Woodland which are in a thin riparian zone along Wollombi Brook about 4 km from the mining areas,

Model predictions do not predict a significant change in baseflow to the Wollombi Brook or Hunter River or drawdown within the alluvium. Therefore any riparian ecosystems or subterranean fauna will not be impacted by the proposal.



LEGEND:
- Groundwater drawdown contour (m)
- Groundwater users (Pinneena 2013)
- Private groundwater user (predicted drawdown >1m)
- Proposed MTO deveopment consent boundary
- Tailings storage facility
- Active model boundary
- Excavated mine area
- Quaternary alluvium (100k)
- Subcrop of Jerrys Plains Formation

GDE Atlas - Surface Expression
- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction
- Identified in previous study: fieldwork

Groundwater Dependent Ecosystems
- Hunter Valley River Oak Forest
- River Red Gum Floodplain Woodland
- Warkworth Sands Woodland

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

GDEs and Predicted Drawdown in the Water Table (Layer 1)

AGE

DATE: 14/5/2014

FIGURE No: **8.8**

8.1.6. Pit Inflows

Figure 8.9 shows simulated inflows to Loders Pit that includes water derived from leakage through spoil combined with dewatering from the Permian coal measures. The split between the two sources is shown on the figure with take from the Permian the highest during the first year of mining (2015) at 1,064 m^3/day. Inflows fall to zero when mining ceases and the pit begins to be backfilled with spoil. The peak water take is 389 ML/year for the first year of the proposal. Post mining the take from the Permian will continue past 2020 at reduced rates.

The inflow from the spoil is initially 2,832 m^3/day in the first year of predicted mining in 2015, increasing to a maximum of 3,721 m^3/day in 2017.

Figure 8.10 shows inflows to the spoil from rainfall infiltration and leakage from Central Ramp TSF (CRTSF), Abbey Green South (AGS) TSF and Loders TSF. This plot shows approximately two thirds of the inflow to spoil is derived from CRTSF leakage.

The presented inflows do not include evaporation at the coal face and retained water bound as moisture in coal and overburden. Not all water simulated inflow will appear at the pit floor during mining. Inflows from spoil have been estimated using annual average rainfall records.

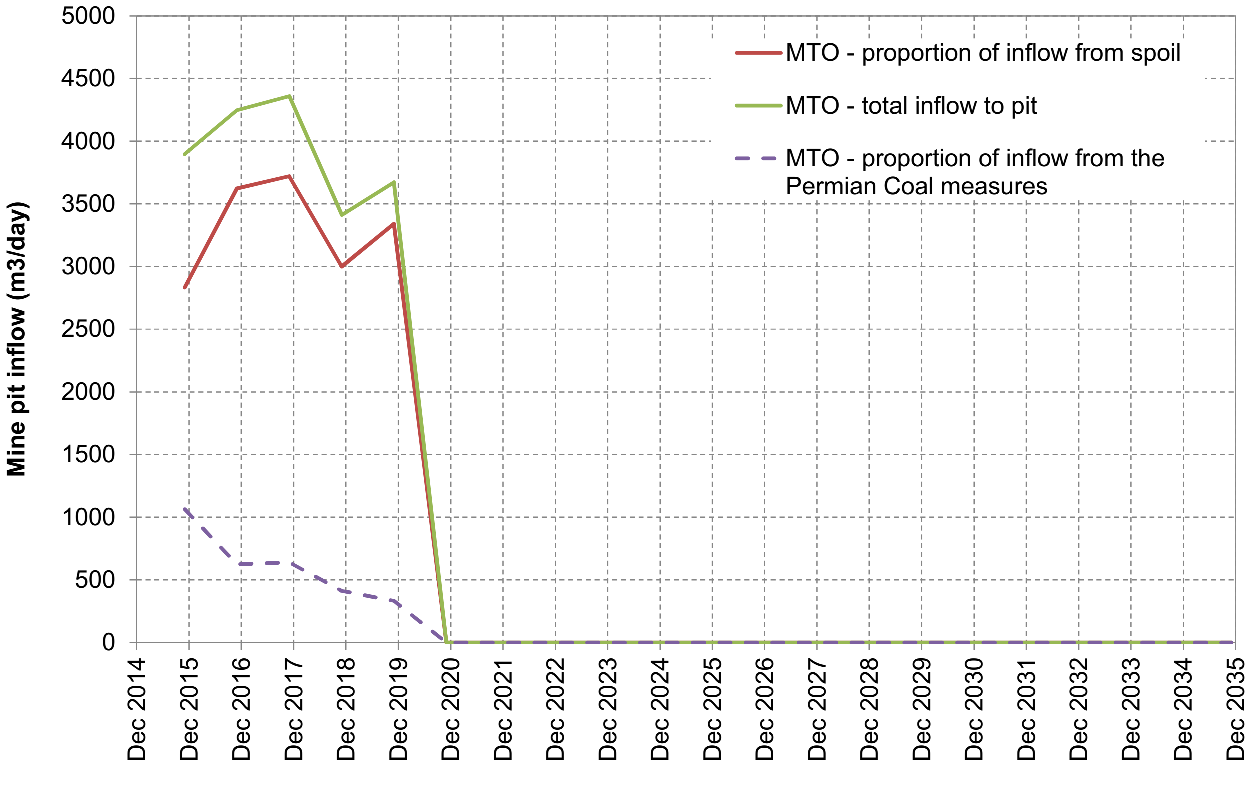


Figure 8.9: Simulated inflows to Loders Pit

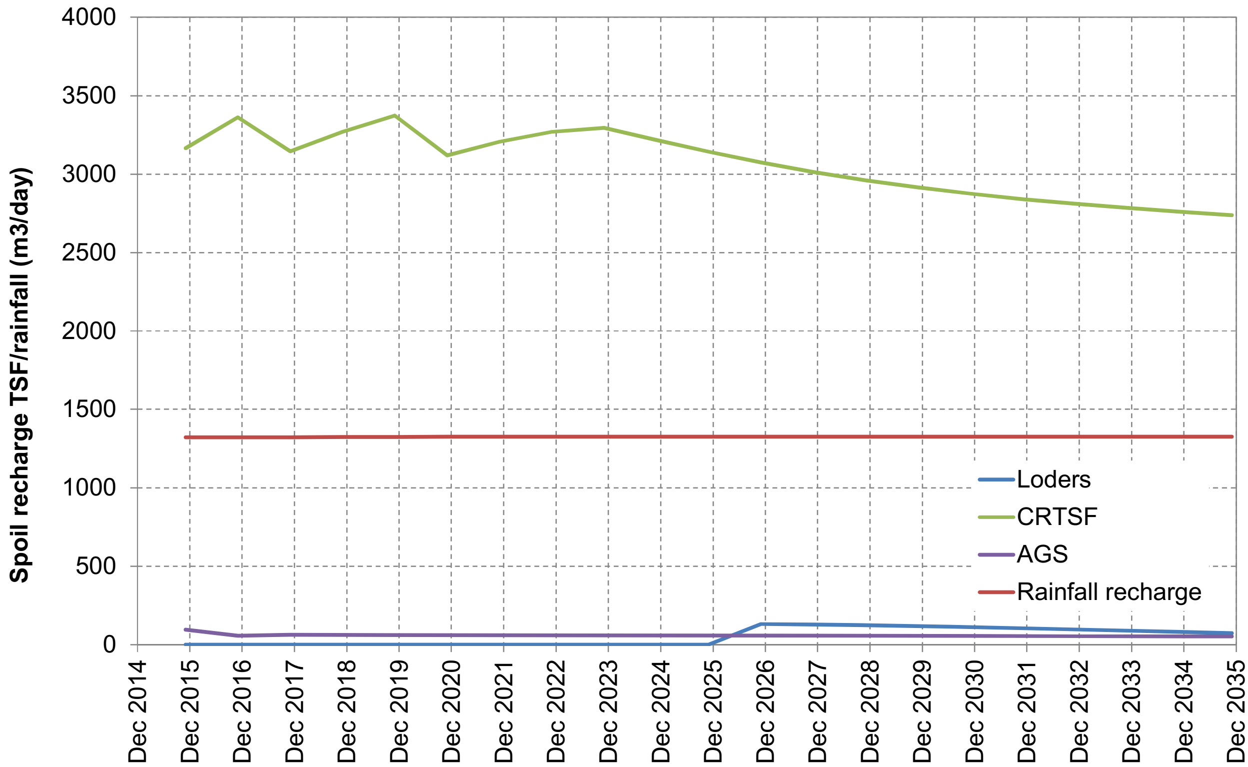


Figure 8.10: Spoil recharge rates from TSFs and rainfall infiltration

8.1.7. Water Quality and Leachate Migration

To protect surface water the AIP requires "no increase of more than 1% per activity in the long term average salinity in a highly connected surface water source at the nearest point to the activity". As discussed in Section 8.1.4, during operations the predicted depressurisation will decrease net baseflow to the Wollombi Brook. Section 8.1.1 discusses that there is head gradient at the end of mining from the Loders Pit spoil towards Wollombi Brook alluvium. It should be noted while in a net bulk sense there is a take from the Wollombi Brook alluvium, there remains an area adjacent to Loders Pit where mounded groundwater may flow from the spoil towards Wollombi Brook and the alluvium.

Loders Pit will be gradually filled with spoil and tailings to a level of 65mRL. A small depression will remain in the north western end of the previous void, about 10 m below the pre-mining ground level. Rainfall will gradually seep through the spoils and a mound of groundwater will develop within the spoil. The more permeable nature of the spoils means the groundwater levels are expected to rise above pre-mining levels, and there will be a net increase in the flow of groundwater from the mining spoils into the Wollombi Brook during and post mining.

Groundwater samples collected from monitoring bores installed within the Wollombi Brook alluvium indicate it is saline, between 15,000 µS/cm to 20,000 µS/cm. The groundwater seepage from the Mount Thorley spoil and void will be controlled by a range of factors including the recharge rate through the spoils and capped tailings, the mineralogy of the spoils / tailings, the flow rate through the spoils evaporative concentration in the remaining open void and prevailing climatic conditions. A salinity balance indicates that the electrical conductivity of the groundwater leaving the mined void and entering the alluvium will be significantly less saline and less than 10,000 µS/cm (WRM 2014). The landform that will remain post mining will therefore not degrade the beneficial use of the alluvial groundwater.

The Aquifer Interference Policy requires proposals do not increase the salinity of baseflow in streams fed by groundwater by more than 1%, which is essentially an undetectable change. The available data indicates that whilst there will be net outflow of groundwater from the final void, the volume will be limited (0.35 ML/day), and the outflowing water will have less salinity than the water that is naturally present within the alluvial system. The impact of the mining on the salinity of the baseflow in the Wollombi Brook will therefore be undetectable, as required by the Aquifer Interference Policy.

8.1.8. Water Licensing

The two key pieces of legislation for the management of water in NSW are the WM Act and the Water Act. Operations at MTW have the potential to interact with water sources that require licensing, namely:

- the Permian groundwater described in Section 5, which is not yet covered by a water sharing plan and is therefore still under the Water Act; and
- the alluvium associated with the Wollombi Brook and Hunter River, which is covered by the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (WSPHUAWS).

The Water Sharing Plan for the Hunter Regulated River Water Source 2003 (WSPHRRWS) is not relevant to the proposal as there will be no take from the Hunter River or other Hunter regulated water sources.

Coal & Allied will have sufficient water licenses in place to account for the predicted water takes summarised in Section 9 of this report.

8.1.9. Post Mining Recovery

The recovery model commenced from the end of mining and used the final groundwater levels at 2035 as the starting heads. The ’drains’ simulating groundwater inflow into the mining pits were removed at the end of mining in Loders pit in 2020 and TSF leakage was removed from the model in 2035 to simulate capping and enabled groundwater levels to recover.

In order to minimise long-term groundwater impacts, the Proposal includes backfilling of the Loders Pit final void to approximately 10 m below the original pre-mining land surface. Groundwater, surface runoff and rainfall inflows will slowly fill the backfilled void either forming a groundwater table within the backfill or a shallow surface water body in the limited depression. The water level will eventually reach an equilibrium influenced by the balance of seepages from groundwater, surface runoff / infiltration and losses from evaporation.

At the cessation of mining in 2020, there will be a relatively high hydraulic gradient between the open void and the surrounding areas, which will result in relatively high initial seepage rates to backfill. As watertable forms in the backfilled spoil, the gradient decreases and the rate of groundwater inflow to the dewatered area will slow. Eventually, a state of equilibrium will occur where inputs are balanced by outputs and the water level will have stabilised.

The rate of recovery of groundwater levels in the aquifers will be dependent on rainfall, with years of below average rainfall extending the recovery period, and wet years reducing the time for steady state conditions to be reached. Evaporation of ponded water from any final void water body results in a continuous flow of groundwater into the void, in an effect known as evaporative pumping. This results in groundwater levels attaining an equilibrium water level at a lower elevation than the pre-mining water level; this, however, is dependent on the magnitude of catchment inputs.

To calculate the recovery water level in the backfilled Loders void the backfill was simulated using calibrated spoil parameters for recharge, permeability and storage. A thin approximately 10 m thick final depression was introduced to the model above the final backfilled landform in Loders pit to analyse if a shallow pit lake would form in the depression or if a lake would form within the backfill.

The recovery model was run for a period of 1000 years post mining. Rainfall, evaporation and surface run-off to the shallow final void in the Loders pit area were supplied by WRM Consultants as used in their calculations of final void levels (WRM 2014b). Rainfall was a looped record of available data to simulate variable climatic periods. Inflows to the backfilled spoil area/ final void were through the recharge package in MODFLOW. Evapotranspiration was set using the final landform surface using the evapotranspiration package in MODFLOW.

Inflows and any potential outflows results from the simulation were supplied to WRM consultants for calculations of Loders final void water level and salinity. Figure 8.11 shows the groundwater inflows to the backfilled Loders pit area, where this is dominated by inflow from the spoil area around the capped CRTSF. As groundwater in the backfilled Loders pit area rises groundwater outflow occurs both to the north towards Warkworth Mine final void and west towards Wollombi Brook alluvium. Inflow from the Permian Coal Measures is negligible peaking at 2.1 m^3/day (0.8 ML/yr) 16 years after mining ceases dropping to long term rate of 0.5 m^3/day.

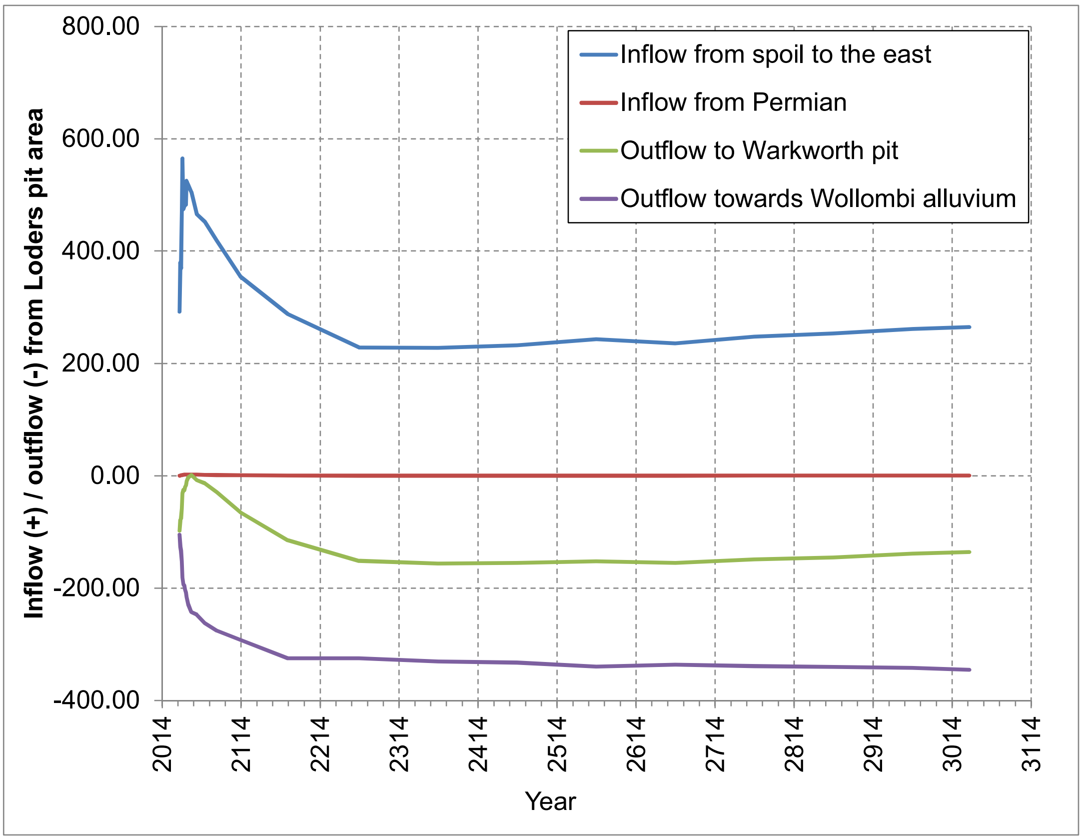
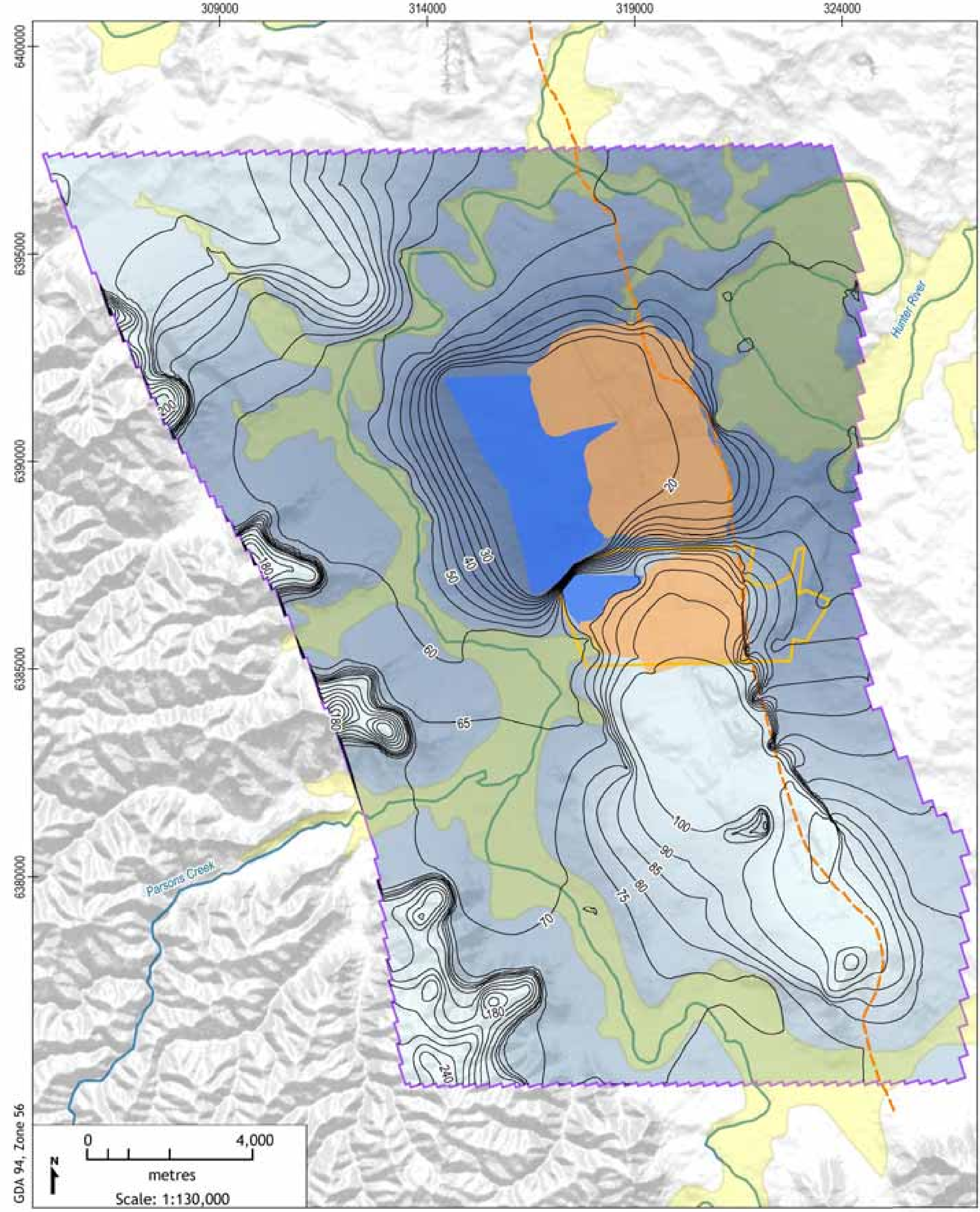


Figure 8.11: Inflows and outflows to the backfilled Loders void (m^3/day)

Groundwater levels within the backfilled Loders pit area recover within about 200 years to the final landform surface, suggesting that a marsh or even shallow pit lake may form in the shallow depression in Loders pit area. Figure 8.12 presents the predicted groundwater levels surrounding the final void post mining. WRM (2014b) using the OPSIM model calculated that intermittent surface water may pond in this area with open water RL between 66 mRL and 60 mRL.

WRM (2014b) also calculated and median EC for the ponded open water of 3000 µS/cm and a 90^{th} percentile value of 8,000 µS/cm. It is possible that mounded groundwater and / or ponded surface water of this EC range will form in the backfilled Loders pit and may migrate at a maximum rate of 345 m^3/day (4 L/s) towards Wollombi Brook alluvium. Both the rate of discharge and salinity are not deemed a threat to salinity increases above 1% in Wollombi Brook alluvium in the long term. Available monitoring data from alluvial monitoring bores west of Loders pit show salinity in excess of 15,000 µS/cm.

Long term post closure take from the Wollombi Brook alluvium due the recovery in groundwater levels reduces at the start of the recovery period from 162 m^3/day to a long term rate of less than 5 m^3/day 200 years after closure. Post closure take from the Wollombi Brook alluvium and the Brook itself peak at 60 ML/yr. Post closure take from the Hunter River and Hunter River Alluvium is negligible (0.3 ML/yr).



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Quaternary alluvium (100k)
- Subcrop of Jerrys Plains Formation
- Groundwater level contour
- Major watercourse
- Modelled pit lake
- Modelled spoil zone

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Water Levels in Post Mining Void

DATE: 14/5/2014

FIGURE No: **8.12**

Figure 8.13 shows the long term post closure net flow to alluvium recovers substantially and is less than the peak recorded during mining. The peak take from the alluvium simulated during mining is more than enough to account for long term effects post closure.

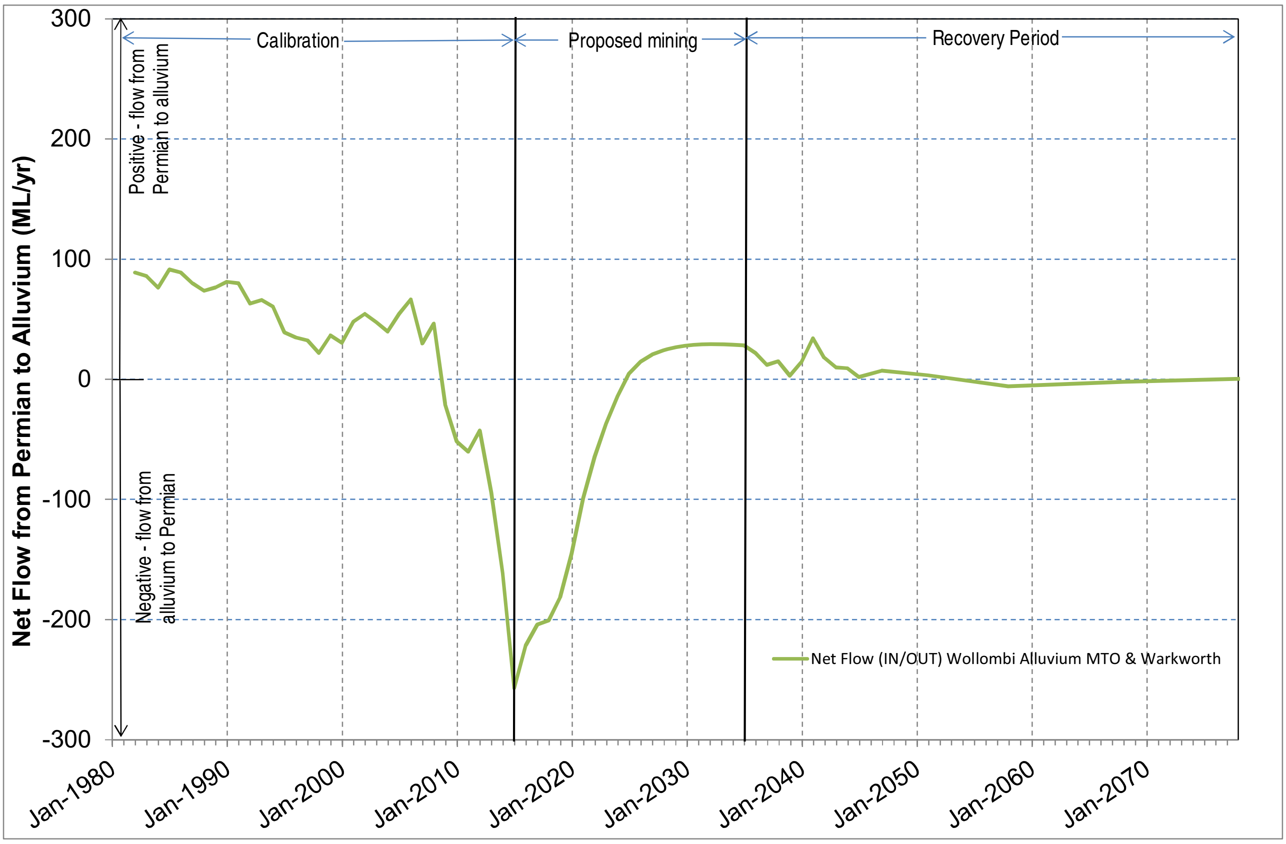


Figure 8.13: Recovery in net flows to Wollombi Alluvium

Due to a recovery in potentiometric levels post mining no additional private bore users will be affected post closure other than those already documented in this report.

8.2. Uncertainty Analysis

8.2.1. Background

This section assesses the uncertainty of the model predictions to natural variability in the calibrated parameters. Analysis of the uncertainty of model outputs is referred to as “uncertainty analysis”. Model calibration does not necessarily result in a unique set of parameter values, especially if the model employs a number of parameters to simulate system complexity. As the model was calibrated to known measurements, a calibration-constrained Monte Carlo analysis was carried out, rather than an unconstrained uncertainly analysis.

The objectives of uncertainty analysis were:

- to describe the numerical approach for quantification of uncertainty for this model; and
- to report the results of applying the methodology to estimate the potential uncertainty associated with the 30-year transient calibration model, and the 20-year development of mining areas.

Detailed reporting of the methodology, implementation, results and recommendations is presented as Appendix D.

Calibration-constrained Monte Carlo method for predictive uncertainty analysis uses many different parameter sets that still match (with certain level of misfit) the measured data. The level of misfit between modelled outcomes and measured field data is in proportion to potential measurement errors within observed data. These errors are represented by ranges defined by parameter bounds obtained by statistical analysis of field data. Two hundred such parameter sets, based on the calibrated mean and range of expected values, were generated. 200 models were rerun and checked against the baseline calibration statistics to ensure the model remained calibrated to observed data. 127 realised models were determined suitable and were therefore used in the calibration and predictive analysis.

It should be noted that the calibrated model used to base the uncertainty analysis on was not the final calibration discussed within this document. Time constraints to maintain the project deliverable meant that uncertainty analysis had to be conducted prior to final model completion. Although the uncertainty analysis was not based on the final model calibration the results of this analysis are still thought of worth in the discussion on the measurement error in the calibration.

All hydraulic parameters explored in the automatic calibration were explored in the analysis, including horizontal hydraulic conductivity, vertical hydraulic conductivity multipliers, specific storage, specific yield, groundwater recharge, and riverbed conductance.

8.2.2. Results

Results from the uncertainty analysis have been discussed in the context of the predicted impacts during mining to put potential errors bars around predictive results. In each case the 95th percentile worst case result from the uncertainty analysis has been discussed.

8.2.2.1. Drawdowns

Figure 8.14 shows the 2 m drawdown (Layer 1 and Layer 9) from the calibrated model against the 95th percentile 2 m drawdown from the uncertainty analysis. The 95th percentile drawdown in Layer 1 extends further west than the calibrated predictive model and extends under the Wollombi Brook river boundary condition. The effects of the river boundary condition were also investigated and discussed earlier within Section 8. The extent of drawdown in Layer 1 for the 95th percentile case are thought to be exaggerated by the way in which the 'mine' and 'no-mine' scenarios were simulated.

The 95th percentile drawdown in Layer 9 can be seen to extend further west and north below Wollombi Brook than the calibrated model. It should be noted that the 95th percentile drawdown in Layer 9 does not extend as far as the predictive model to the south west of Bulga Mine. This is a result of differences in spoil parameter base case model parameterisation between the comparison runs.

8.2.2.2. Groundwater Users

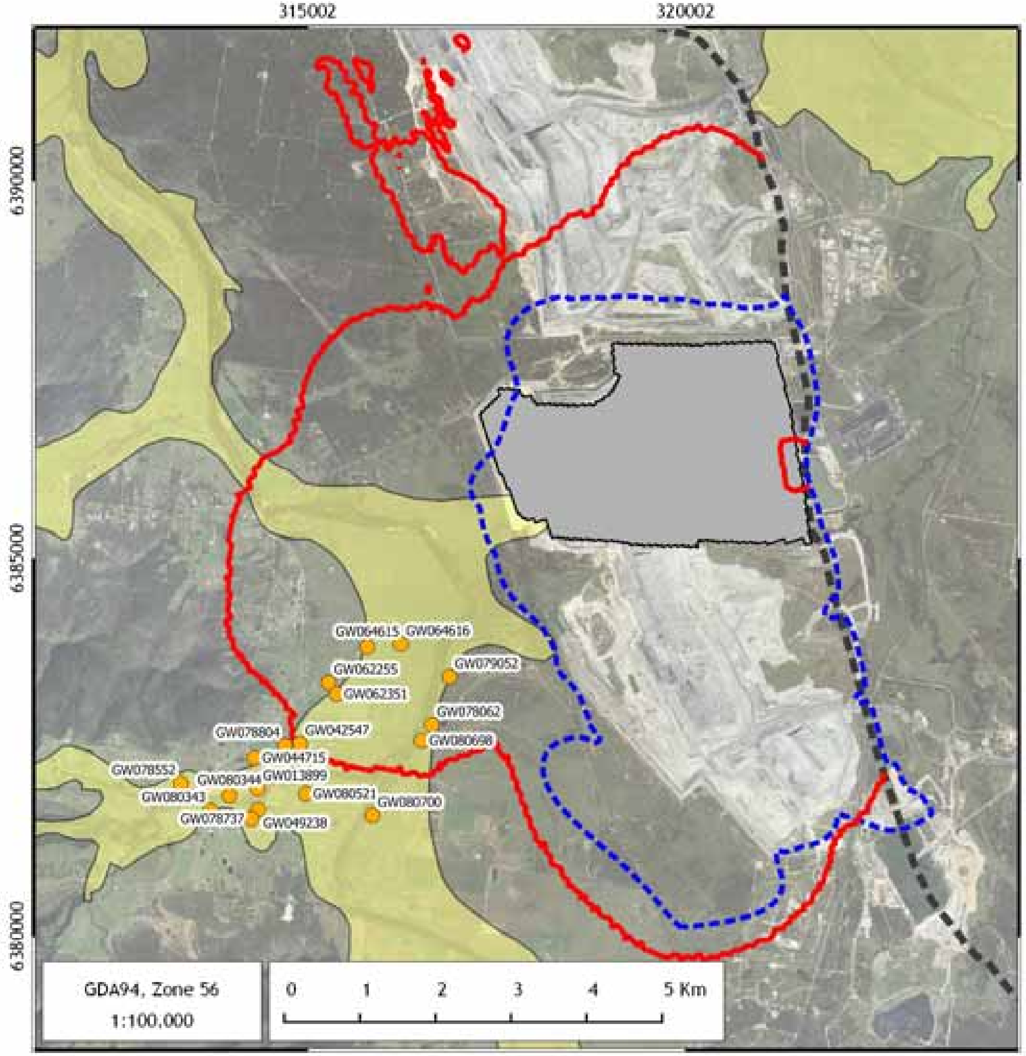
The uncertainty analysis 95th percentile drawdown identified 18 additional bores within Wollombi Brook alluvium or shallow regolith (Layer 1) with >1m drawdown compared to the bores already identified in Section 8. Table 8.2 and Figure 8.14 shows details of the 18 bores. Six appear to be on the east of Wollombi Brook on land owned by Bulga Mine, the rest of the bores appear to be private. The largest worst case 95th percentile drawdown is 3.55m at bore GW062255.

The 95th percentile drawdown in the Permian strata identified no additional private bores would be impacted by the Proposal over those already discussed in Section 8.1.2.

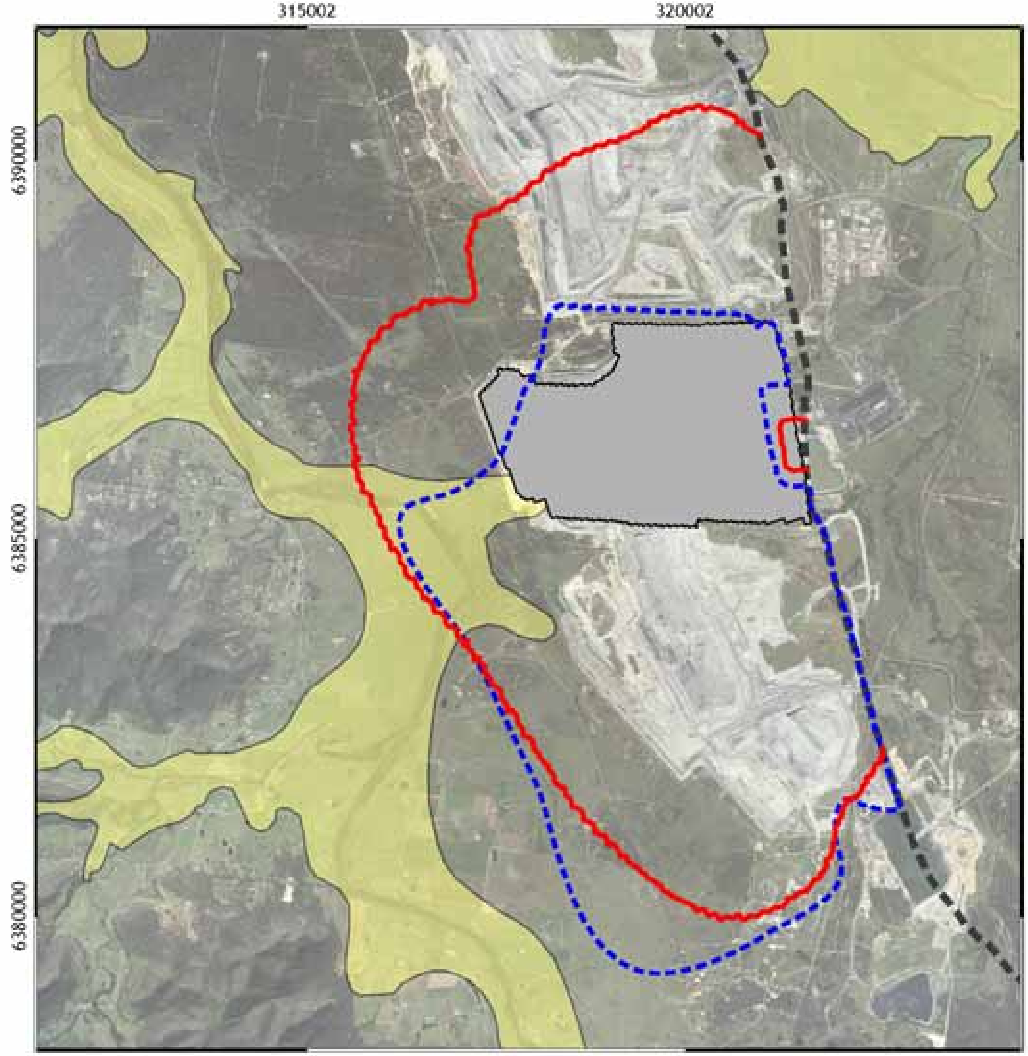
Table 8.2: IMPACTS OF THE MINING ACTIVITIES ON GROUNDWATER USERS

Bore ID	Easting	Northing	Formation	Owner	95th Percentile Drawdown (m)
GW064616	316236	6383867	Alluvium	Bulga Mine owned land	8.76
GW079052	316880	6383433	Alluvium	Bulga Mine owned land	7.38
GW064615	315793	6383828	Alluvium	Bulga Mine owned land	7.32
GW078062	316646	6382796	Alluvium	Bulga Mine owned land	3.8
GW062255	315281	6383356	Alluvium	Private	3.55
GW062351	315388	6383204	Alluvium	Private	3.33
GW080698	316514	6382589	Alluvium	Bulga Mine owned land	3.12
GW042547	314905	6382548	Alluvium	Private	2.06
GW078804	314701	6382520	Alluvium	Private	1.85
GW080521	314977	6381886	Alluvium	Private	1.59
GW013899	314343	6381952	Alluvium	Private	1.45
GW044715	314302	6382362	Alluvium	Private	1.44
GW049238	314348	6381675	Alluvium	Private	1.4
GW078737	314261	6381555	Alluvium	Private	1.34
GW080344	313969	6381859	Alluvium	Private	1.29
GW080700	315862	6381598	Alluvium	Bulga Mine owned land	1.23
GW080343	313719	6381665	Alluvium	Private	1.19
GW078552	313325	6382024	Alluvium	Private	1.14

Layer 1



Layer 9



LEGEND

- Groundwater users - 95th percentile drawdown > 1m
- Calibrated model 2m drawdown
- 95th percentile 2m drawdown
- Mt Thorley mine
- Alluvium
- Subcrop line Jerrys Plains

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

95th percentile 2m drawdown extent - Layer 1 and Layer 9

DATE
14/5/2014

FIGURE No:
8.14

8.2.2.3. Impact on Alluvium

The predictive model simulation shows a gradual increase in take from the Wollombi Brook alluvium to a peak calculated take of 532 m^3/day (195 ML/yr) at year 2019, which corresponds to the final year of active mining simulated in Loders Pit. The 95th percentile worst case take from the Wollombi Brook Alluvium is 609 m^3/day (222 ML/yr). This is a 15% increase over the calibrated predicative model and shows relatively tight variance in the uncertainty results.

8.2.2.4. Groundwater Inflow to Mining Areas

The predictive model simulation showed inflow from the Permian to the Loders open pit peaks at 1,064 m^3/day (389 ML/yr) in 2015. The 95th percentile worst case inflows peak at 2736 m^3/day (999 ML/yr) is also at 2015. This is a 157% increase over the calibrated predicative model and shows the largest variance in the analysed uncertainty results.

9 COMPLIANCE

Assessment of the proposed modification against the NSW AIP is detailed under Section 9.1 to Section 9.3, below.

9.1. Accounting for, or Preventing the Take of Water

Table 9.1: ACCOUNTING FOR OR PREVENTING THE TAKE OF WATER

AIP Requirement		Proponent Response
1	Described the water source (s) the activity will take water from?	Based on the AIP the groundwater system impacted by the proposed modification can be separated into two systems, as follows: • porous and/or fractured consolidated sedimentary rock of the Permian coal measures; and • groundwater within alluvium associated with the Wollombi Brook and Hunter River alluvium. Water quality and yields for the coal measures and Wollombi Brook is considered a less productive aquifer according to the AIP, while the Hunter River alluvium is considered a highly productive aquifer.
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	Predicted peak annual take from: • Permian coal measures: 389ML/yr • Wollombi Brook alluvium: 194ML/yr • Wollombi Brook (surface water): 110ML/yr (accounted for in the alluvial take) • Hunter River alluvium: none • Hunter River (surface water): none See Section 8 for further details.
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?	Predicted take from: • Permian coal measures: 0.8ML/yr • Wollombi Brook alluvium: 60ML/yr • Wollombi Brook (surface water): 60ML/yr (accounted for in the alluvial take) • Hunter River alluvium: 0.3ML/yr • Hunter River (surface water): 0.3ML/yr (accounted for in the alluvial take) See Section 8 for further details.
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (page 27)	Based on 3D numerical modelling
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?	Predicted take from: • Permian coal measures: 0.8ML/yr • Wollombi Brook alluvium: 60ML/yr • Wollombi Brook (surface water): 60ML/yr (accounted for in the alluvial take) • Hunter River alluvium: 0.3ML/yr • Hunter River (surface water): 0.3ML/yr (accounted for in the alluvial take) See Section 8 for further details.
6	Described how any licence exemptions might apply?	Not necessary.
7	Described the characteristics of the water requirements?	There are no water requirements; however, additional interception of groundwater due to the proposed modification is predicted.
8	Determined if there are sufficient	Coal & Allied will make sure appropriate water license are in place to account for

Table 9.1: ACCOUNTING FOR OR PREVENTING THE TAKE OF WATER		
AIP Requirement		Proponent Response
	water entitlements and water allocations that are able to be obtained for the activity?	predicted takes. See Section 8.1.8 for further details
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?	Compliant – see Section 8 of report
10	Determined how it will obtain the required water?	Via seepage to the high-wall face, but most will likely evaporate or be removed as moisture in coal and will not enter the site water circuit.
11	Considered the effect that activation of existing entitlement may have on future available water determinations?	
12	Considered actions required both during and post-closure to minimize the risk of inflows to a mine void as a result of flooding?	Flood assessment was undertaken as part of the Warkworth Extension Project. The results indicated that the Project's footprint was above the 1 in 100 year ARI flood event.
13	Developed a strategy to account for any water taken beyond the life of the operation of the project?	Surrender of existing water entitlements that are used to license take of water.
	Will uncertainty in the predicted inflows have a significant impact on the environment or other authorized water users? *Items 14-16 must be addressed if so.*	Risks to groundwater systems are low as the proposal does not entail any modification to the disturbance footprint, and involves resurfacing of the final mine void. Uncertainty analysis, presented in Section 8.2, indicates that the predicted impact on alluvium has a relatively low degree of uncertainty (±15%). However, the predicted inflows from Permian units shows a high degree of uncertainty (±150%)
14	Considered any potential for causing or enhancing hydraulic connections, and quantified the risk?	See Section 8 of report
15	Quantified any other uncertainties in the groundwater or surface water impact modeling conducted for the activity?	Risks to groundwater systems are low as the proposal does not entail any modification to the disturbance footprint, and involves backfilling of the final mine void. Available monitoring data indicates the two existing groundwater models MER (2002) and AGE (2010), and the current model results presented in this report have been relatively conservative. Despite this conservatism the predicted impacts are still negligible and manageable, so the uncertainty in the predictions is not considered to have the potential to impact on the environment or water users.
16	Considered strategies for monitoring actual and reassessing any predicted take of water throughout the life of the project, and how these requirements will be accounted for?	Yes. See Section 10 of report

9.2. Determining Water Predictions in Accordance with AIP (Section 3.2.3)

Table 9.2: DETERMINING WATER PREDICTIONS		
AIP Requirement		Proponent response
1	Addressed the minimum requirements found on page 27 of the AIP for the estimation of water quantities both during and following cessation of the proposed activity?	Based on conservative numerical modelling, see Section 8 and Appendix C of report.

9.3. Other Requirements to be Reported in Accordance with AIP (Section 3.2.3)

Table 9.3: OTHER REQUIREMENTS		
AIP Requirement		Proponent response
1	Establishment of baseline groundwater conditions?	Compliant – see Section 5 of report.
2	A strategy for complying with any water access rules?	Water licences held by or will be purchased by proponent.
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	No predicted impact of over 2m for water supply bores in alluvium or Permian. Predicted impacts over 2m are restricted to bores located on land owned by adjoining mines. See Section 8.1.2
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?	No predicted impact of over 2m for water supply bores in alluvium or Permian. Predicted impacts over 2m are restricted to bores located on land owned by adjoining mines. See Section 8.1.2
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	None predicted - see Section 8.1.5 of report
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	None predicted - see Section 8.1.5 of report
7	Potential to cause or enhance hydraulic connection between aquifers?	None predicted - see Section 8 of report
8	Potential for river bank instability, or high-wall instability or failure to occur?	Not assessed, but improbable.
9	Details of the method for disposing of extracted activities (for CSG activities)?	N/A

10 MITIGATION AND MONITORING

10.1. Review of Current Monitoring Programme

Groundwater management is currently undertaken based on the existing MTW groundwater monitoring program, which is included in the Water Management Plan (WMP) (Coal & Allied, 2013). The WMP includes scheduled monitoring of 30 groundwater monitoring bores within and around MTW. Review of the MTW groundwater database indicates that groundwater level data is currently collected at 50 monitoring locations (see Appendix A).

The Groundwater Monitoring Programme (Appendix F of WMP) details that the monitoring bores will be monitored for field parameters of pH, EC and water level on a quarterly basis, and a comprehensive water quality analysis conducted annually.

Review of the MTW groundwater database indicates that the groundwater samples are being collected on an annual basis for all bores.

10.2. Proposed Amendments to Monitoring Programme

The following recommendations are made to update the existing monitoring programme, to assist ongoing assessment and quantification of any potential surface water and groundwater impacts:

- Installation of nested monitoring bores along the Wollombi Brook (PZ10, PZ11, PZ12).

Yearly audits of the performance of the monitoring network should also be included as part of the annual groundwater review, and optimisation of the monitoring sites and frequency should be undertaken where required.

10.3. Mine Water Seepage Monitoring

It is recommended that monitoring of mine water seepage be undertaken, particularly to identify seepage rates and quality. The seepage monitoring program should include:

- recording of the time, location and estimated volume of any unexpected increased groundwater outflow from the high-wall and end-wall;
- measurement of water pumped from the void, preferably using flow meters or other suitable gauging apparatus;
- correlation of rainfall records with mine seepage records so groundwater and surface water can be separated; and
- monitoring of coal moisture content.

10.4. Trigger Values

Trigger values provide a quantifiable measure for identifying adverse changes in groundwater levels and quality. The existing WMP (Coal & Allied, 2013) details that key water quality triggers include pH, EC and Total Suspended Solids (TSS). In the absence of licence or applicable ANZECC (2000) criteria, the 95th percentile of the available data is adopted and compared to monitoring results on a monthly basis. Water quality trigger levels at the 95th / 5th percentile, based on baseline data, is considered adequate to identify mine related impacts, while still accounting for natural and seasonal variations.

As detailed in the WMP A site specific investigation into trigger level exceedance if:

- *“professional judgement determines that the single deviation or a developing trend could result in environmental harm; or*
- *Three consecutive measurements exceed trigger values.”*

10.5. Data Management and Reporting

It is recommended that data management and reporting include:

- establishment of trigger levels;
- quarterly review of groundwater levels and field water quality against trigger levels, with site specific investigations initiated, as detailed in Section 10.4;
- annual reporting (including all water level and water quality data); and
- all groundwater data should be stored in a database customised for MTW with suitable QA / QC controls.

10.6. Future Model Iterations

Every three years the validity of the model predictions should be assessed. If these data indicate substantial differences (previously unrecognised information) to those interpreted, these data should be incorporated into the model and revised predictions made and reported.

10.7. Make Good Agreements

According to the AIP, make good agreements are required when a 2 m or greater cumulative decline occurs at any water supply work. As detailed in Section **Error! Reference source not found.**, drawdowns of greater than 2 m are not predicted to occur at any privately owned bores.

11 CONCLUSION

Mount Thorley Operations is an open cut coal mine approximately 10.5 kilometres south-west of Singleton in the Hunter Valley, NSW. Mining commenced in 1981, and much of the coal resource has been removed and the site rehabilitated. The operator of the mine, Coal and Allied seeks to extend the current approval, which expires in 2017, by a further 18 years until 2035. This additional time will allow Coal and Allied time to complete remaining mining of Loders Pit by 2020, and Abbey Green North Pit by 2023. Loders pit will then be backfilled with spoil trucked in from the Warkworth Mine and used to store tailings until 2035.

All available geological and groundwater data was assessed to develop a conceptual understanding of the hydrogeological regime at MTO. As shown in Figure 5.3, the coal measures of the Jerrys Plains Subgroup dip towards the west of the MTO. The multiple coal seams in the Jerrys Plains Sub-group form low to moderately permeable aquifer, confined by very low yielding interburden / overburden. The coal measures sub-crop immediately east of the mine area, along the Mt Thorley Monocline, with the basal Archerfield Sandstone and Bulga Formation of the Vane Subgroup underlying the Hunter River.

Groundwater levels within the Permian stratigraphy are highly influenced by existing mining, flowing towards the active open-cut pits at MTW (see Figure 5.5). The Permian stratigraphy is recharged where it occurs at sub-crop, to the east. However, the saline water quality and high ion concentrations indicate that the Permian groundwater has a low rate of recharge. Groundwater within the Wollombi Brook alluvium appears to be unaffected by current mining, and contains brackish to saline groundwater. Review of stream flow levels and alluvial groundwater levels indicates that the Wollombi Brook west of MTO is a gaining stream (baseflow contributions from Permian), while to the north it is likely a losing stream (downward leakage to Warkworth Sands and Permian stratigraphy).

Review of the NSW groundwater database (PINEENA, 2013) identified that there are numerous private groundwater users along Wollombi Brook, primarily accessing the alluvial groundwater. There are also some private bores intercepting the Permian stratigraphy, however, these are largely located on land owned by mines. There are also GDEs identified from previous studies along the Wollombi Brook (see Figure 5.11).

Results from the numerical groundwater model identified:

- minor impact on the Wollombi Brook alluvium, with:
  - drawdown levels within the Wollombi Brook alluvium is largely predicted to be less than 1 m at the end of mining;
  - predicted reduction in baseflow to the Wollombi Brook (all reaches) at a maximum rate of 300 m^3/day (110 ML/yr) at 2020;
  - predicted maximum additional take from the Wollombi Brook alluvium (at the end of mining) is estimated at 532 m^3/day (194 ML/yr); and
  - as spoil is placed in Loders Pit, after 2019, the predicted take from the Wollombi alluvium decrease to a rate of 320 m^3/day (117 ML/yr);
- no impact on the Hunter River and Hunter River alluvium, with:
  - drawdown in the Hunter River alluvium is less than 1 m;
  - there is no detectable reduction in baseflow to the Hunter River; and
  - there is no detectable take from the Hunter River alluvium;
- minor impact on groundwater users, with:

    - no predicted drawdown in any private water supply bores within alluvium;
    - there are no drawdowns of over 2 m are predicted for private water supply bores within the Permian units; and
    - no predicted impacts on GDEs relating to the Warkworth Sands, as it has a perched groundwater system that is not in direct hydraulic connection with the underlying Permian fractured rock;
- mine pit inflow estimates of:
    - predicted inflow to the proposal from the Permian units is highest during the first year of mining (2015), at a rate of 1,064 m^3/day (389 ML/yr); and
    - predicted inflows from the spoil into the proposal peaks at a maximum of 3,721 m^3/day in 2017;
- predicted groundwater levels within the reshaped (to 10 m depth) final void will slowly recover and reach equilibrium at about 70 mRL to 75 mRL, after approximately 1000 years post mining; and
- salinity balance indicates that the electrical conductivity of the groundwater leaving the mined void and entering the alluvium will be less than 10,000 µS/cm. This is well below recorded salinity levels within the Wollombi Brook alluvium (see Section 5.8); therefore, the final landform will not degrade the beneficial use of the alluvial groundwater.

Ongoing groundwater monitoring will be undertaken as per the existing requirements under the WMP (Coal & Allied, 2013), with additional recommendations to improve the program stipulated under Section 10.

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LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of EMGA Mitchell McLennan in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in Proposal dated 11 February 2014, and Change of Scope dated 24 February 2014 and 2 May 2014.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

This study was undertaken between 20 January 2014 and 21 May 2014 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Appendix A

Monitoring Bore Summary Table

Table A- 1- MONITORING BORE SUMMARY

Bore ID	Alternate ID	Easting	Northing	Type	Collar Elevation mRL	Target Formation Bottom	SWL (mRL)		Model Layer
							Av.	Q4 2013	
OH786	OH786	320542	6392674	Standpipe	55.65	Alluvium	53.9	49.8	1
OH787	OH787	320982	6391921	Standpipe	49.96	Alluvium	36.0	36.3	1
OH788	OH788	321482	6390967	Standpipe	45.38	Alluvium	35.7	35.8	1
OH942	OH942	320536	6392622	Standpipe	55.75	Alluvium	46.9	46.7	1
OH943	OH943	321476	6390963	Standpipe	45.04	Alluvium	35.7	35.9	1
OH944	OH944	321113	6391035	Standpipe	47.88	Alluvium	40.1	40.2	1
OH1121	OH1121 (1?)	321902	6391030	Standpipe	45.64	Vaux Seam	35.1	35.4	15
OH1122 (1)	OH1122 (1)	318545	6387877	Standpipe	101.19	Blakefield Seam	52.7	55.8	7
OH1122 (2)	OH1122 (2)	318545	6387877	Standpipe	101.18	Woodlands Hill Seam*	44.4	-	9
OH1122 (3)	OH1122 (3)	318545	6387877	Standpipe	101.15	Bowfield Seam*	42.4	30.0	11
OH1123 (1)	OH1123 (1)	316967	6389501	Standpipe	99.2	Woodlands Hill Seam	51.8	51.5	9
OH1123 (2)	OH1123 (2)	316967	6389501	Standpipe	99.22	Blakefield Seam	47.6	40.3	7
OH1123 (3)	OH1123 (3)	316967	6389501	Standpipe	99.18	Bowfield Seam	45.4	39.7	11
OH1124 (1)	OH1124 (1)	316893	6391526	Standpipe	88.2	Unknown - no depth info		-	7
OH1124 (2)	OH1124 (2)	316893	6391526	Standpipe	88.2	Unknown - no depth info	41.8	-	9
OH1124 (3)	OH1124 (3)	316893	6391526	Standpipe	88.2	Unknown - no depth info	42.1	-	11
OH1125 (1)	OH1125 (1)	316511	6392875	Standpipe	85.4	Unknown - no depth info	58.0	59.8	7
OH1125 (2)	OH1125 (2)	316511	6392875	Standpipe	85.4	Unknown - no depth info	60.0	-	9
OH1125 (3)	OH1125 (3)	316511	6392875	Standpipe	85.4	Unknown - no depth info	39.8	49.9	11
OH1126	OH1126	318579	6393394	Standpipe	63.7	Vaux Seam*	53.4	50.7	15
OH1127	OH1127(1?)	321444	6392097	Standpipe	51.22	Bayswater Seam*	35.5	35.6	16
OH1137	OH1137	318266	6393377	Standpipe	67.7	Vaux Seam	57.0	55.5	15
OH1138 (1)	OH1138 (1)	317835	6393346	Standpipe	70.72	Warkworth Seam	62.9	61.8	12
OH1138 (2)	OH1138 (2)	317835	6393346	Standpipe	70.72	Warkworth Seam	57.7	56.4	13
GW9706	GW9706	322404	6387589	Standpipe	64.24	Bayswater Seam*	62.1	61.9	16
GW9707	GW9707	322319	6387569	Standpipe	63.93	Bayswater Seam*	60.8	60.3	16
GW9708	GW9708	322158	6387209	Standpipe	73.14	Bayswater Seam*	61.6	60.9	16
GW9709	GW9709	322251	6388026	Standpipe	60.33	Bayswater Seam*	53.6	51.4	16
G3	G3	317786	6385251	Standpipe	73.04	Wambo Seam*	30.5	20.3	5
WOH2141A	PZ6	314989	6392647	Standpipe	91.59	Wynot Seam B-D	0.0	-	6
WOH2141B	PZ6	314989	6392647	Standpipe	91.52	Blakefield Seam - E, F	0.0	51.1	7
WOH2139A	PZ5	315249	6391511	Standpipe	91.71	Blakefield Seam - E, F	0.0	54.5	7
WOH2153A	PZ2	313881	6391429	Standpipe	68.26	Redbank Creek Seam - D, E	0.0	59.8	4
WOH2153B	PZ2	313881	6391429	Standpipe	68.26	Wambo Seam - B, C	0.0	61.9	5
WOH2154A	"PZ1"	313976	6389990	Standpipe	68.89	Redbank Creek Seam - D, E	0.0	57.6	4
WOH2154B	"PZ1"	313976	6389990	Standpipe	68.65	Wambo Seam - B, C	0.0	60.7	5
WOH2155A	PZ4	315278	6390138	Standpipe	74.55	Redbank Creek Seam - D, E	0.0	67.5	4
WOH2155B	PZ4	315278	6390138	Standpipe	74.55	Wambo Seam - B, C	0.0	59.8	5
WOH2156A	PZ3	315874	6388866	Standpipe	80.38	Redbank Ck Seam - D, E	0.0	66.5	4
WOH2156B	PZ3	315874	6388866	Standpipe	80.38	Wambo Seam - B, C	0.0	69.5	5
PZ7D	PZ7D	314057	6392684	Standpipe	58.42	Shallow overburden	51.6	51.8	2

Table A- 1- MONITORING BORE SUMMARY									
Bore ID	Alternate ID	Easting	Northing	Type	Collar Elevation mRL	Target Formation Bottom	SWL (mRL)		Model Layer
							Av.	Q4 2013	
PZ7S	PZ7S	314055	6392671	Standpipe	58.44	Alluvium/*Whybrow Seam /OVB	51.3	51.5	1
PZ8D	PZ8D	317001	6385418	Standpipe	65.77	Shallow overburden	60.1	59.0	2
PZ8S	PZ8S	317002	6385411	Standpipe	65.75	Alluvium	60.5	60.6	1
PZ9D	PZ9D	317541	6385652	Standpipe	65.52	Shallow overburden	58.6	52.0	2
PZ9S	PZ9S	317542	6385642	Standpipe	65.43	Alluvium	61.6	60.7	1
GW98 MTCL1	GW98 MTCL1	322188	6387032	Standpipe	77.75	Bayswater Seam*	67.2	66.3	16
GW98 MTCL2	GW98 MTCL2	322669	6387462	Standpipe	79.47	Bayswater Seam*	70.0	69.3	16
WD609	UG_10	318803	6392211	VWP	129.98	Spoil	0.0	45.7	1
WD615_P1	UG_15_VWP1	319281	6391347	VWP	159.96	Piercefeild Seam	0.0	32.0	14
WD615_P2	UG_15_VWP2	319281	6391347	VWP	159.96	Bayswater Seam	0.0	39.2	16
WD625_P1	UG_16_VWP1	314663	6390483	VWP	76.42	Woodlands Hill Seam	0.0	44.3	9
WD625_P3	UG_16_VWP3	314663	6390483	VWP	76.42	Vaux Seam	0.0	34.3	15
WD625P	UG_16	314669	6390487	Standpipe	76.4	Whybrow Seam	0.0	57.9	2
WD622_P1	UG_24_VWP1	316236	6389588	VWP	84.52	Wambo Seam	0.0	58.0	5
WD622_P2	UG_24_VWP2	316236	6389588	VWP	84.52	Woodlands Hill Seam	0.0	33.6	9
WD622_P3	UG_24_VWP3	316236	6389588	VWP	84.52	Mt Arthur Seam	0.0	31.3	13
WD622_P4	UG_24_VWP4	316236	6389588	VWP	84.52	Vaux Seam	0.0	28.8	15
WD622_P5	UG_24_VWP5	316236	6389588	VWP	84.52	Bayswater Seam	0.0	34.6	16
WD622P	UG_24	316229	6389585	Standpipe	84.46	Wambo Seam			5
MTD613	UG_48	320778	6387025	VWP	150.45	Broonie Seam (possible)/Bayswater	50.8	50.7	16
MTD605_P1	UG_49_VWP1	317265	6386174	VWP	77.08	Weathering zone above Whybrow Seam*	54.6	54.0	2
MTD605_P2	UG_49_VWP2	317265	6386174	VWP	77.08	Whybrow Seam*	59.8	56.5	3
MTD605_P3	UG_49_VWP3	317265	6386174	VWP	77.08	Between Wambo and Whynot seams	47.8	47.3	6
MTD605_P4	UG_49_VWP4	317265	6386174	VWP	77.08	Blakefield Seam	30.9	28.2	7
MTD605_P5	UG_49_VWP5	317265	6386174	VWP	77.08	Mt Arthur Seam	13.4	12.1	13
MTD605_P6	UG_49_VWP6	317265	6386174	VWP	77.08	Vaux Seam	33.0	31.0	15
MTD605_P7	UG_49_VWP7	317265	6386174	VWP	77.08	Bayswater Seam	36.4	35.0	16
MTD614_P1	UG_50_VWP1	317265	6386174	VWP	72.43	Whybrow Seam	49.0	48.3	3
MTD614_P2	UG_50_VWP2	317265	6386174	VWP	73.43	Glen Munro Seam	26.5	20.2	8
MTD614_P3	UG_50_VWP3	317265	6386174	VWP	74.43	Mt Arthur Seam	27.9	27.0	13
MTD614_P4	UG_50_VWP4	317265	6386174	VWP	75.43	Vaux Seam	28.0	26.7	15
MTD614_P5	UG_50_VWP5	317265	6386174	VWP	76.43	Bayswater Seam	38.6	39.2	16
WD456_P1	C09_21_P1	317929	6388545	VWP	100.59	Vaux Seam	24.8	-	15
WD456_P2	C09_21_P2	317929	6388545	VWP	100.59	Bowfield Seam	-10.2	52.0	11
WD456_P3	C09_21_P3	317929	6388545	VWP	100.59	Blakefield Seam	82.9	60.7	7
WD462_P1	C09_04_P1	315529	6391358	VWP	101.67	Vaux Seam	25.2	17.8	15
WD462_P2	C09_04_P2	315529	6391358	VWP	101.67	Bowfield Seam	10.7	8.3	11
WD462_P3	C09_04_P3	315529	6391358	VWP	101.67	Woodlands Hill Seam	34.2	29.9	9
MTD517_P1	UG09_21_P1	317521	6386147	VWP	77.27	Mt Arthur Seam	30.6	26.9	13
MTD517_P2	UG09_21_P2	317521	6386147	VWP	77.27	Woodlands Seam	18.7	10.5	9

Table A- 1- MONITORING BORE SUMMARY									
Bore ID	Alternate ID	Easting	Northing	Type	Collar Elevation mRL	Target Formation Bottom	SWL (mRL)		Model Layer
							Av.	Q4 2013	
MTD517_P3	UG09_21_P3	317521	6386147	VWP	77.27	Wambo Seam*	49.2	47.4	5
MTD518_P1	UG09_20_P1	316512	6386156	VWP	79.96	Mt Arthur Seam	38.7	37.0	13
MTD518_P2	UG09_20_P2	316512	6386156	VWP	79.96	Blakefield Seam/Woodlands Hill	40.5	40.5	9
MTD518_P3	UG09_20_P3	316512	6386156	VWP	79.96	Wambo Seam	45.1	44.0	5

Notes: Projection MGA94 Zone 56

* in Target Formation infers a best estimate was made based on available data

Appendix B

HISTORIC WATER QUALITY DATA (1993 – 2013)

APPENDIX B: Historic Water Quality Data (1993 - 2013)

Bore ID	Alternate ID	Target Formation Bottom	Model Layer	EC (Field)			PH (Field)			Ca (mg/L)			Mg (mg/L)			K (mg/L)			SO_4 (mg/L)			P (mg/L)			Na (mg/L)		
				Median	5%	95%	Median	5%	95%	Median	5%	95%	Median	5%	95%	Median	5%	95%	Median	5%	95%	Median	5%	95%	Median	5%	95%
WRM 2014		**Wollombi Brook**	**1**	764	368	1060	7.4	7.0	8.0	14	12	15	18	16	19	5	4	6	5	2	13	0.02	0.02	0.02	104	102	110
OH786	OH786	Alluvium	1	931	931	21270	7.4	7.4	8.0	70	70	130	22	22	38	11	11	15	18	18	90	1.25	1.25	2.82	89	89	191
OH787	OH787	Alluvium	1	17230	17230	26700	7.6	7.6	8.0	95	95	170	323	323	339	40	40	47	244	244	275	1.46	1.46	2.89	3770	3770	4009
OH788	OH788	Alluvium	1	12590	12590	27800	7.4	7.4	8.0	145	145	181	219	219	296	37	37	60	427	427	537	0.34	0.34	1.03	2040	2040	2636
OH942	OH942	Alluvium	1	13505	13505	26365	6.8	6.8	8.3	120	120	191	651	651	896	40	40	64	863	863	929	0.10	0.10	0.33	4140	4140	5432
OH943	OH943	Alluvium	1	8520	8520	9626	7.5	7.5	8.3	36	36	104	186	186	195	33	33	36	153	153	153	10.55	10.55	12.76	1515	1515	1547
OH944	OH944	Alluvium	1	7710	7710	8847	7.8	7.8	8.9	35	35	51	54	54	55	30	30	31	750	750	794	0.55	0.55	6.15	1650	1650	1740
PZ7S	PZ7S	Alluvium?	1	1563	1563	2152	6.9	6.9	7.6	46	46	66	37	37	60	10	10	10	19	19	21	0.57	0.57	1.19	208	208	219
PZ8S	PZ8S	Alluvium	1	14335	14335	15245	6.7	6.7	7.0	109	109	113	337	337	374	17	17	18	493	493	505	0.08	0.08	0.08	2780	2780	2859
PZ9S	PZ9S	Alluvium	1	15130	15130	16620	6.8	6.8	6.9	95	95	99	554	554	755	71	71	79	821	821	859	0.14	0.14	0.20	2775	2775	2900
PZ7D	PZ7D	Shallow overburden	2	1730	1730	2084	8.0	8.0	8.1	14	14	23	15	15	26	6	6	6	31	31	31	0.03	0.03	0.14	376	376	410
PZ8D	PZ8D	Shallow overburden	2	8295	8295	8815	7.7	7.7	8.0	33	33	41	46	46	60	15	15	16	50	50	56	0.34	0.34	0.48	1945	1945	1960
PZ9D	PZ9D	Shallow overburden	2	9925	9925	10625	7.1	7.1	7.3	167	167	177	344	344	428	33	33	36	407	407	481	0.05	0.05	0.11	1690	1690	1774
WD625P	UG_16	Whybrow	2	12000	12000	12099	7.2	7.2	7.2	67	67	67	212	212	212	21	21	21	241	241	241	0.04	0.04	0.04	2270	2270	2270
WOH2153A	PZ2	Redbank Ck - D, E	4	1848	1848	2010	7.8	7.8	8.1	5	5	9	3	3	3	4	4	5	62	62	76	0.15	0.15	13.82	426	426	485
WOH2154A	"PZ1"	Redbank Ck - D, E	4	4690	4690	4830	7.6	7.6	7.8	6	6	15	5	5	18	9	9	10	118	118	141	0.10	0.10	10.13	1080	1080	1174
WOH2155A	PZ4	Redbank Ck - D, E	4	7040	7040	7301	7.6	7.6	7.7	32	32	48	57	57	94	16	16	21	321	321	875	0.09	0.09	3.17	1470	1470	1928
WOH2156A	PZ3	Redbank Ck - D, E	4	2360	2360	11090	7.3	7.3	7.6	21	21	104	12	12	239	9	9	30	238	238	1142	0.34	0.34	3.56	367	367	3734
G3	G3	Wambo?	5	7275	7275	7673	7.3	7.3	7.8	32	32	37	27	27	29	25	25	29	0	0	0	0.32	0.32	0.89	1660	1660	1767
WD622P	UG_24	Wambo	5	14075	14075	17698	7.2	7.2	7.5	167	167	167	533	533	533	42	42	42	1470	1470	1470	0.03	0.03	0.03	3720	3720	3720
WOH2153B	PZ2	Wambo - B, C	5	1840	1840	1947	7.8	7.8	8.1	5	5	8	5	5	8	4	4	6	57	57	70	0.20	0.20	3.64	466	466	478
WOH2154B	"PZ1"	Wambo - B, C	5	4700	4700	4815	7.6	7.6	7.9	5	5	6	6	6	9	8	8	11	112	112	134	0.16	0.16	3.64	1100	1100	1172
WOH2155B	PZ4	Wambo - B, C	5	6180	6180	7424	7.5	7.5	7.6	44	44	44	44	44	75	14	14	17	344	344	583	0.22	0.22	4.13	1385	1385	1660
WOH2156B	PZ3	Wambo - B, C	5	8375	8375	15859	7.4	7.4	7.9	75	75	107	70	70	263	18	18	37	402	402	1253	0.52	0.52	4.26	1960	1960	3848
WOH2141A	PZ6	Wynot B-D	6	6690	6690	6848	7.5	7.5	7.8	74	74	84	123	123	164	18	18	19	320	320	425	0.11	0.11	3.60	1250	1250	1370
OH1122 (1)	OH1122 (1)	Blakefield Seam	7	12880	12880	14164	7.1	7.1	7.5	93	93	175	259	259	370	37	37	48	457	457	755	0.26	0.26	0.35	2490	2490	2616
OH1123 (2)	OH1123 (2)	Blakefield	7	18250	18250	19602	6.8	6.8	7.4	135	135	201	488	488	562	45	45	52	1260	1260	1474	0.23	0.23	0.29	3858	3858	4090
OH1124 (1)	OH1124 (1)	Unknown	7	16675	16675	17863	6.7	6.7	7.1	260	260	302	586	586	668	56	56	58	885	885	885	1.08	1.08	2.00	1314	1314	2476
OH1125 (1)	OH1125 (1)	Unknown	7	16115	16115	18070	6.7	6.7	7.0	274	274	301	683	683	772	35	35	46	860	860	922	0.23	0.23	2.98	2175	2175	2633
WOH2139A	PZ5	Blakefield - E, F	7	2010	2010	2230	7.2	7.2	7.4	18	18	37	15	15	43	7	7	9	15	15	39	0.26	0.26	3.44	426	426	460
WOH2141B	PZ6	Blakefield - E, F	7	5770	5770	8727	8.6	8.6	10.3	41	41	47	67	67	76	15	15	17	228	228	272	1.45	1.45	4.11	1690	1690	1780
OH1122 (2)	OH1122 (2)	Woodlands Hill	9	13230	13230	14428	6.9	6.9	7.7	100	100	143	267	267	293	37	37	39	695	695	721	6.22	6.22	11.42	2825	2825	2857
OH1123 (1)	OH1123 (1)	Woodlands	9	17550	17550	19318	6.9	6.9	7.3	130	130	213	316	316	468	42	42	52	895	895	1220	0.10	0.10	12.04	3925	3925	4158
OH1124 (2)	OH1124 (2)	Unknown	9	13680	13680	14353	6.9	6.9	7.3	160	160	298	360	360	361	35	35	36	692	692	692	6.58	6.58	12.36	2310	2310	2391
OH1125 (2)	OH1125 (2)	Unknown	9	16150	16150	17130	6.7	6.7	7.6	270	270	320	747	747	816	63	63	87	857	857	890	0.41	0.41	0.58	2145	2145	2366
OH1122 (3)	OH1122 (3)	Bowfield Seam?	11	12090	12090	12899	7.3	7.3	7.8	82	82	97	262	262	338	39	39	48	296	296	385	0.39	0.39	1.02	2460	2460	2582
OH1123 (3)	OH1123 (3)	Bowfield	11	17720	17720	19610	6.9	6.9	7.5	130	130	157	188	188	384	37	37	47	400	400	1047	0.22	0.22	1.33	4035	4035	4386
OH1124 (3)	OH1124 (3)	Unknown	11	13915	13915	15863	6.8	6.8	7.1	190	190	275	491	491	580	54	54	74	830	830	830	0.08	0.08	0.09	2460	2460	2586
OH1125 (3)	OH1125 (3)	Unknown	11	15290	15290	16458	6.7	6.7	7.3	289	289	506	673	673	810	35	35	43	833	833	918	0.08	0.08	12.02	2225	2225	2308
OH1138 (1)	OH1138 (1)	Warkworth Seam	12	13000	13000	15820	6.9	6.9	7.3	324	324	474	470	470	711	42	42	77	418	418	572	0.18	0.18	0.44	1920	1920	2848
OH1138 (2)	OH1138 (2)	Warkworth Seam	12	10750	10750	11791	6.9	6.9	7.1	375	375	462	375	375	429	27	27	32	780	780	934	0.16	0.16	0.32	1570	1570	1628
OH1121	OH1121 (1?)	Vaux	15	7730	7730	8658	7.0	7.0	7.2	99	99	182	117	117	222	15	15	24	180	180	821	0.08	0.08	1.72	1490	1490	1765
OH1126	OH1126	Vaux?	15	7960	7960	8468	7.1	7.1	7.3	78	78	86	195	195	200	32	32	34	867	867	1168	0.16	0.16	0.26	1550	1550	1610
OH1137	OH1137	Vaux	15	15290	15290	17554	7.0	7.0	7.4	110	110	150	396	396	532	42	42	54	808	808	886	0.20	0.20	3.03	3310	3310	3970
GW9706	GW9706	Bayswater Seam?	16	3625	3625	5385	7.3	7.3	7.7	144	144	156	110	110	137	16	16	17	1110	1110	1292	0.02	0.02	0.05	828	828	1130
GW9707	GW9707	Bayswater Seam?	16	16760	16760	20900	7.3	7.3	7.8	315	315	370	635	635	729	23	23	34	4160	4160	5060	0.08	0.08	0.14	4690	4690	4823
GW9708	GW9708	Bayswater Seam?	16	14450	14450	16080	6.9	6.9	7.1	460	460	488	457	457	494	27	27	35	4020	4020	5012	0.05	0.05	0.11	2370	2370	3018
GW9709	GW9709	Bayswater Seam?	16	22900	22900	24700	6.9	6.9	7.3	546	546	616	923	923	959	30	30	42	5500	5500	6168	0.03	0.03	0.09	4975	4975	5123
GW98 MTCL1	GW98 MTCL1	Bayswater?	16	9645	9645	10033	7.2	7.2	7.6	90	90	396	182	182	403	24	24	29	870	870	4223	0.10	0.10	0.32	1935	1935	2253
GW98 MTCL2	GW98 MTCL2	Bayswater?	16	15700	15700	16322	6.9	6.9	7.2	603	603	728	599	599	788	48	48	64	4300	4300	4596	0.12	0.12	0.33	2700	2700	2875
OH1127	OH1127(1?)	Bayswater Seam?	16	11610	11610	12895	6.9	6.9	7.2	134	134	145	145	145	150	22	22	26	5	5	8	0.03	0.03	0.55	2450	2450	2577

Appendix C

NUMERICAL MODEL – DEVELOPMENT & CALIBRATION

1. MODEL DEVELOPMENT AND CALIBRATION

1.1 Model Objectives

A numerical model was developed to assess the impacts of the Proposal on the surrounding groundwater regime. Whilst developing the model, the requirements of the NSW AIP were considered to ensure the model would predict the:

- volume of water produced by dewatering Permian strata and coal seams;
- drawdown induced in the Permian strata and coal seams groundwater system;
- drawdown (or water take) from alluvial aquifers;
- potential for changes in baseflow to Wollombi Brook and the Hunter River;
- potential for drawdown in surrounding private landholder bores; and
- potential for changes in groundwater salinity.

1.2 Previous Models

In 2002 Coal & Allied commissioned Mackie Environmental Research (MER, 2002) to assess the impact of a proposed extension to Warkworth Mine on surface- and groundwater as part of the 2002 Environmental Impact Statement (EIS). That study included the development of a numerical groundwater flow model and recommended that additional monitoring bores be installed to monitor depressurisation and water quality in areas to the west of the proposed extension. Coal & Allied subsequently installed monitoring bores WOH2154A to WOH2141A in 2004 after planning approval was granted in 2003. Groundwater level monitoring in these bores has shown that the predictions of MER (2002) were conservative as the magnitude or the extent of depressurisation has not been as extensive as predicted by the model. The inflows to the open cut pit have also not reached the rates predicted by MER (2002).

In 2010, Coal & Allied proposed to further extend Warkworth Mine (the *Warkworth Extension Project*) about 1 km down-dip (to the west) of the area approved in 2003 and commissioned Australasian Groundwater and Environment (AGE) to assess potentially associated groundwater impacts (AGE, 2010). That study included the development of another numerical model that built upon the work of MER (2002). Both the Commonwealth and NSW Governments approved this project, but a subsequent appeal in the NSW Land and Environment Court overturned the approval based on issues unrelated to groundwater.

Since 2010 Coal & Allied have increased the groundwater monitoring network through the installation of several multi-level vibrating wire piezometers (VWPs) west and down-dip of the active MTW mining areas (Golder, 2013). The data obtained from those VWPs have been included in the calibration of the latest (AGE, 2014 – this report) model, discussed below.

Four new monitoring bores within the Permian coal measures around the Project and within the spoil (Loders Pit) were installed in early 2014. Groundwater level and water quality data from these were included in the 2014 model calibration.

1.3 Model Design and Construction

1.3.1 Conceptual Model and Extent

A conceptual understanding of the groundwater regime developed from field measurements, observations and experience is the basis for the development of any numerical groundwater flow model. Section 5 of this report outlines the conceptual groundwater model for Mount Thorley Warkworth (MTW). This conceptual model is a summary of how the groundwater system is believed to operate based upon the available information and represents the natural system in an idealised and simplified way.

The extent of the numerical model boundaries were selected to be suffiently distant from the currently approved and proposed mining so as to not influence the drawdown predictions. These boundaries are as follows:

- The eastern model boundary was defined along the line of sub-crop of the Jerrys Plain Subgroup. The Jerries Pains Subgroup is the target of current and future mining activities and groundwater level monitoring has indicated that there is very limited hydraulic connection between the mine and the area to the east of this line.

- The western model boundary was defined along the base of the outcropping Hawkesbury Sandstone. This sandstone has not been included in the model as previous work has indicated that groundwater drawdown associated with currently approved and proposed mining would not extend far beyond Wollombi Brook.

- The northern and southern boundaries have been set at a distance to capture cumulative impacts from the adjacent active mines of Wambo and Bulga, and lie well beyond the likely influence of the proposed mining activity being assessed at Warkworth.

1.3.2 Software Used

The MODFLOW SURFACT code (referred to as SURFACT for the remainder of the report) was used to simulate of groundwater flow.

SURFACT is a commercial derivative of the standard MODFLOW code and has some distinct advantages over the standard MODFLOW for simulating mining projects. SURFACT simulates variably saturated conditions. This is beneficial for mining where coal seams can become progressively dewatered which avoids the rewetting of cells that can be problemetic with standard MODFLOW. The SURFACT also includes adaptive time-steps, and robust numerical solver that help to converge the numerical solution.

The MODFLOW pre- and post-processor PMWIN (Chaing and Kinzelbach, 1996) was used to generate some of the input files for the SURFACT model. Where files differ to allow for the additional capabilities of SURFACT, these changes were undertaken through manual editing of the model files.

1.3.3 Time

The model used days as the unit of time. The model represented the progress of mining and recharge with annual stress periods. The stress period duration was set as one year (365.25 days).The model simulated mining in stages representing the progression of the pit floor (using drain cells) and creation of spoil piles (by changing hydraulic properties with time). After every modelling stage, the model paused and the hydraulic heads were extracted to use as the starting conditions for the next stage. The hydraulic properties of the spoils were updated, and the next stage started. The stage duration for the calibrated model was:

- five years for the first six stages from 1981 to 2010;
- four years for stage seven from 2011 to 2014; and
- annual increments of one year length for predictive modelling years 2014 to 2035.

The first seven stages from 1981 to 2013 were used to calibrate the model as groundwater monitoring data was available for this period. Stages eight to 28 from 2014 to 2035 simulated the currently approved and proposed mining to predict future impacts on the groundwater regime.

1.3.4 Model Dimensions, Extent and Layers

The model grid consisted of 98,644 cells per model layer (271 columns, 364 rows, 76,089 active cells per layer, 16 layers). The upper left corner of the grid was set at: x = 304400, y = 6397500 (GDA94, MGA zone 56) and rotated by 18.43°. The cell size varied from a minimum of 30 x 30 m in the mining areas to a maximum of 100 x 225 m outside these zones. Figure C-5 shows the rotated grid and active model domain, as well as the refined grid over MTW.

The main difference between the current and previous models is that the interburden between selected major coal seams was represented with a model layer, whereas in the AGE (2010) model the interburden aquitards were simulated using the vertical conductance term in SURFACT. More coal seams were also added to the updated model to better represent the geology and mining activities in different pits at MTW.

Each of the coal seams within the Jerrys Plains subgroup have numerous plies, typically between 5 and 15, that coalesce and split over the mining area. The complexity of the coal seam structure was simplified for the numerical model by merging several coal seams plys into single model layers. In all instances the total measured thickness of the coal plys was preserved in the model to ensure seam transmissivity remains the same. The model consists of 16 model layers including seven coal seams. Table C- 1 summarises the hydrostratigraphic units represented by each model layer and the seams targeted by each mining operation.

Table C- 1:UPDATED MODEL LAYERING

Unit			Coal Seam	Model Layer
Alluvium/ Regolith				L1
Wittingham Coal Measures	Jerrys Plains Subgrp.	Mt. Leonard	*Overburden*	L2
			Whybrow	L3
			Interburden	L4
		Althorpe Fmtn.		
		Malabar Fmtn.	*Interburden*	
			Redbank Crk	
			Interburden	
			Wambo	L5
			Interburden	L6
			Whynot	
			Interburden	
			Blakefield	L7
		Mt. Ogilvie Fmtn.	*Interburden*	L8
			Glen Munro	
			Interburden	
			Woodlands Hill	L9

Table C- 1:UPDATED MODEL LAYERING

Unit	Coal Seam	Model Layer
	Interburden	L10
Milbrodale Fmtn.		
Mt. Thorley Fmtn	*Interburden*	
	Arrowfield	
	Interburden	
	Bowfield	L11
	Interburden	L12
	Warkworth	
	Interburden	
Fairford Fmtn.		
Burnamwood Fmtn.	*Interburden*	
	Mt. Arthur	L13
	Interburden	L14
	Piercefield	
	Interburden	
	Vaux	L15
	Interburden	L16
	Broonie	
	Interburden	
	Bayswater	

The model layers represent:

- Layer 1:
  - alluvial aquifers associated with Wollombi Brook and the Hunter River - the thickness of the alluvial sediments was based on the available driller's logs;
  - outside the alluvial plain where the Permian strata outcrop, the thickness of Layer 1 was set at 5 m to represent a regolith / soil zone;
- Layer 2 - the overburden above the uppermost coal seams;
- Layer 3 - the Whybrow Seam, with an average thickness of 5.1m;
- Layer 4 - interburden;
- Layer 5 - the Wambo and Redbank Seams, with a combined average thickness of 3.8 m measured from the base of the Wambo Seam;
- Layer 6 - interburden;
- Layer 7 - the Blakefield and Whynot Seams, with a combined average thickness of 5.4 m measured from the base of the Blakefield Seam;
- Layer 8 - interburden;
- Layer 9 - Glen Munro and Woodlands Hill Seams, with a combined average thickness of 6.4 m measured from the base of the Woodlands Hill Seam (base of mining in MTO);
- Layer 10 - interburden including the Milbrodale Formation;
- Layer 11 - the Arrowfield and Bowfield Seams, with a combined average thickness of 5.7 m measured from the base of the Bowfield Seam;
- Layer 12 - interburden including the Fairford Formation;

- Layer 13 - Mt Arthur Seam, with an average thickness of 4.15 m measured from the base of the seam (base of mining in Warkworth Mine);
- Layer 14 - interburden;
- Layer 15 - the Piercefield and Vaux Seams, with a combine average thickness of 4.85 m measured from the base of the Vaux Seam, representing an in coal seam below the Proposal; and
- Layer 16 - interburden and the top of the low permeability Archerfield Sandstone at the base of the Jerrys Plain sub-group.

Figure C- 1 shows a west to east cross section through the model. The thin blue lines show the cells representing the individual coal seams.

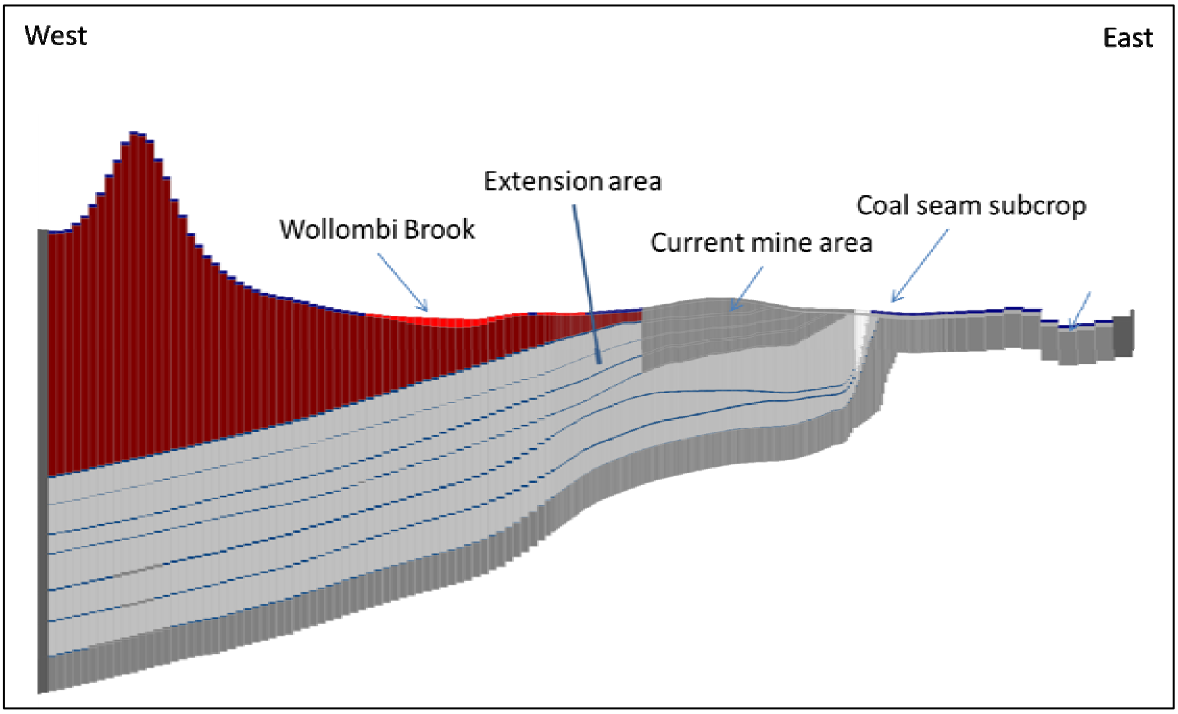
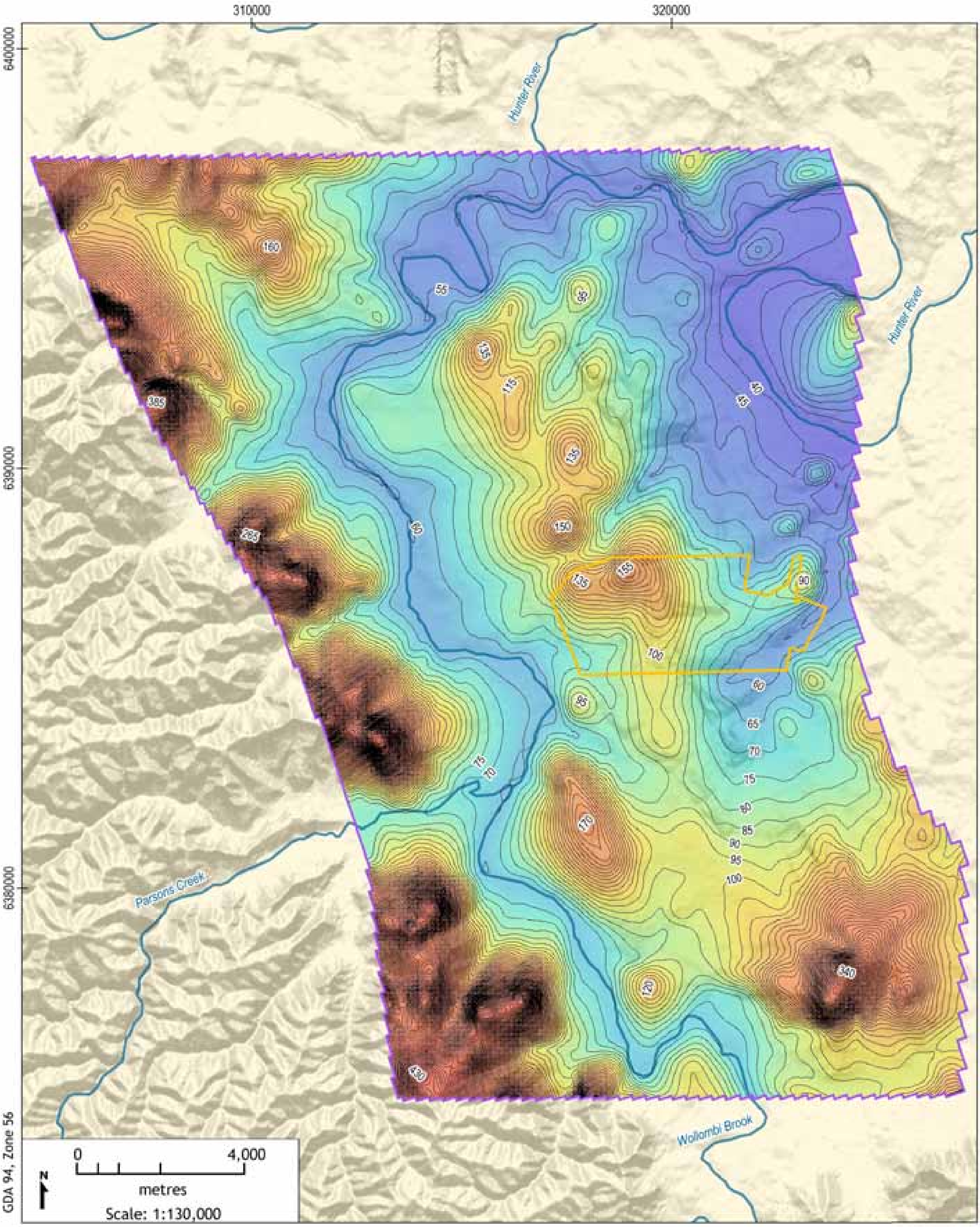


Figure C- 1: West to east cross-section through the model layers

Publicly available nine-second digital elevation data with a 250m x 250m grid spacing were used to represent the ground surface in the model during calibration. These data were chosen as the open cut pits were not evident and therefore the dataset was suitable for the pre-mining calibration. Figure C- 2 shows the top of Layer 1 in the model showing the pre-mining land surface.



LEGEND:

- Active model boundary
- Contour (5m interval)
- Major watercourse
- Proposed MTO development consent boundary

Elevation (mAHD)

- 485
- 300
- 200
- 100
- 90
- 80
- 70
- 60
- 50
- 35

Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Model Topographic Surface

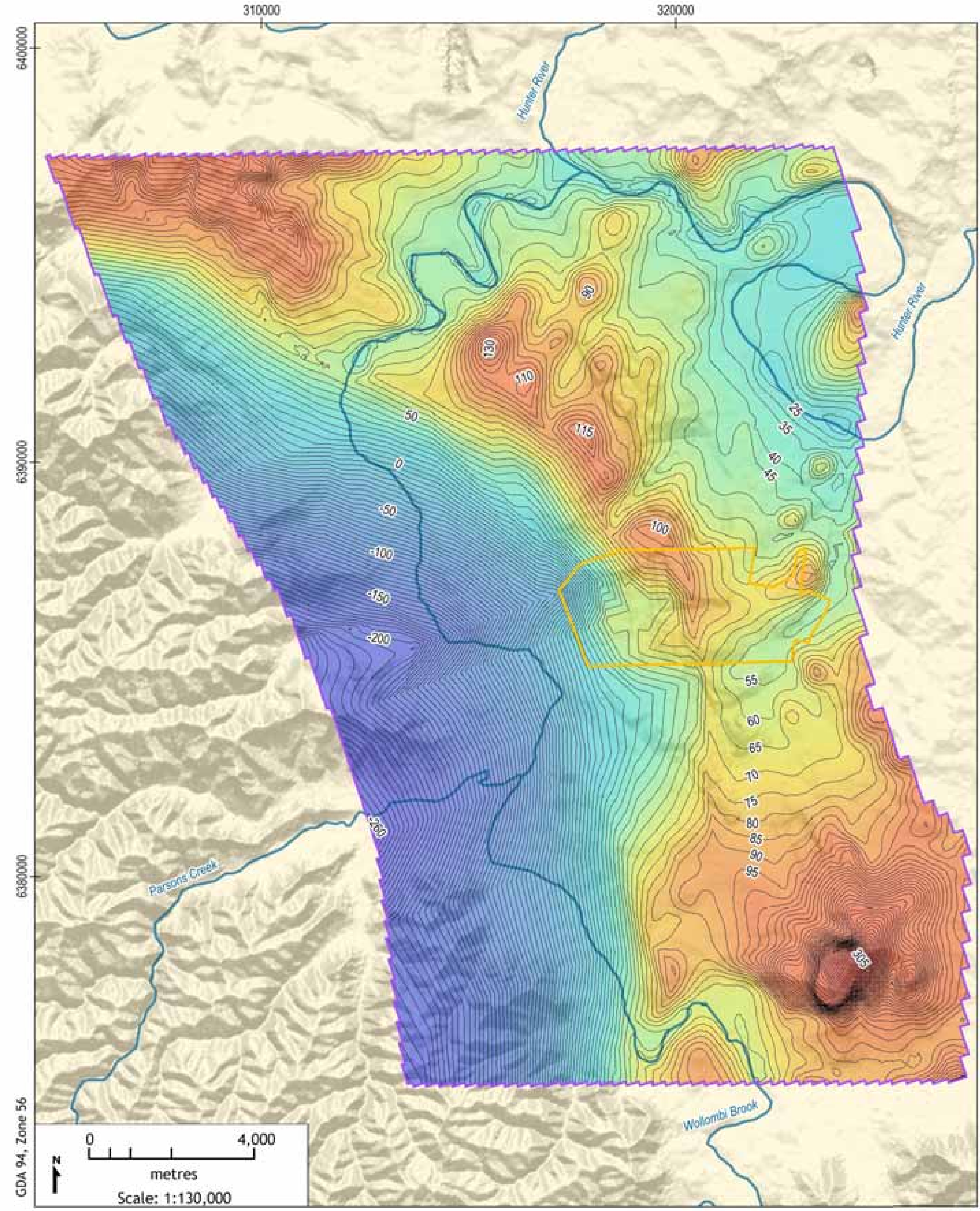
DATE: 3/4/2014

FIGURE No: **C-2**

Within MTW, the structure of the coal seams being mined has been mapped on relatively close drill spacing by the exploration program. As the groundwater model extended outside the mining lease, geologists from MTW mapped the structure of the key coal seams using publicly available data from exploration companies, regional exploration data and the NSW Geological Survey.

In the western section of the model, in the Wollemi National Park area, no data on coal seam structure was available due to a lack of exploration. In this area the coal seams were extended to the west with a constant dip and terminated at the Redmanvale Fault zone, which marks the western boundary of the model. The coal seam structure is considered to be accurate within the mining lease but less certain outside this area due to the limited availability of spatial data.

Figure C- 3 and Figure C- 4 show the base of Layer 3 (Whybrow Seam) and base of Layer 13 (Mt Arthur Seam) to show the westerly dipping structure within the model.



LEGEND:

- Active model boundary
- Contour (5m interval)
- Major watercourse
- Proposed MTO development consent boundary

Elevation (mAHD)

- 310
- 200
- 100
- 70
- 60
- 50
- 0
- -50
- -100
- -265

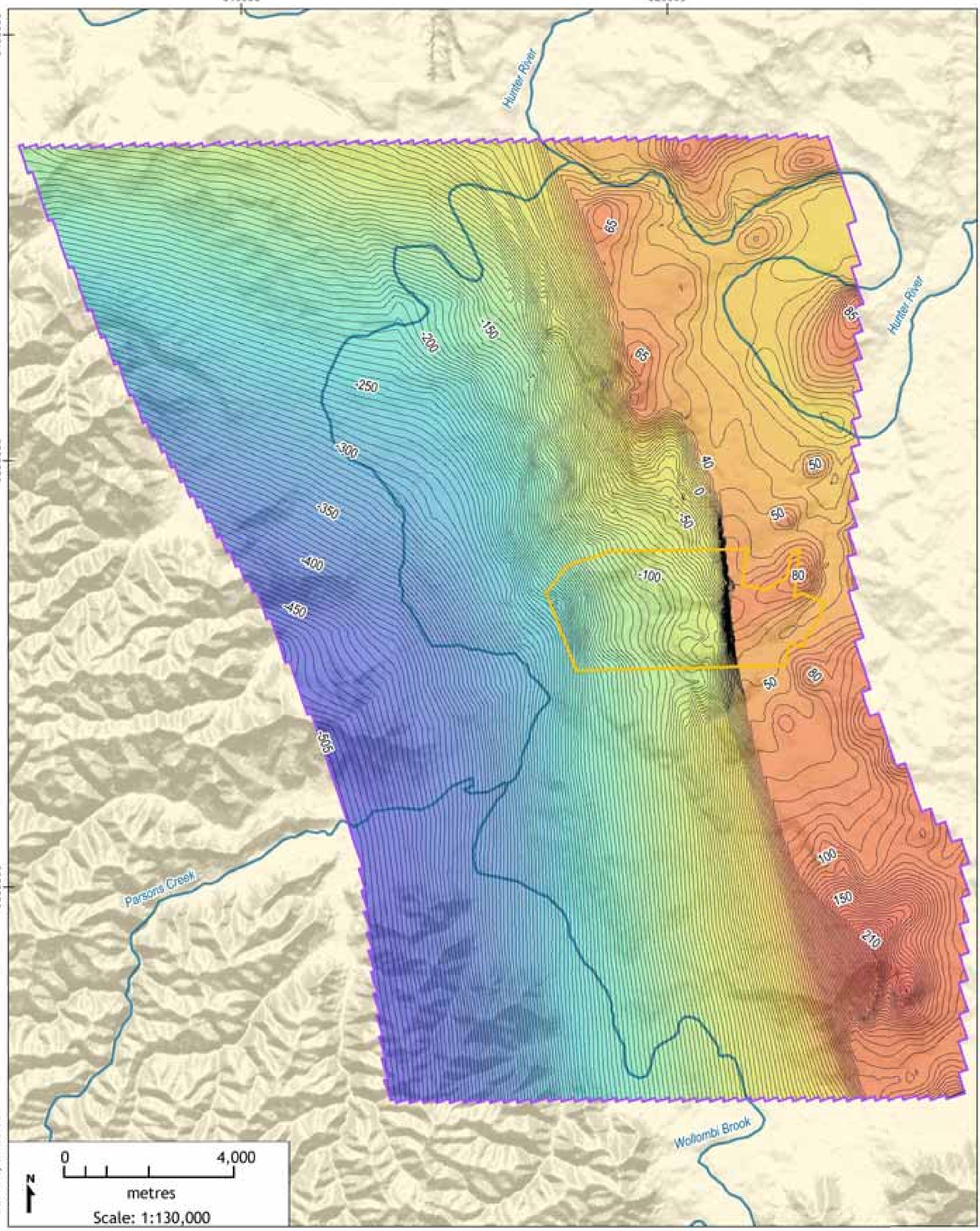
Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Model Layer 3 - Floor Whybrow Seam

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 3/4/2014

FIGURE No: **C-3**



LEGEND:

- Active model boundary
- Contour (5m interval)
- Major watercourse
- Proposed MTO development consent boundary

Elevation (mAHD)

- 220
- 100
- 50
- 0
- -50
- -100
- -200
- -300
- -400
- -510

Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Model Layer 13 - Floor
Mount Arthur Seam

AGE GROUNDWATER & ENVIRONMENTAL

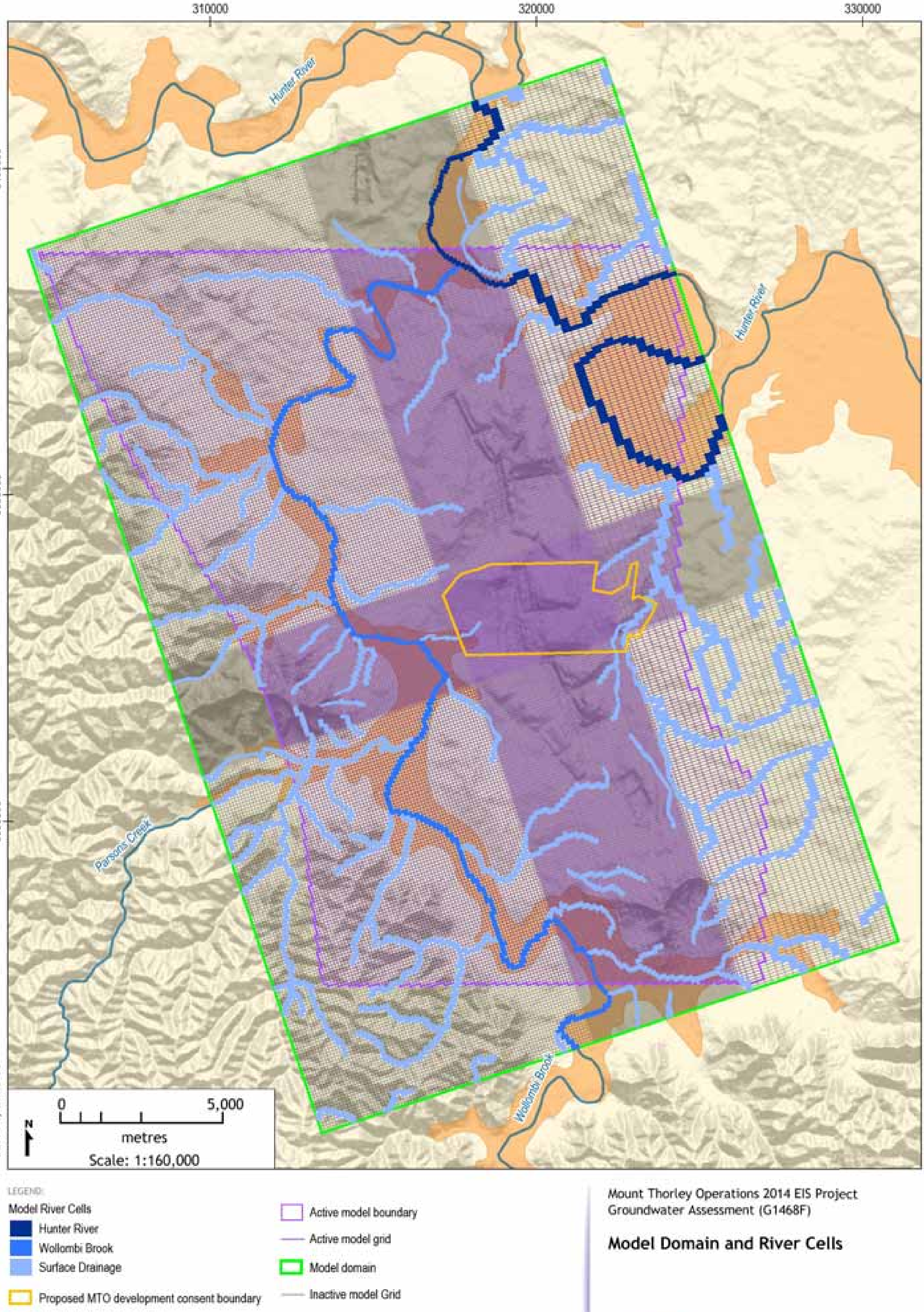
DATE: 3/4/2014

FIGURE No: **C-4**

The model domain is surrounded by “no flow” boundaries as follows:

- the Redmanvale Fault Zone under the Wollemi National Park marks the western boundary;
- the outcrop of the Jerrys Plains subgroup along the Loder Anticline marks the eastern boundary - note the outcrop zone for each seam varies;
- the Hunter River Cross Fault marks the northern boundary;
- an arbitrary distance to the south judged to be beyond the influence of MTW; and
- the base of Layer 16 in the model, which represents the floor of the Bayswater Seam/ top of Archerfield Sandstone.

Figure C- 5 shows the model domain and boundaries.



Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Model Domain and River Cells

DATE: 3/4/2014

FIGURE No: **C-5**

1.3.5 Data Exclusions

Prior to the transient calibration, datasets representing the vibrating wire piezometers (VWP) were used to help with the conceptualisation of vertical leakage between different hydrostratigraphic units. Given the model stress period length (one year for the predictive part of the model run), the use of the high density (15 minutes intervals) data for the transient calibration was not practical and did not contribute to the quality of the calibration. The dataset was thus resampled from the 15 minutes intervals to monthly intervals in order to speed up the processing of the modelled results.

During the calibration process, several bores with detrimental influence on the calibration process were identified. These observations were either not relevant to the performance of model in the critical areas, identified as faulty (providing data contradicting to the observation in surrounding areas) or identified as influenced by underground works previously unacounted for in the model. Such observations were removed from the calibration by weighting their contribution towards the objective function to zero.

Bores weighted out of the calibration were: OH1122_1, OH1122_2, OH1122_3, OH1124_1, OH1124_2, OH1124_3, wd615_p2, wd622_p5

1.3.6 Boundary Conditions

1.3.6.1 Rivers and Streams

The SURFACT River package can represent the permanent rivers and ephemeral streams within the active model domain. The river boundary condition was set with a permanent 0.5 m of water in the Hunter River, and 0.1 m in Wollombi Brook to allow for surface – groundwater interconnectivity. The minor surface drainage lines were set as drains and only discharged groundwater from the groundwater systems if groundwater level reached the base of the rivers. Figure C- 5 shows the location of the river cells.

LIDAR elevation data was available for the reach of Wollombi Brook adjacent to MTW. The LIDAR data was used to set the level of the river bed, the coarser SRTM data used where LIDAR coverage was not available. The availability of LIDAR means the bed elevation is accurate along a critical reach of Wollombi Brook (adjacent to the proposed mining).

The vertical hydraulic conductivity of the bed of Wollombi Brook and Hunter River river boundary cells were set as 0.01 m/day and 0.1 m/day respectively. The bed thickness was 2 m for the Hunter River and 1.5 m for the Wollombi Brook. The sensitivity analysis also simulated an extended dry period with no flow in the Wollombi Brook by removing the fixed stream water level.

1.3.6.2 Recharge

Table C-2 shows rainfall data used for the model calibration – sourced from Bulga mine.

Table C- 2: ANNUAL RAINFALL FROM BULGA USED IN MODEL CALIBRATION

Year	Rainfall (mm/year)	Year	Rainfall (mm/year)
1981	810.8	1998	797.4
1982	601	1999	641.6
1983	641.9	2000	777.7

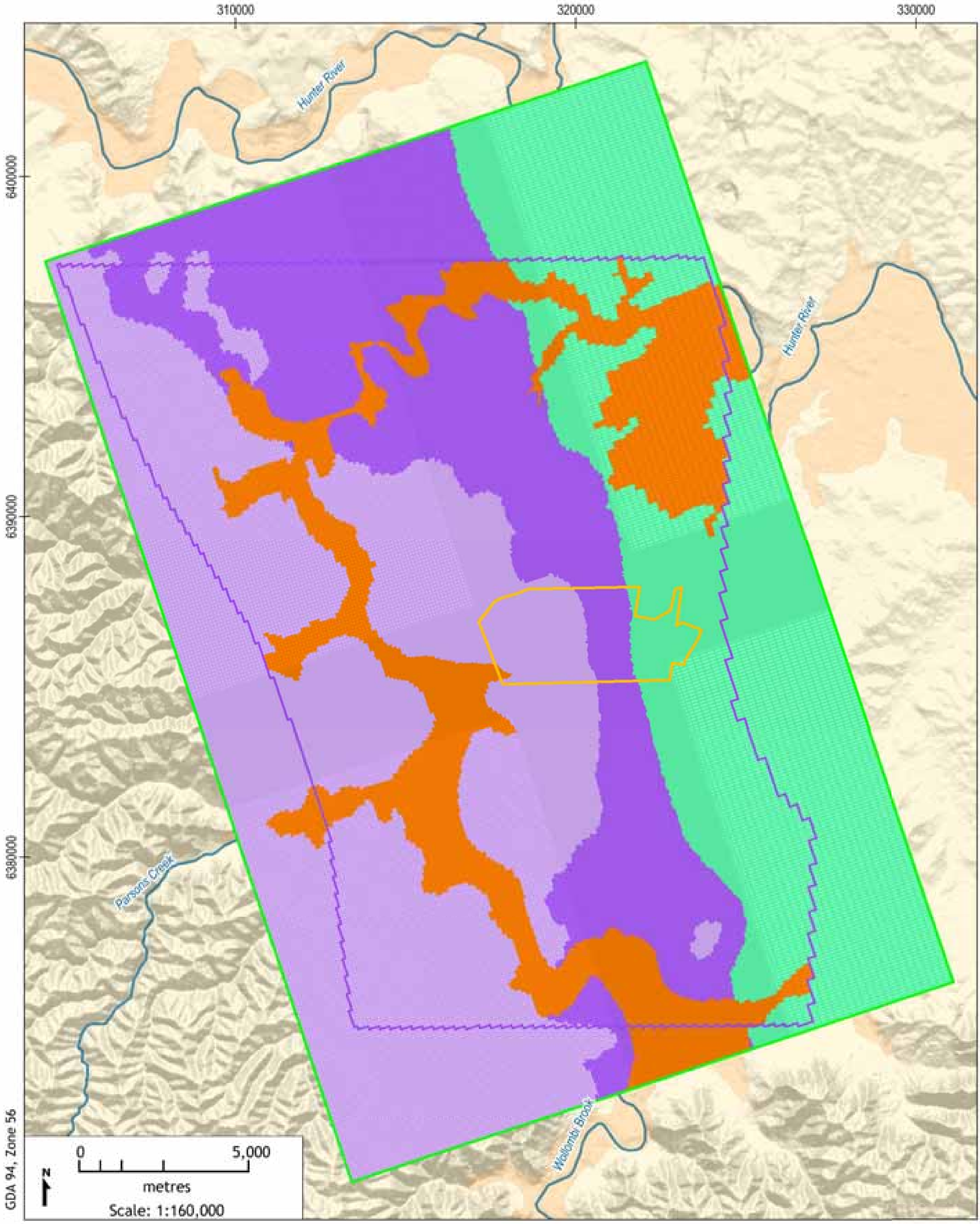
Table C- 2: ANNUAL RAINFALL FROM BULGA USED IN MODEL CALIBRATION			
Year	**Rainfall (mm/year)**	**Year**	**Rainfall (mm/year)**
1984	791	2001	579.98
1985	588	2002	505.7
1986	618.6	2003	615.5
1987	748.8	2004	750.66
1988	867	2005	566.9
1989	860	2006	385.6
1990	742.6	2007	875.3
1991	603.6	2008	659.55
1992	700.6	2009	705.7
1993	540.6	2010	820.3
1994	487.2	2011	871.4
1995	658.6	2012	606.5
1996	619.4	2013	833.9
1997	622.2		

The SURFACT Recharge package applied recharge to the first layer in the model. The rate of recharge to the alluvial aquifer was initially set at 12.5% of rainfall. The recharge rate for the Permian outcrop areas (similar to the rate adopted by MER 2002) was initially set at 0.5 % of rainfall. These values were used as initial starting point to calibrate the model and were the values previously adopted by AGE (2010). The recharge rate (as a proportion of rainfall) was later varied in subsequent transient model calibration runs.

Figure C-6 shows the recharge zones for the alluvium and Permian derived regolith. The model applied recharge over the calibration period as a fixed proportion of annual rainfall recorded at Bulga. Water levels in both the Permian and alluvium recorded with data loggers show a very subdued response to rainfall events. Individual rainfall events therefore did not need to be represented in the model. Table C-3 shows calibrated model recharge values.

As mining progressed, the model increased recharge to the expanding zones of spoil.

Table C-3: CALIBRATED RECHARGE		
Recharge zone		**% of annual rainfall**
Zone 1	alluvium	3.00
Zone 2	regolith	1.50×10^{-1}
Zone 3	Permian outcrops west of Jerrys Plains Subgrp outcrop line	9.27×10^{-2}
Zone 4	Permian outcrops east of Jerrys Plains Subgrp outcrop line	1.00×10^{-7}
Zone 5	spoil	10.32



LEGEND:

Recharge zones:
- Alluvium
- Regolith and Permian overburden
- Permian coalseams outcrop/subcrop
- Archerfield Sandstone (below Bayswater seam)

- Model domain
- Model grid
- Active model boundary
- Proposed MTO development consent boundary
- Quaternary alluvium (100k)
- Major watercourse

Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Recharge Zones - Layer 1

AGE Groundwater & Environmental

DATE: 13/5/2014

FIGURE No: **C-6**

1.3.6.3 Drain Cells, Mining and Spoil

The SURFACT drain package was used to simulate both open-cut and underground mining. A conductance term of 100m/day was applied to all drain cells.

Available mine plans for MTW and publically available mine plans for Bulga and Wambo open-cut and underground mines were used to define the yearly progress of mining for the calibration period from 1980 to 2013. The main body of the report (Section 3) documents the coal seams targeted by each mining operation.

Figure C- 7 shows the simulated progress for mining in all model layers. In each case drain cells were set at the base of the layer that best represented the basal seam being mined in each open pit or longwall.

Within each stage of mining the model increased the amount of the drain cells to simulate the progress of the mine, and at the end of the stage, the hydraulic properties of the mined area changed to represent spoil in the open-cut or the goaf in underground mines.

The lengthy transient calibration period, and the detailed mine progress was implemented to provide the best antecedent conditions possible prior to the proposed mining.

Due to limited availability of historic mine plans each yearly mine strip was simulated by applying drain cells to the base of the seam being mined in each pit or underground operation. This approach may have overestimated the drawdowns during the simulation, and also affected the ability of the model to match observed water levels in some bores during the calibration process.

1.3.6.4 Tailings Storage Facilities

Tailings at MTW are stored in several cells within the spoil heaps and are represented in the model by river cells. The main report Figure 1.1 shows the locations of the tailings storage facilities (TSF). The base of each TSF river cell was set at TSF floor elevation, with the bed thickness increased with time to simulate filling with tailings.

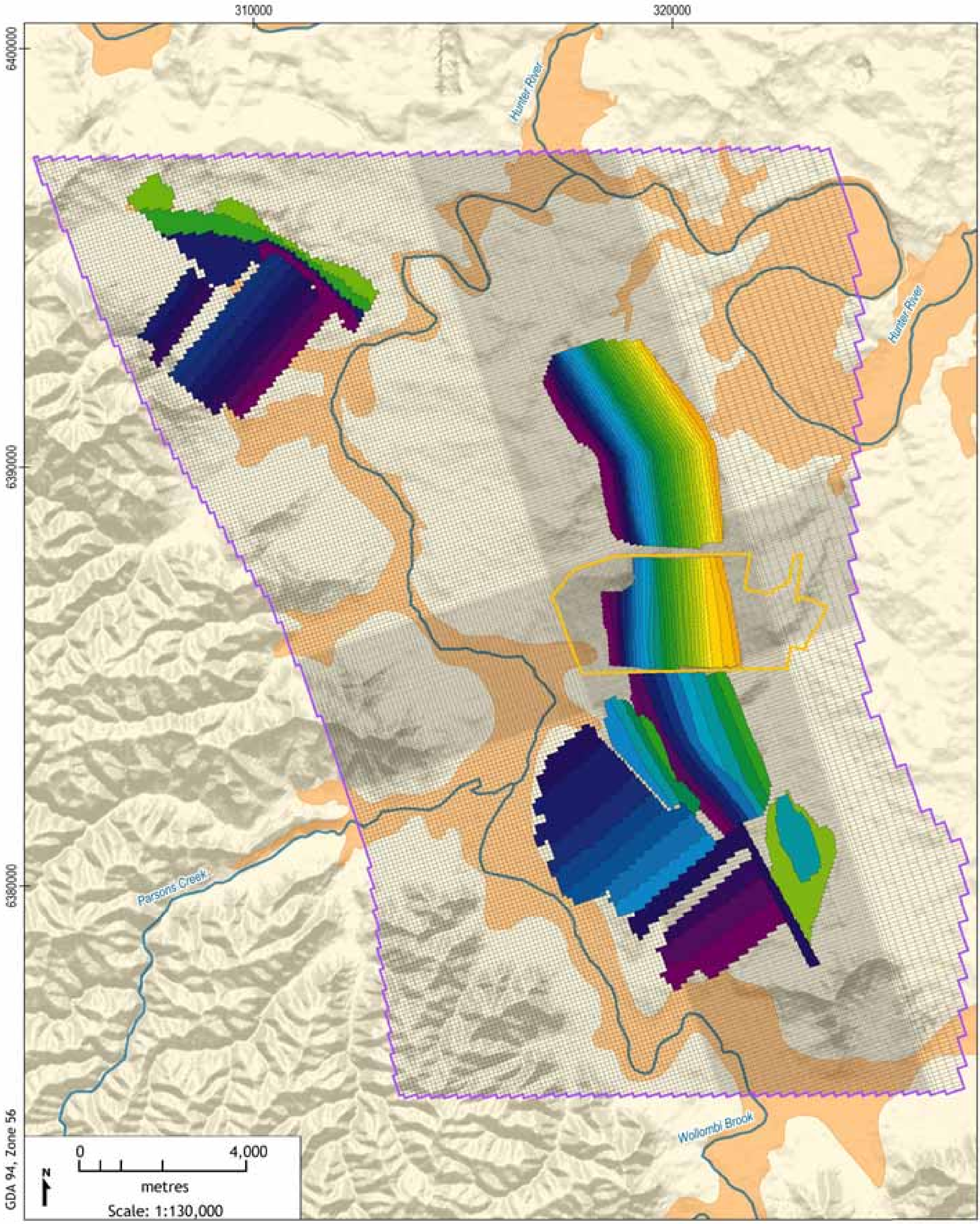
When the TSF were actively being filled the water level within the cells was set at 1 m above the fill elevation. The hydraulic conductivity (k) of the thickening TSF (b) was held constant, resulting in the conductance term (proportional to k/b) reducing as the TSF filled with sediment. This supports field evidence that the TSF have initially high leakage rates which progressively reduce over time as the tailings consolidate and thicken.

All simulated TSFs are located on or within spoil piles and (based on field evidence) contributed to mounded water tables within spoils. The mounding within spoils appears to have contributed to groundwater level recovery in Permian units north of Warkworth mine spoil following mining.

Historical information of TSF fill rates and timing was sourced from ATC (2014a) for Tailings Dam 1 (TD1), ATC (2014b) for Tailings Dam 2 (TD2), ATC (2014c) for the Centre Ramp Tailing Storage Facility (CRTSF) and ATC (2014d) for Abbey Green South (AGS). The smaller mining strip TSF located between Warkworth Pit and Loders pit was not simulated. Table C-4 summarises input data collated for the simulated TSFs, the area of each TSF has also been used to calculated bed conductance through time for each TSF as they fill.

Table C- 4: TSF BED CONDUCTANCE, FILL RATES AND CAPPING SCHEDULES				
Facility	Year	Sediment thickness (m)	Head (mRL)	Conductance (m2/day)
Tailings Dam 1 - TD01				
Tailings Dam 1 - TD01	1984	1	59	37.944
Tailings Dam 1 - TD01	1985	3	61	12.648
Tailings Dam 1 - TD01	1986	5	63	7.589
Tailings Dam 1 - TD01	1987	7	65	5.421
Tailings Dam 1 - TD01	1988	9	67	4.216
Tailings Dam 1 - TD01	1989	11	69	3.449
Tailings Dam 1 - TD01	1990	13	71	2.919
Tailings Dam 1 - TD01	1991	15	73	2.53
Tailings Dam 1 - TD01	1992	17	75	2.232
Tailings Dam 1 - TD01	1993	19	77	1.997
Tailings Dam 1 - TD01	1994	21	79	1.807
Tailings Dam 1 - TD01	1995	23	81	1.65
Tailings Dam 1 - TD01	1996	23	81	1.65
Tailings Dam 1 - TD01	1997	23	81	1.65
Tailings Dam 1 - TD01	1998	23	81	1.65
Tailings Dam 1 - TD01	1999	23	80.1	1.65
Tailings Dam 1 - TD01	2000	23	80.1	1.65
Tailings Dam 1 - TD01	2001	23	80.1	1.65
Tailings Dam 1 - TD01	2002	23	80.1	1.65
Tailings Dam 1 - TD01	2003	23	80.1	1.65
Tailings Dam 1 - TD01	2004	23	80.1	1.65
Tailings Dam 1 - TD01	2005	23	80.1	1.65
Tailings Dam 1 - TD01	2006	23	80.1	1.65
Tailings Dam 1 - TD01	2007	23	80.1	1.65
Tailings Dam 1 - TD01	2008	23	80.1	1.65
Tailings Dam 1 - TD01	2009	23	80.1	1.65
Tailings Dam 1 - TD01	2010	23	80.1	1.65
Tailings Dam 1 - TD01	2011	23	80.1	1.65
Tailings Dam 1 - TD01	2012	23	80.1	1.65
Tailings Dam 1 - TD01	2013	23	80.1	1.65
Tailings Dam 1 - TD01	2014	23	80.1	1.65
Abby Green South - AGS				
Abby Green South - AGS	2010	20	29	0.045
Abby Green South - AGS	2011	20	29	0.045
Abby Green South - AGS	2012	24	36	0.038
Abby Green South - AGS	2013	50	62	0.018
Abby Green South - AGS	2014	50	61	0.018
Abby Green South - AGS	2015	57	68	0.016
Abby Green South - AGS	2016	65	76	0.014
Abby Green South - AGS	2017	70	81	0.013
Abby Green South - AGS	2018	70	79	0.013
Abby Green South - AGS	2019	70	79	0.013
Abby Green South - AGS	2020	70	79	0.013
Abby Green South - AGS	2021	70	79	0.013
Tailings Dam 2 - TD02				
Tailings Dam 2 - TD02	2001	6	121	6.324
Tailings Dam 2 - TD02	2002	7	122	5.421
Tailings Dam 2 - TD02	2003	7	122	5.421
Tailings Dam 2 - TD02	2004	8	123	4.743
Tailings Dam 2 - TD02	2005	8	123	4.743
Tailings Dam 2 - TD02	2006	9	124	4.216
Tailings Dam 2 - TD02	2007	10	125	3.794
Tailings Dam 2 - TD02	2008	12	127	3.162
Tailings Dam 2 - TD02	2009	14	129	2.71
Tailings Dam 2 - TD02	2010	15	130	2.53
Tailings Dam 2 - TD02	2011	15	130	2.53
Tailings Dam 2 - TD02	2012	14.5	129.5	2.617
Tailings Dam 2 - TD02	2013	14.5	129.5	2.617
Tailings Dam 2 - TD02	2014	14.5	129.5	2.617
Tailings Dam 2 - TD02	2015	14.5	129.5	2.617
Tailings Dam 2 - TD02	2016	14.5	129.5	2.617
Tailings Dam 2 - TD02	2017	14.5	129.5	2.617
Tailings Dam 2 - TD02	2018	14.5	129.5	2.617
Tailings Dam 2 - TD02	2019	14.5	129.5	2.617
Tailings Dam 2 - TD02	2020	14.5	129.5	2.617
Tailings Dam 2 - TD02	2021	14.5	129.5	2.617
Tailings Dam 2 - TD02	2022	14.5	129.5	2.617
Tailings Dam 2 - TD02	2023	14.5	129.5	2.617
Tailings Dam 2 - TD02	2024	14.5	129.5	2.617
Tailings Dam 2 - TD02	2025	14.5	129.5	2.617
Tailings Dam 2 - TD02	2026	14.5	129.5	2.617
Tailings Dam 2 - TD02	2027	14.5	129.5	2.617
Tailings Dam 2 - TD02	2028	14.5	129.5	2.617
Tailings Dam 2 - TD02	2029	14.5	129.5	2.617
Tailings Dam 2 - TD02	2030	14.5	128.5	2.617
Tailings Dam 2 - TD02	2031	14.5	128.5	2.617
Tailings Dam 2 - TD02	2032	14.5	128.5	2.617
Tailings Dam 2 - TD02	2033	14.5	128.5	2.617
Tailings Dam 2 - TD02	2034	14.5	128.5	2.617
Tailings Dam 2 - TD02	2035	14.5	128.5	2.617
Tailings Dam 2 - TD02	2036	14.5	128.5	2.617
Central Ramp TSF				
Central Ramp TSF	2001	30	56	0.379
Central Ramp TSF	2002	48	74	0.237
Central Ramp TSF	2003	64	90	0.178
Central Ramp TSF	2004	72	98	0.158
Central Ramp TSF	2005	78	104	0.146
Central Ramp TSF	2006	78	104	0.146
Central Ramp TSF	2007	80	106	0.142

Table C- 4: TSF BED CONDUCTANCE, FILL RATES AND CAPPING SCHEDULES									
	Year	Sediment thickness (m)	Head (mRL)	Conductance (m2/day)		Year	Sediment thickness (m)	Head (mRL)	Conductance (m2/day)
	2022	70	79	0.013		2008	84	110	0.136
	2023	70	79	0.013		2009	90	116	0.126
	2024	70	79	0.013		2010	92	118	0.124
	2025	70	79	0.013		2011	98	124	0.116
	2026	70	79	0.013		2012	100	126	0.114
	2027	70	79	0.013		2013	102	128	0.112
	2028	70	79	0.013		2014	106	132	0.107
	2029	70	79	0.013		2015	112	138	0.102
	2030	70	79	0.013		2016	118	144	0.096
	2031	70	79	0.013		2017	122	148	0.093
	2032	70	79	0.013		2018	126	152	0.09
	2033	70	79	0.013		2019	130	156	0.088
	2034	70	79	0.013		2020	135	161	0.084
	2035	70	79	0.013		2021	140	166	0.081
	2036	70	79	0.013		2022	145	171	0.079
	Loders TSF					2023	149	175	0.076
Loders TSF	2020	1	-78	11.383		2024	149	175	0.076
	2021	30	-49	0.379		2025	149	175	0.076
	2022	55	-24	0.207		2026	149	175	0.076
	2023	80	1	0.142		2027	149	175	0.076
	2024	90	11	0.126		2028	149	175	0.076
	2025	100	21	0.114		2029	149	175	0.076
	2026	110	31	0.103		2030	149	175	0.076
	2027	120	41	0.095		2031	149	175	0.076
	2028	130	51	0.088		2032	149	175	0.076
	2029	130	51	0.088		2033	149	175	0.076
	2030	130	51	0.088		2034	149	175	0.076
	2031	130	51	0.088		2035	149	175	0.076
	2032	130	51	0.088		2036	149	175	0.076
	2033	130	51	0.088					
	2034	130	51	0.088					
	2035	130	51	0.088					
	2036	130	51	0.088					



LEGEND:

- Active Model Boundary
- Active Model Grid
- Quaternary Alluvium
- Major Watercourse
- Proposed MTO development consent boundary

Mine Progress

1981	1990	1999	2008
1982	1991	2000	2009
1983	1992	2001	2010
1984	1993	2002	2011
1985	1994	2003	2012
1986	1995	2004	2013
1987	1996	2005	
1988	1997	2006	
1989	1998	2007	

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Mine Progress

AGE
GROUNDWATER & ENVIRONMENTAL

DATE: 3/4/2014

FIGURE No: **C-7**

1.4 Model Calibration

Calibration of a groundwater flow model is a process that demonstrates that a model is capable of replicating observed field data. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error.

1.4.1 Calibration Method

The model calibration method was primarily driven by adjusting selected parameters within realistic ranges to match transient groundwater levels. A secondary calibration target was baseflow in Wollombi Brook.

The calibration strategy initially involved manual testing and adjusting parameters to obtain an initial fit against the observation data. The final calibration was completed using PEST to refine the manual calibration. The PEST control file was later used to guide uncertainty analysis.

Matching declining water level trends where these had been measured at monitoring sites was the primary objective of the manual calibration process; whilst obtaining an absolute match was considered secondary. Less weighting was given to bores close to the mine pit face, with groundwater levels at a distance from the mine (towards third-party groundwater users and alluvial aquifers) deemed more important. Parameters were only adjusted within realistic parameter bounds, and were not allowed to move to extremes just to meet statistical objectives.

The steady state model simulated pre-mining conditions and starting heads for the transient model which commenced in 1981. It should be noted that some surrounding mining did commence prior to 1981, with some unknown dewatering effects prior to mining. This historical mining was not simulated in the steady state model, however its impact on groundwater levels is considered to be relatively minor.

A long transient model run from 1981 to 2000 simulated the cumulative impact of mining and served as a suitably long period to represent antecedent conditions prior to the first groundwater levels measurements at MTW in the early 2000's.

The transient model was calibrated or verified against available transient groundwater level data for the MTW site. A significant data set from multiple locations surrounding the mine was available for this including multi-level monitoring at point locations. Unfortunately no transient groundwater level data was available from the adjoining mines.

1.4.2 Calibration Targets

A selection of groundwater levels measured in monitoring bores and registered water bores were used as the calibration targets for the steady-state model representing approximately pre-mine conditions. Therefore bores which had been potentially affected by mining activities were removed from the calibration process. A total of 60 bores were used to calibrate the steady-state model.

Groundwater levels were collated for monitoring bores at Wambo Mine and Bulga Mine from publicly available AEMR reports. Water levels for registered bores were obtained from NSW Office of Water (NOW), and water levels for the mine monitoring bores were provided by MTW.

All available transient groundwater level data was initially used in the calibration. The main report (Section 5, Figure 5.4) shows the location of bores and VWPs with transient data. Some erroneous outlying data points were given zero weighting during the calibration (see Section 1.3.5). Due to some boreholes only having manual dip data and some bores sites having finely spaced automatic data equal weighting to the calibration was given to each bore site. Following initial calibration a higher weighting was given the three key nested bores in and below the Wollombi Alluvium (PZ7, PZ8 and PZ9).

1.4.3 Calibrated Parameters

Adjustable parameters for all model layers within the calibration process were:

- horizontal hydraulic conductivity (HC);
- vertical hydraulic conductivity (VHC) converted to VCONT in SURFACT;
- specific yield and specific storage;
- river bed vertical conductivity (rivers/streams and TSFs); and
- recharge.

The first model layer was divided into two zones: alluvium and regolith. All other model layers comprised a single zone. The alluvium, interburden and regolith were assigned uniform hydraulic properties for each layer. The hydraulic conductivity of the coal seam layers decreased with depth according to Equation 1 below.

$$HC = HC_0 \times e^{(-0.012*depth)} \qquad \text{(Eq. 1)}$$

Where: *HC* is horizontal hydraulic conductivity at specific depth
HC_0 is horizontal hydraulic conductivity at depth of 0 m (surface)
depth is depth of the floor of the coalseam

The Equation 1 was derived from field data presented in the main report. Figure C- 8 shows how hydraulic conductivity was assumed to decrease with depth.

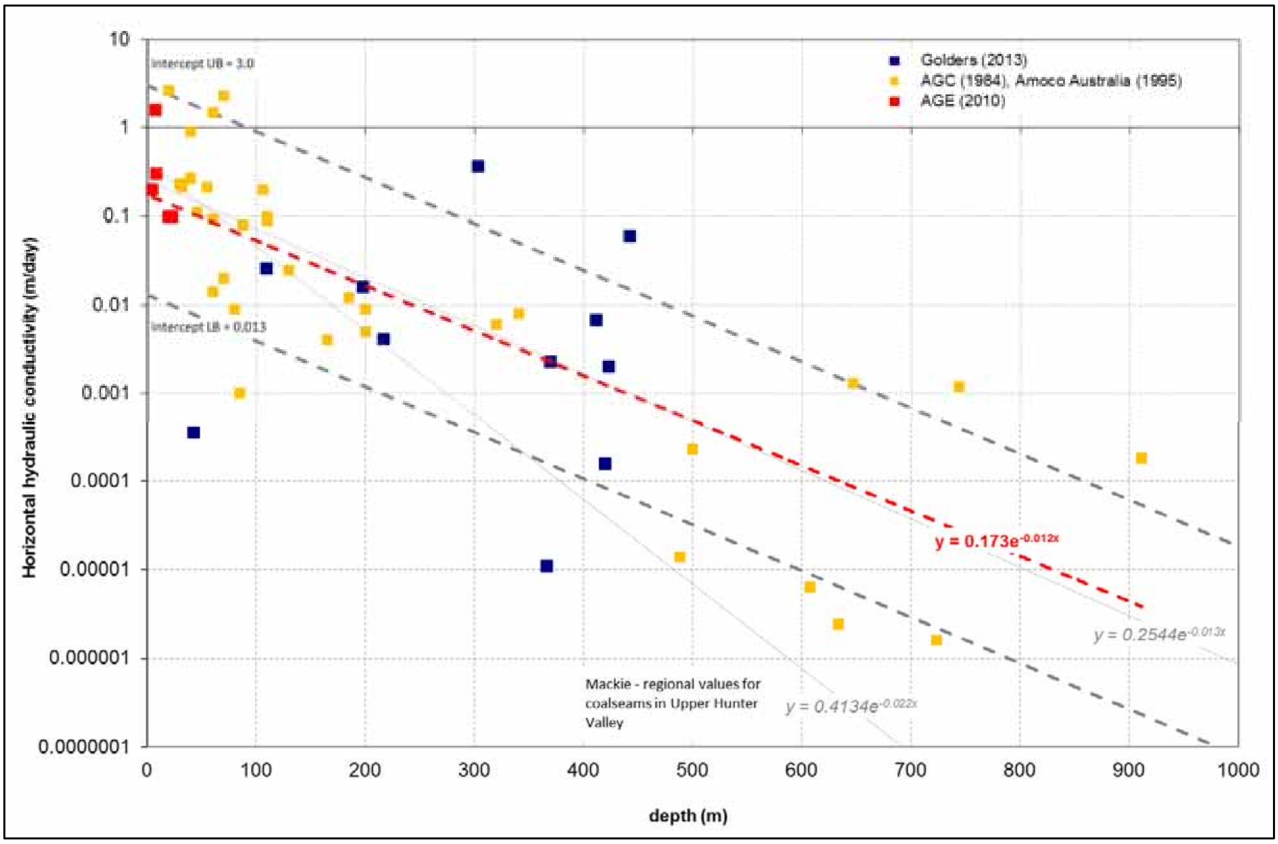


Figure C- 8: Change of hydraulic conductivity with depth – field data

The red fit line shown in this figure was the starting point to the calibration with an upper bound and lower constraints as shown by two grey dotted line in Figure C- 8. The bounds these were set manually within measured data ranges. It is possible setting these tight bounds limited the ability of the model to reproduce some local scale drawdowns processes observed in the monitoring data. However it was considered that keeping parameters within realistic ranges was more important than achieving an absolute fit through measured data points.

Vertical hydraulic conductivity was calculated using the VHC factor (multiplier) using Equation 2. In the case of coal seams VHC (derived from variable HC) is also depth dependant.

$$VHC = HC \times VHC_{factor} \quad \text{(Eq. 2)}$$

Table C-5summarises the calibrated hydraulic properties.

Table C-5: CALIBRATED HYDRAULIC PROPERTIES					
Model layer		HC, HC0 (m/day)	VHC factor (-)	SS (-)	SY (-)
L01	Regolith	2.37 x10^{-01}	1.04 x10^{-03}	2.00 x10^{-03}	5.00 x10^{-03}
L01	Alluvium	9.44 x10^{+00}	4.01 x10^{-04}	2.00 x10^{-03}	8.00 x10^{-02}
L01 - L02	Permian outcrop	1.00 x10^{-05}	1.00 x10^{-02}	1.00 x10^{-05}	1.00 x10^{-04}
L02	Overburden	3.36 x10^{-03}	1.00 x10^{-02}	1.97 x10^{-05}	2.19 x10^{-04}
L03	Whybrow Seam	9.38 x10^{-02}	9.39 x10^{-03}	6.27 x10^{-06}	5.50 x10^{-03}
L04	Interburden	3.40 x10^{-04}	4.22 x10^{-03}	6.28 x10^{-06}	1.10 x10^{-03}
L05	Wambo Seam	3.36 x10^{-02}	1.00 x10^{-02}	6.30 x10^{-06}	5.50 x10^{-03}

Table C-5: CALIBRATED HYDRAULIC PROPERTIES					
Model layer		HC, HC0 (m/day)	VHC factor (-)	SS (-)	SY (-)
L06	Interburden	1.76×10^{-04}	4.66×10^{-03}	6.30×10^{-06}	1.10×10^{-03}
L07	Blakefield Seam	1.30×10^{-02}	1.00×10^{-02}	4.00×10^{-06}	5.50×10^{-03}
L08	Interburden	3.18×10^{-04}	4.66×10^{-03}	4.00×10^{-06}	1.10×10^{-03}
L09	Woodlands Hill Seam	2.69×10^{-02}	6.15×10^{-03}	5.92×10^{-06}	5.50×10^{-03}
L10	Interburden	5.00×10^{-05}	2.87×10^{-03}	5.92×10^{-06}	1.10×10^{-03}
L11	Bowfield Seam	2.12×10^{-02}	6.15×10^{-03}	8.77×10^{-06}	5.50×10^{-03}
L12	Interburden	5.00×10^{-05}	2.87×10^{-03}	8.77×10^{-06}	1.10×10^{-03}
L13	Mt Arthur Seam	1.65×10^{-01}	4.70×10^{-03}	4.32×10^{-06}	5.50×10^{-03}
L14	Interburden	1.08×10^{-04}	2.19×10^{-03}	4.32×10^{-06}	1.10×10^{-03}
L15	Vaux Seam	1.68×10^{-01}	2.35×10^{-03}	4.00×10^{-06}	5.50×10^{-03}
L16	Basement	1.00×10^{-06}	1.00×10^{-02}	1.00×10^{-06}	1.00×10^{-03}
L01 - L13	spoil - open cut	$1.33 \times 10^{+00}$	1.13×10^{-02}	1.00×10^{-04}	1.09×10^{-02}
L03 - L15	spoil - underground	5.00×10^{-01}	1.00×10^{-03}	1.00×10^{-04}	1.00×10^{-01}

Note: *HC – horizontal hydraulic conductivity, HC0 – horizontal hydraulic conductivity at depth of 0m, SS – specific storage, SY – specific yield.*

Table C-5 also presents the calibrated storage parameters. Optimal calibration occurred with a specific yield (sy) in the alluvium of 5% with 2% for the regolith. Specific yield for open cut spoil was estimated to be 2%.

Figure C- 9 shows the calibrated coal seam hydraulic conductivity values for each coal seam. The graph indicates the calibrated values are towards the lower bound, but still well within the measured data limits.

The model calibrated to a low value of vertical hydraulic conductivity for the interburden, which is considered reasonable given that the interburden sediments effectively confine individual coal seams. Vertical hydraulic conductivity for alluvium was set to a low value to represent vertical conductance between the alluvium and underlying Permian overburden.

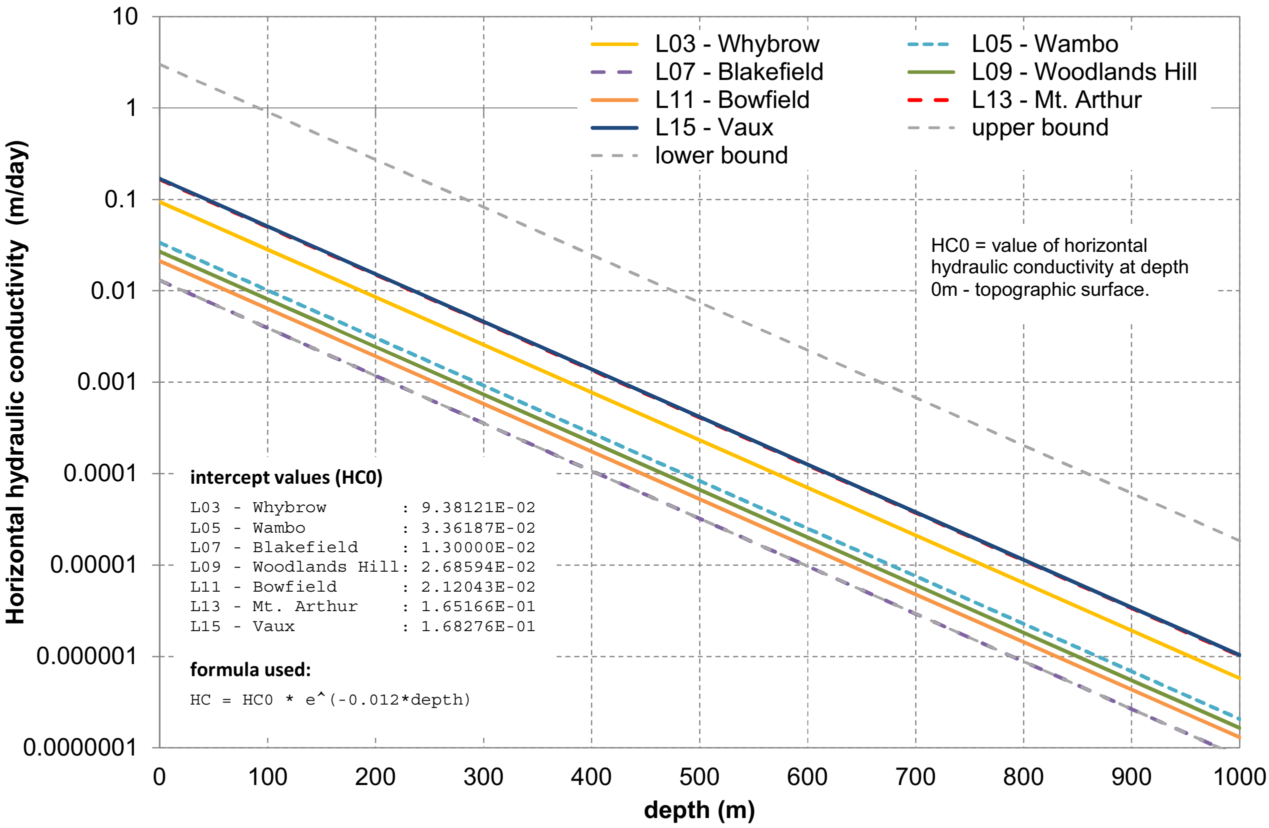


Figure C- 9: Change of hydraulic conductivity with depth – calibrated model data

Optimal calibration was achieved for recharge within expected bounds, with 3% of annual rainfall for the alluvium, 0.15% for the Permian regolith west of the Jerrys Plains subcrop line, 10^{-7}% for the regolith east of Jerrys Plains subcrop line and 10.3% for spoil.

The parameter calibrated for the river boundary condition was the vertical conductivity of the stream bed. As presented in Table C-6 below, the bed vertical conductivity was estimated to be 0.10 m/day for Hunter River, 0.01m/day for Wollombi Brook and 0.10m/day for minor surface drainage.

Table C- 3: CALIBRATED RIVER PARAMETERS

River zone	Bed thickness (m)	Bed vertical conductivity (m/day)	Head (m)
RIV1 - Hunter River	2.00	0.10	1.00
RIV2 - Wollombi Brook	1.50	0.01	1.00
RIV3 - minor surface drainage	1.00	0.10	0.00

1.4.4 Hydraulic Heads

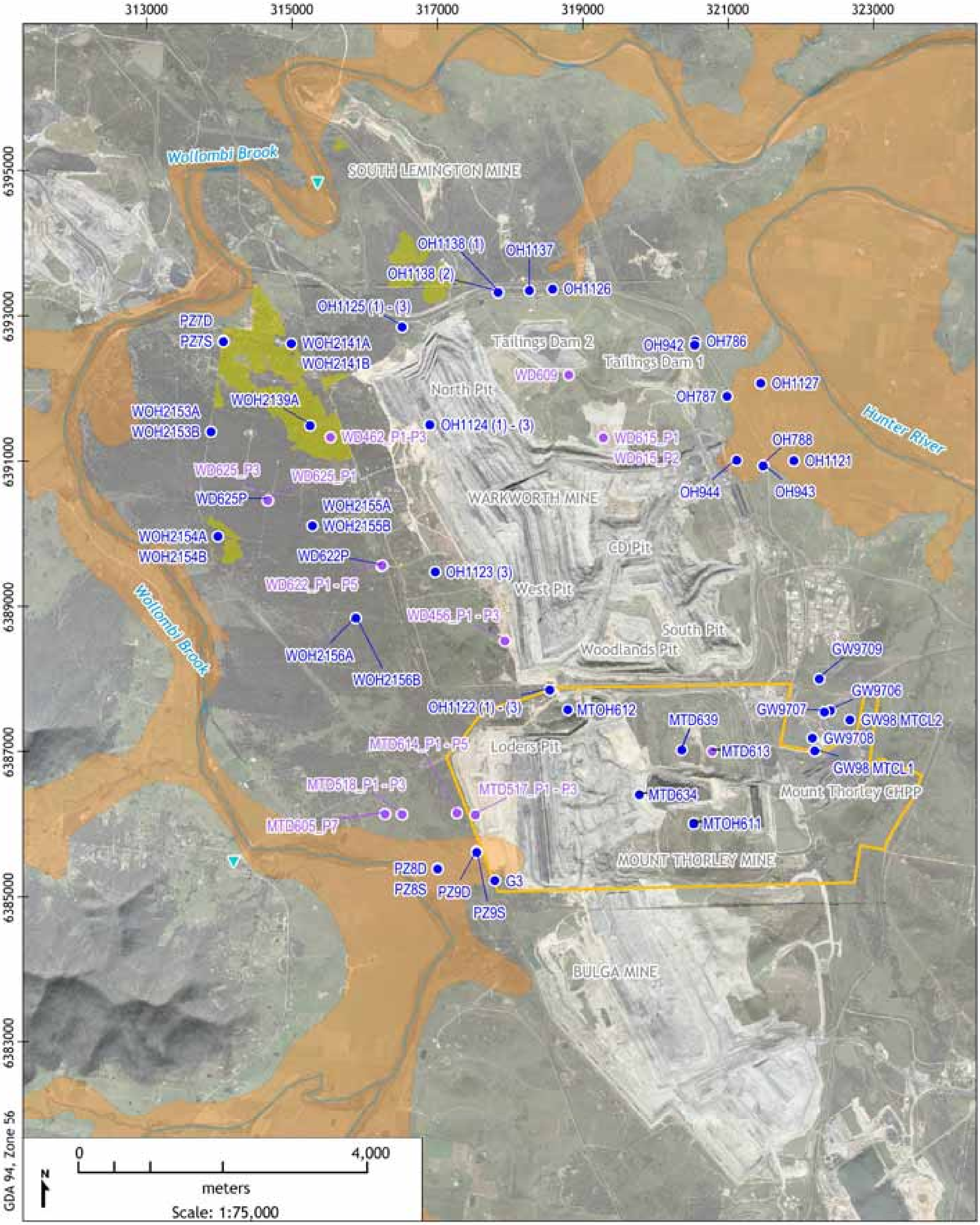
Table C-7 shows the steady state model calibration statistics. As described above this was run to generate the initial heads for the transient model run. Table C-7 shows that the steady state run is above the 10% target (15%) for SRMS lined out in the Australian Groundwater Modelling Guidelines (Barnett *et al* 2012).

Table C- 4: STEADY STATE CALIBRATION STATISTICS		
Parameter	**Value**	**Unit**
sum of residuals (SR):	354.04	[m]
mean sum of residuals (MSR):	7.53	[m]
scaled mean sum of residuals (SMSR):	12.90	[%]
sum of squares (SSQ):	3941.94	[m^2]
mean sum of squares (MSSQ):	83.87	[m^2]
root mean square (RMS):	9.16	[m]
root mean fraction square (RMFS):	18.70	[m]
scaled RMFS (SRMFS):	18.85	[%]
scaled RMS (SRMS):	15.68	[%]

Statistics for the transient run are presented in Table C-8 and these also show SRMS above the target described within the guidelines. Whilst the transient model has statistics above prescribed limits it is still deemed a suitable simulation of the Proposal. This is because the parameters remain within realistic ranges and the model simulates the groundwater depressurisation trends. Further discussion about calibrated model results are present in the main body of the report in Section 7 with contour plots of steady state heads and heads at the end of the calibration for Layer 1 and Layer 13 also presented.

Table C- 5: TRANSIENT CALIBRATION STATISTICS		
Parameter	**Value**	**Unit**
sum of residuals (SR):	21410.65	[m]
mean sum of residuals (MSR):	12.93	[m]
scaled mean sum of residuals (SMSR):	10.91	[%]
sum of squares (SSQ):	530229.79	[m^2]
mean sum of squares (MSSQ):	320.19	[m^2]
root mean square (RMS):	17.89	[m]
root mean fraction square (RMFS):	82.35	[m]
scaled RMFS (SRMFS):	31.86	[%]
scaled RMS (SRMS):	15.10	[%]

The modelled-versus-observed hydrographs for all bores surrounding MTW are included in Figures C-11 to C-20. Figure C- 10 shows the location of the calibration bores.



LEGEND:

Monitoring Bores
- Standpipe
- VWP
- NOW stream gauge station
- Alluvium (100k)
- Warkworth Sands Woodland
- Major watercourse
- Proposed MTO development consent boundary

Mount Thorley Operations 2014 EIS Project
Groundwater Assessment (G1468F)

Monitoring Bores

AGE
GROUNDWATER & ENVIRONMENTAL

DATE: 9/5/2014

FIGURE No: **C-10**

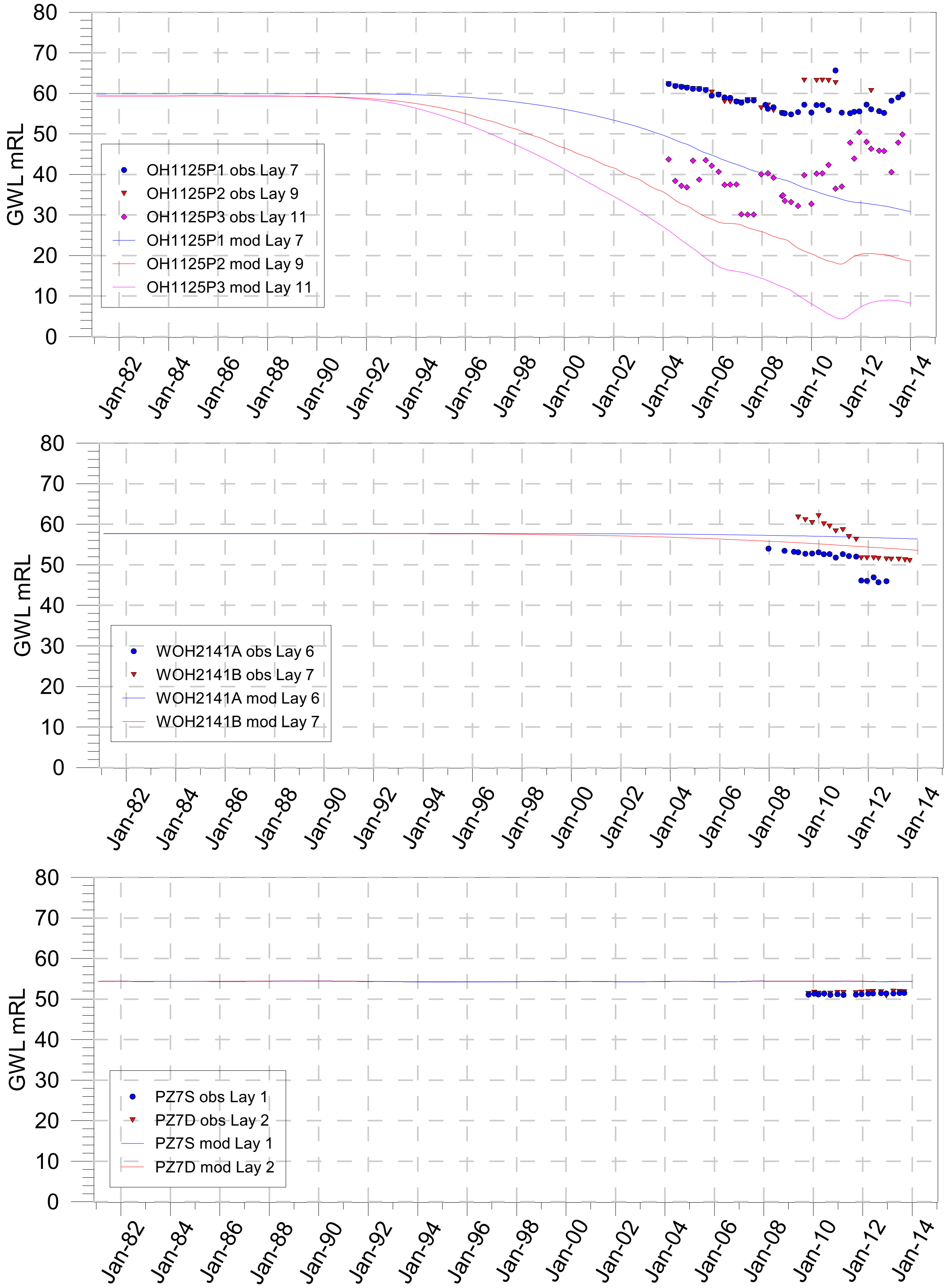


Figure C- 11: Transient modelled versus observed hydrographs

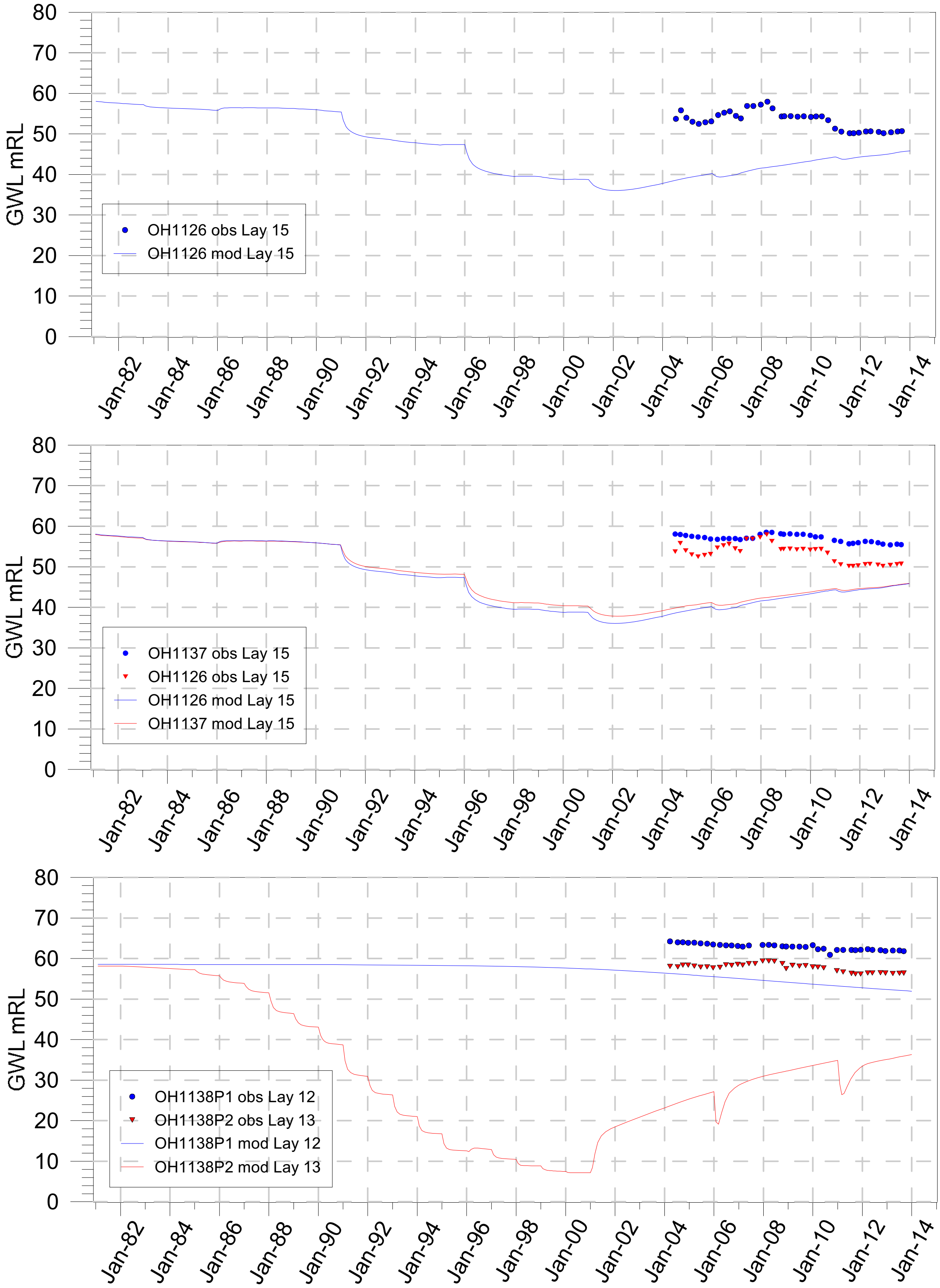


Figure C- 12: Transient modelled versus observed hydrographs

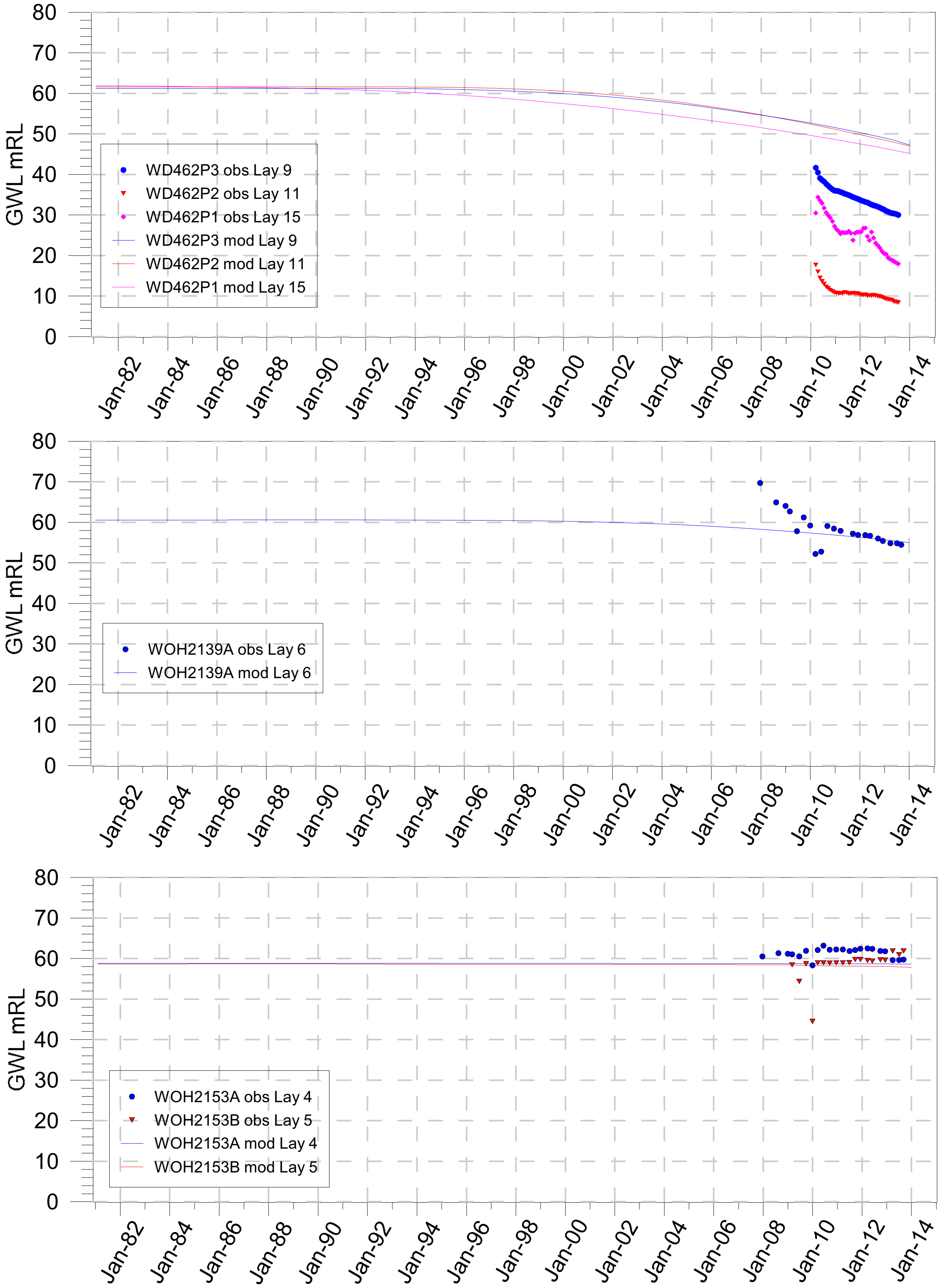


Figure C- 13: Transient modelled versus observed hydrographs

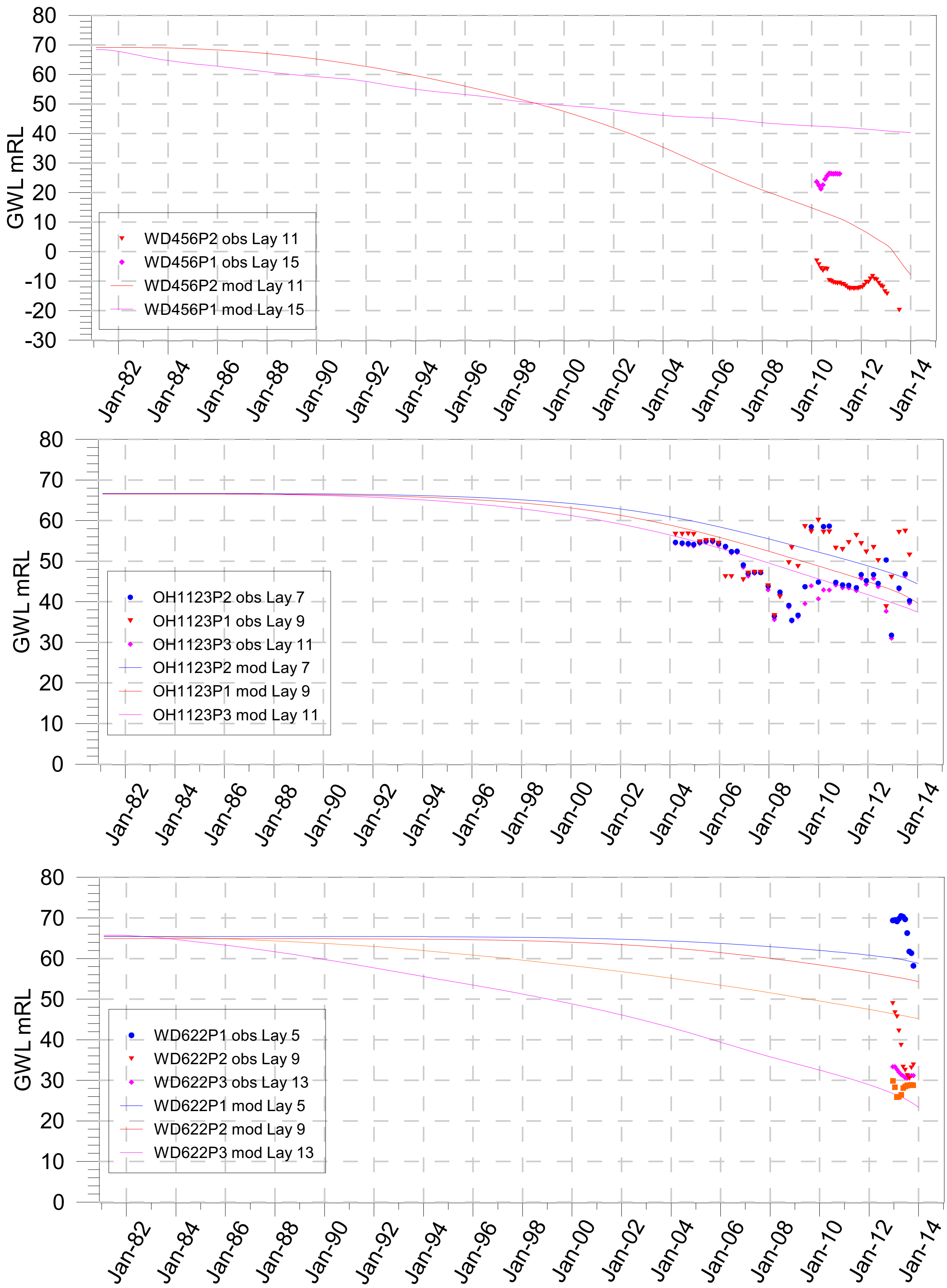


Figure C- 14: Transient modelled versus observed hydrographs

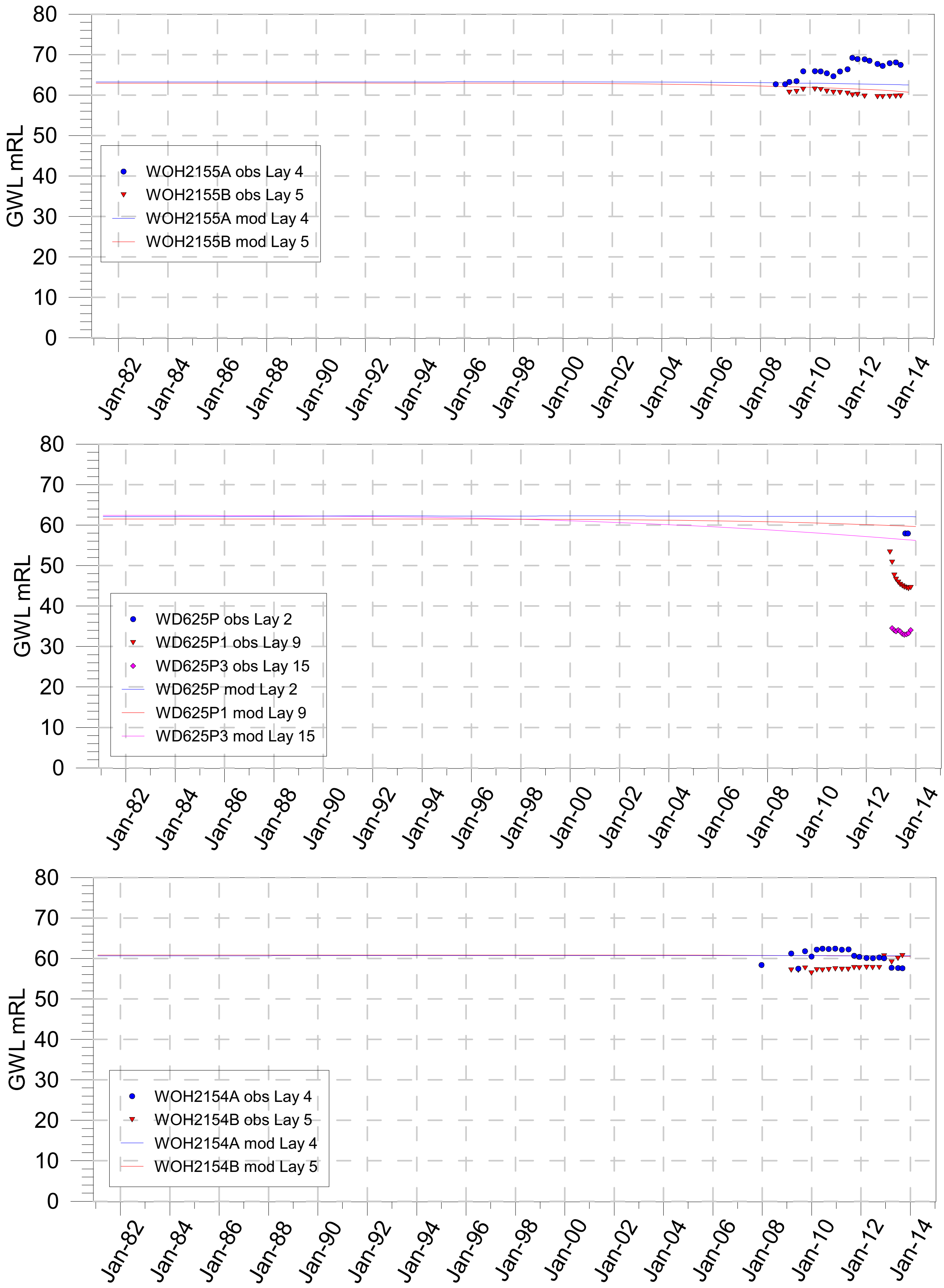
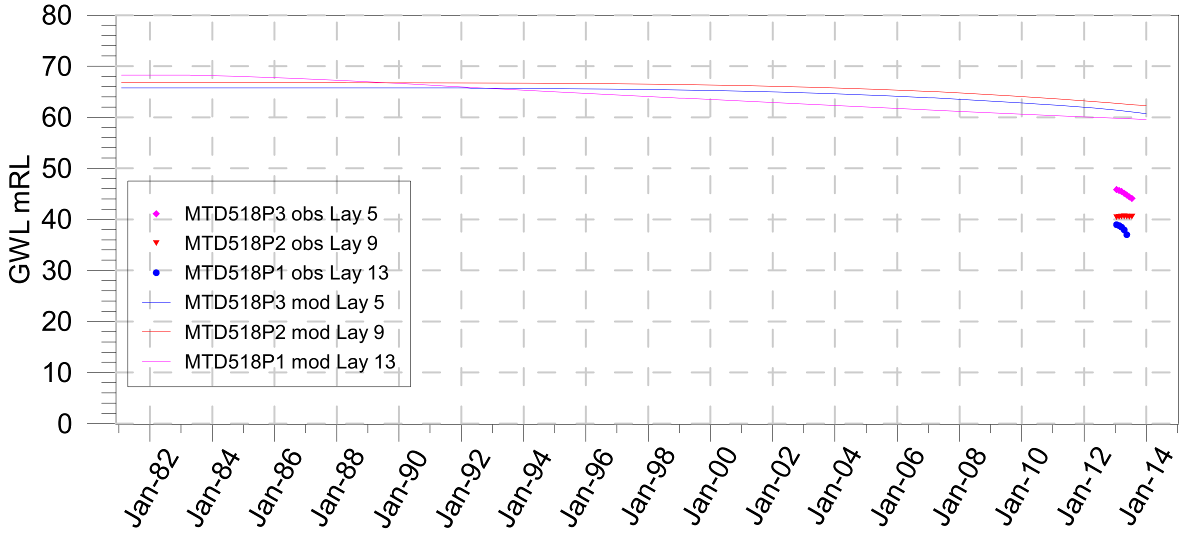


Figure C- 15: Transient modelled versus observed hydrographs



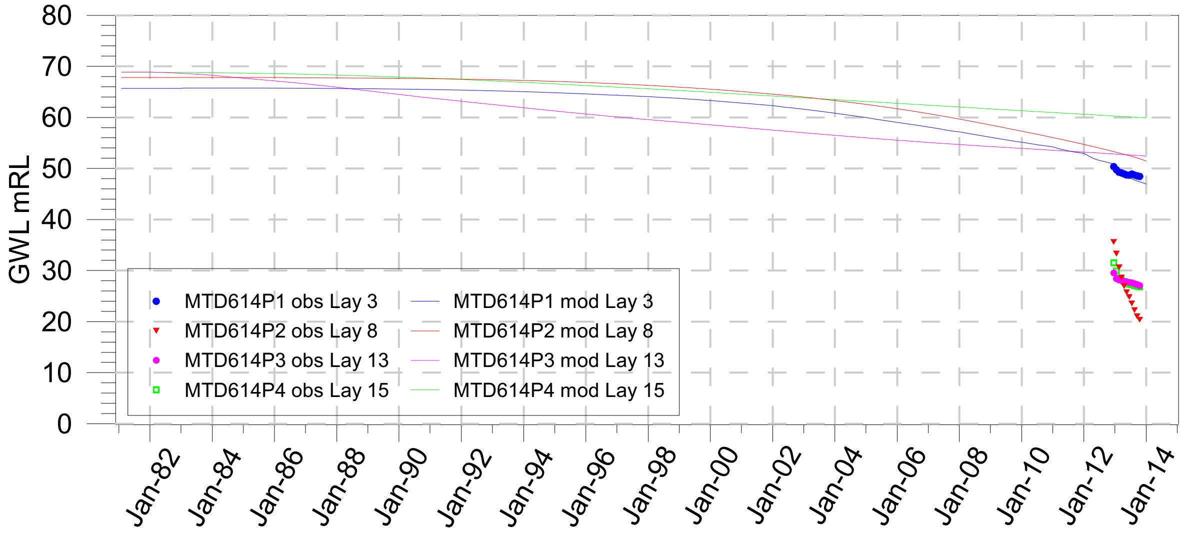


Figure C- 16: Transient modelled versus observed hydrographs

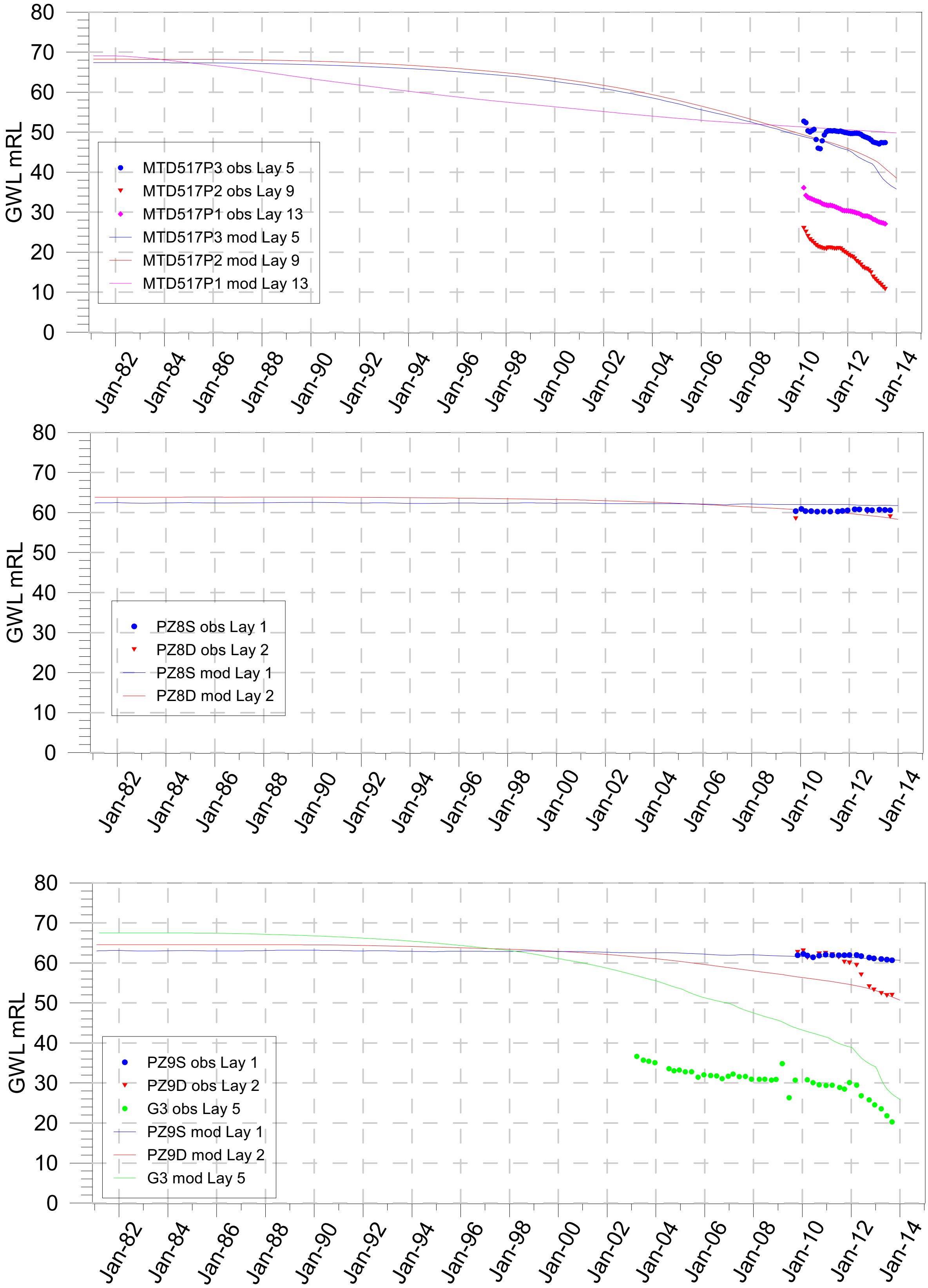


Figure C- 17: Transient modelled versus observed hydrographs

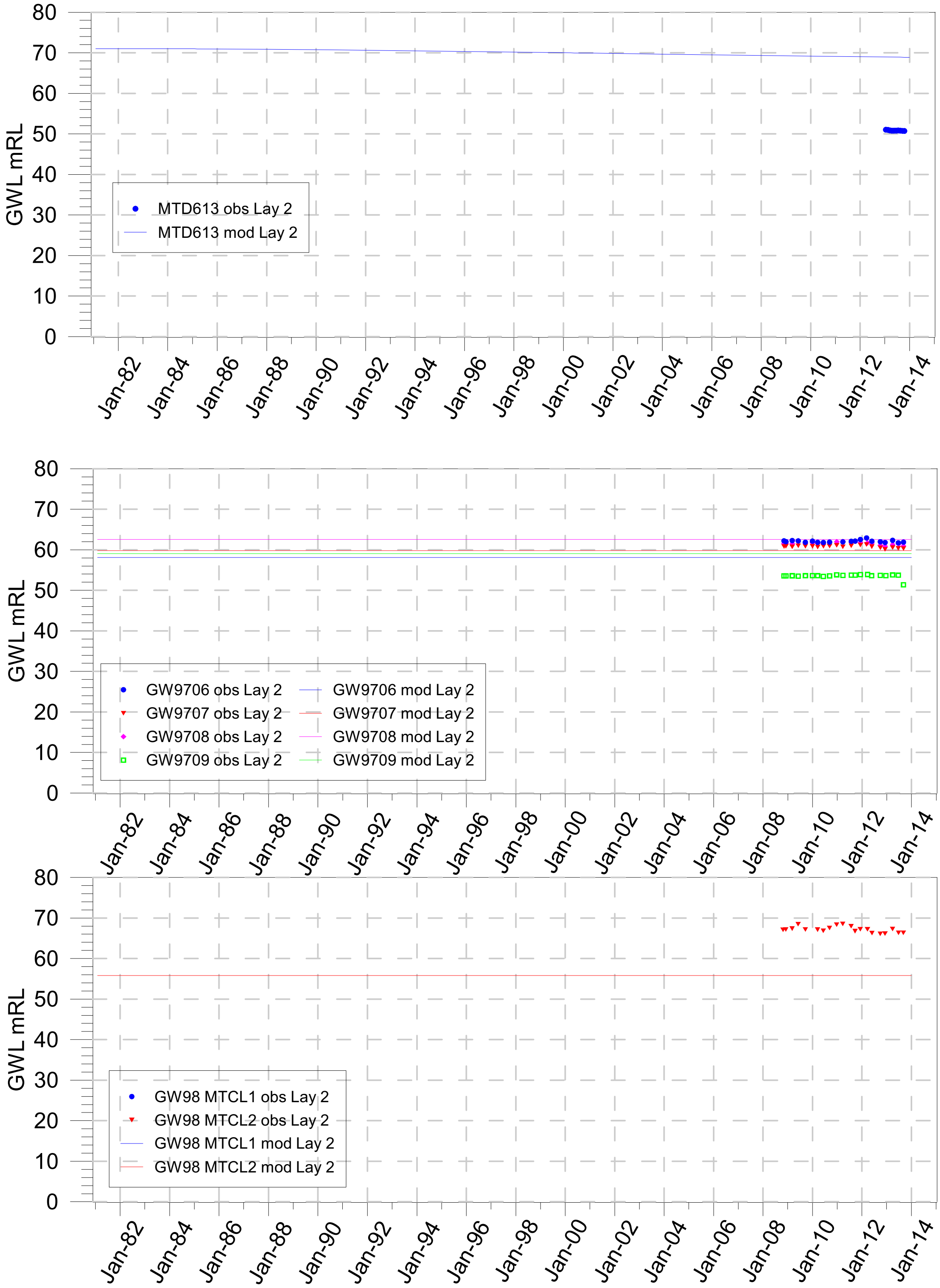


Figure C- 18: Transient modelled versus observed hydrographs

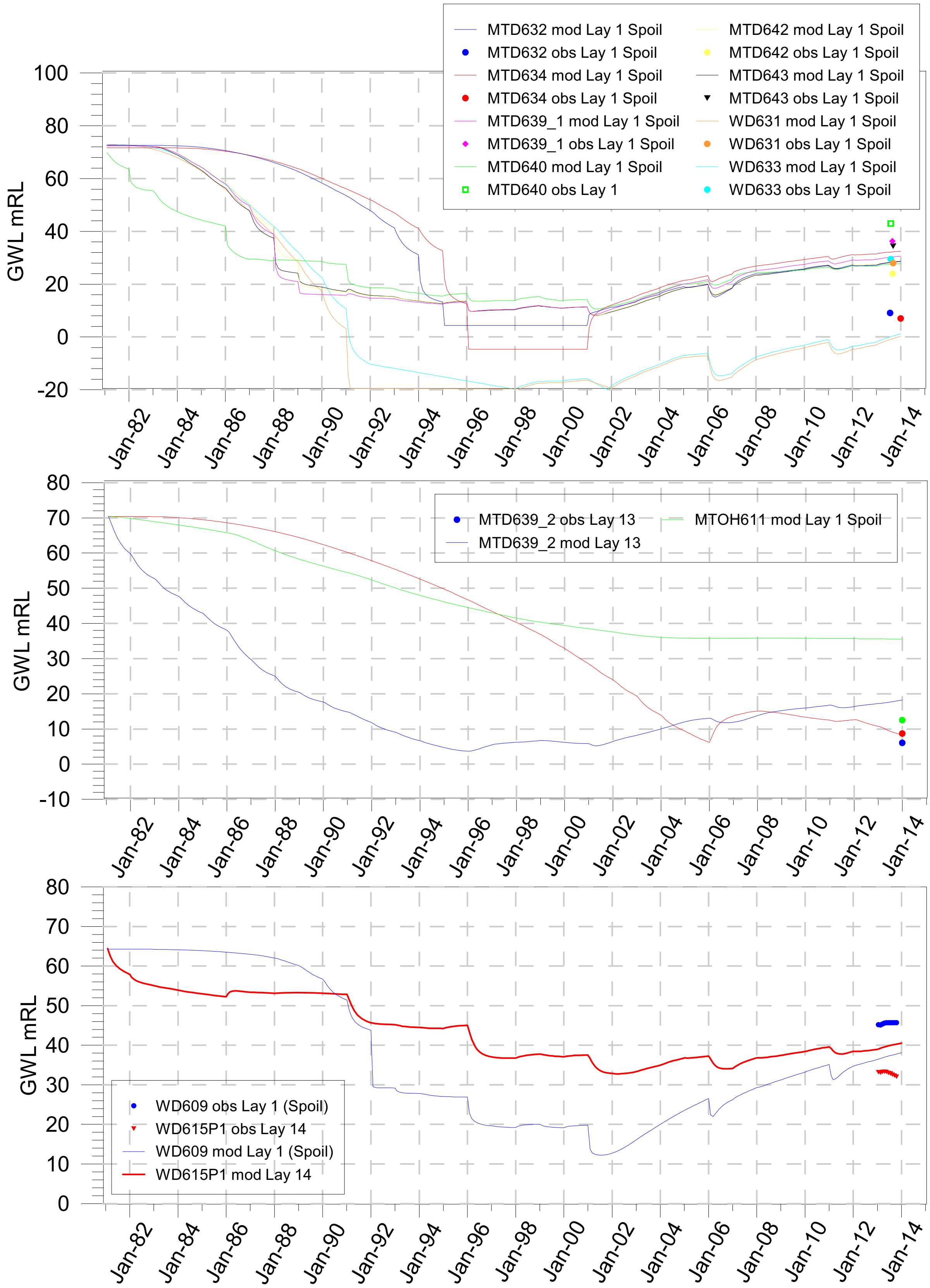


Figure C- 19: Transient modelled versus observed hydrographs

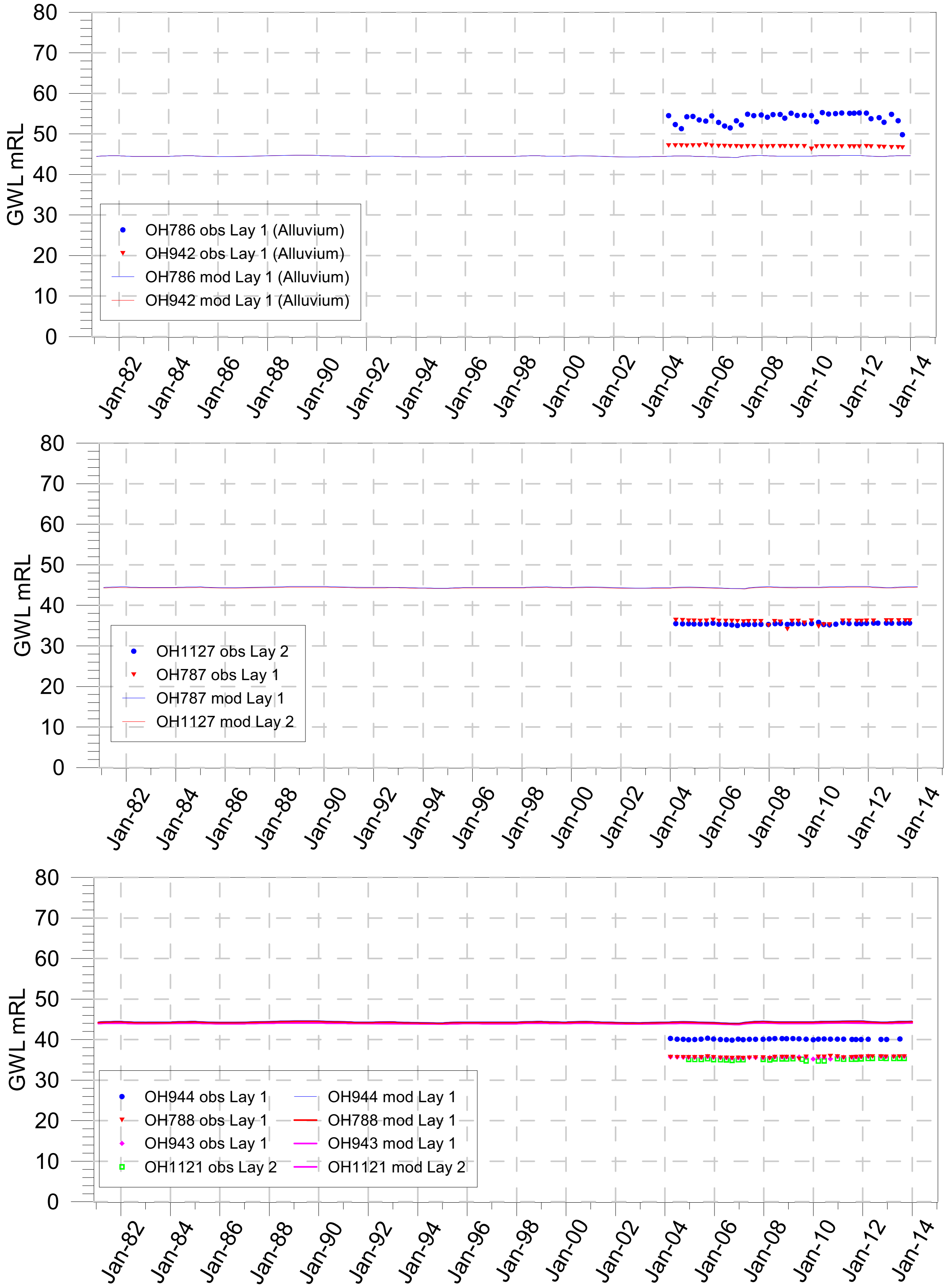


Figure C- 20: Transient modelled versus observed hydrographs

1.5 Calibrated Model Sensitivity Analysis

Following manual calibration, the transient model was calibrated with PEST. Figure C- 21 shows the parameters sensitivities for the first optimisation in the PEST.

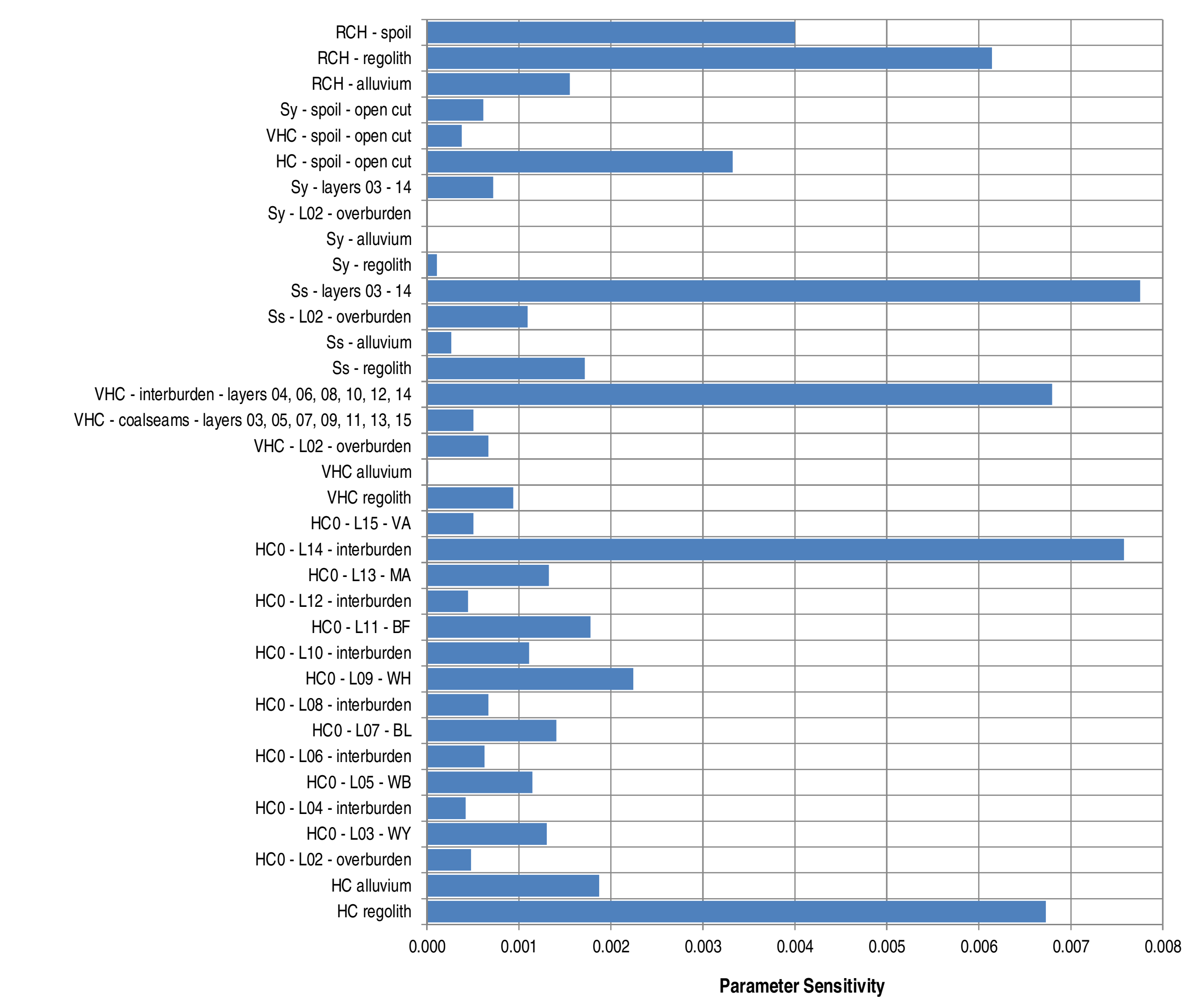


Figure C- 21: Initial automated calibration parameter sensitivities

As some parameters were tied during the initial calibration run they appear with combined sensitivities. Sensitive parameter groups were:

- recharge (RCH) to spoil and regolith (Permian);
- specific storage (ss) in all confined layers;
- horizontal (HCO) and vertical (VHC) hydraulic conductivity in interburden aquitards; and
- horizontal hydraulic conductivity in regolith.

The remaining parameter groups had lower sensitivity. The sensitivity analysis confirms what was evident from manual calibration that the permeability of interburden aquitards plays an important role confining each coal seam, and producing the hydraulic gradient seen on most nested monitoring sites.

Appendix D

NUMERICAL MODEL – UNCERTAINTY ANALYSIS

1. UNCERTAINTY ANALYSIS

1.1 Introduction

This section assesses the uncertainty of the model predictions to natural variability in the calibrated parameters. Analysis of the uncertainty of model outputs is referred to as “uncertainty analysis”. Model calibration does not necessarily result in a unique set of parameter values, especially if the model employs a number of parameters to simulate system complexity. As the model was calibrated to known measurements, a calibration-constrained Monte Carlo analysis was carried out, rather than an unconstrained uncertainly analysis.

Typically, groundwater models employ numerous levels of simplification and assumptions, in order to represent reality. Therefore, a number of issues may arise, including:

(i) adequacy in representing naturally complex processes;

(ii) gaps in our understanding of the hydrogeological system process; and,

(iii) measurement ‘noise’ in observed aquifer measurements.

A calibration-constrained Monte Carlo analysis was carried out with the following objectives:

- to describe a numerically-tractable approach for quantification of uncertainty for this model; and
- report the results of potential uncertainty associated with calibration and predictive model simulations.

The calibration-constrained Monte Carlo method was used for predictive uncertainty analysis to generate variable model parameter sets. To ensure the model remained calibrated, the results from the models were then compared against observed data, accounting for intrinsic errors associated with observed data (i.e. measurement error).

It should be noted that the calibrated model used to base the uncertainty analysis on was not the final calibration discussed within this document. Time constraints to maintain the project deliverable meant that uncertainty analysis had to be conducted prior to final model completion. Although the uncertainty analysis was not based on the final model calibration the results of this analysis are still thought of worth in the discussion on the measurement error in the calibration.

1.2 Methodology

During the pre-calibration stage, appropriate bounds were established for each parameter set, based on observed data, textbook sources and best knowledge. These bounds could represent, for example, the 95^{th} confidence interval of field hydraulic testing data, or one-magnitude variability in specific storage as suggested from similar hydrostratigraphic units in the region. The groundwater model was manually calibrated using these conceptual bounds as parameter limits then set in the automated calibration software, (e.g. PEST).

Model calibration does not necessarily produce a unique set of parameter values, therefore model predictions can vary with a ‘calibrated’ parameter set. The analysis of the variability in these predictions is known as a calibration-constrained Monte Carlo approach.

Given large variability in the expected range of hydraulic parameters required to create a groundwater model, it is assumed that the predictive results will be subject to a similar level of uncertainty (although the level of uncertaimty depends on type of prediction).

In this study, predictive uncertainty analysis was applied to the MTW Underground groundwater model, which was calibrated to a measurement dataset. This dataset was selected to best represent the groundwater response to seasonal and mining induced stresses on the system from years 1981 to 2014. These parameter sets were 'realized' using a stochastic random number generator, using an adopted set of parameter statistical properties to best represent the observed and/or estimated range.

The randomised realized fields represent the possible variability of the parameter dataset that leads to variability in model predictions. An acceptable level of 'de-calibration' of the calibration model was sought to ensure a calibration constrained and therefore realistic analysis was honoured.

Randomised parameter sets were generated by allowing random heterogeneity on a cell-by-cell basis, to better represent the type of aquifer variability that exists in the real world (Tonkin and Doherty, 2009). Each spatial parameter field was generated using a cell-by-cell stochastic field generator (e.g. the GSLIB geostatistical suite of Deutsch and Journel, 1998). Cell-by-cell variability of parameters also assumed a log-normal prior probability distribution, with means corresponding to optimised parameter values and a variogram sill (upper bound) corresponding to the assumed parameter variance.

200 realised parameter sets were explored for the calibration model, using bounds to correspond with 95% confidence intervals from the expected calibrated parameter bounds used in PEST. The rejection of these parameter sets was determined by ranking the objective function (i.e. Phi) from the transient calibration simulation for each realisation. Realisations that exceeded the calibrated objective function by more than 200% were rejected from the predictive calibration analysis, which was determined from the spread of the Phi results and subsequent levels of de-calibration. Of the 200 realised parameter sets, 127 fell within the acceptable calibrated objective function. The suite of 127 realisations was used to predict the degree of uncertainty within the model outputs, and computing the statistical probabilities of the results (e.g. groundwater drawdown) from all model runs.

1.3 Application of Uncertainty Analysis

1.3.1 Variable Parameters

All hydraulic parameters explored in the automatic calibration were explored in the analysis, including horizontal hydraulic conductivity, vertical hydraulic conductivity multipliers, specific storage, specific yield, groundwater recharge, and riverbed conductance.

The original calibration process employed layer-wide parameters to represent aquifer hydraulic properties for the undisturbed country rock, spoil and underground longwall areas. Thus, these parameters were replaced with spatially varying fields to replicate cell-by-cell variability across the model domain.

The reduction of hydraulic conductivity with depth below surface was represented using an exponential decline function determined from measurement data (refer Section 5.5 of the main report). To introduce a variability of hydraulic parameters, the obsereved decline of horizontal hydraulic conductivity with depth was honored, however a multiplier array changing the calculated hydraulic conductivity value was applied. The multiplier array adjusted the calculated horizontal hydraulic conductivity of the coal seam by a value of 1 standard derivation of the calibrated parameter interval.

Cell-by cell groundwater recharge rates from diffuse rainfall were also included in the uncertainty analyses, using the random-generated multiplication fields. Realised fields representing daily recharge rates were generated for the regolith and alluvial zones, using bounds utilised in the automated calibration process.

Zonal parameter schemes for vertical riverbed permeability were modified for uncertainty analyses, again using random-generated multiplier field (using statistical bounds of expected riverbed conductance rates). The application of vertical riverbed conductivity was split into three separate zones, namely the Hunter River, Wollombi River and 'other' zones.

1.3.2 Statistical Representation

The covariance matrix C(**k**) represents information on hydraulic properties available from outside of the calibration process, and represents "expert knowledge" in the model parameterisation process. The hydraulic parameters within the C(**k**) matrix were set realistic bounds based on the "expert knowledge". The uncertainty of the predictions made by an uncalibrated model is a function of C(**k**).

Information used to assemble the components of the C(**k**) matrix for random parameter generation is presented in Figure D-1 to Figure D- **7**. All parameters and standard deviations were converted to log values given the relationship between parameter and model output is likely to approach linearity. Note, the exponential variogram range in kilometres applied to realised parameter fields was based on expected structural variances in the model (e.g. 2000 m).

Within Table D-1 to Table D- **7**, the calculation of standard deviation of each parameter was based on the assumption that the parameter has a normal distribution and parameter bounds represent the 95% confidence limit. Variance, or the multiplying range applied to the random number generator, is the square of the standard deviation. The mean represents the calibrated value attained from automated PEST calibration, which best replicates the calibrated parameter set. Section 1.4 presents the spatial distribution of the randomised fields, and their native parameter values across the model domain.

Table D-1: HYDRAULIC CONDUCTIVITY CELL-BY-CELL FIELD GENERATION STATISTICS

Parameter Zone	Parameter Name	Mean (m/day)	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
1	Regolith	4.19E-01	0.37	0.14	2000
2	Interburden 1	3.95E-03	0.42	0.18	2000
3	Whybrow Seam	7.61E-02	0.50	0.25	2000
4	Interburden 2	2.19E-04	0.25	0.06	2000
5	Wambo Seam	2.79E-02	0.50	0.25	2000
6	Interburden 3	1.48E-04	0.25	0.06	2000
7	Blakefield Seam	2.56E-02	0.50	0.25	2000
8	Interburden 4	7.31E-05	0.25	0.06	2000
9	Woodlands Seam	2.60E-02	0.50	0.25	2000
10	Interburden 5	6.97E-05	0.25	0.06	2000
11	Bowfield Seam	2.17E-02	0.50	0.25	2000
12	Interburden 6	5.00E-05	0.25	0.06	2000

Table D-1: HYDRAULIC CONDUCTIVITY CELL-BY-CELL FIELD GENERATION STATISTICS

Parameter Zone	Parameter Name	Mean (m/day)	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
13	Mt Arthur Seam	7.79E-02	0.50	0.25	2000
14	Interburden 7	1.92E-04	0.25	0.06	2000
15	Vaux Seam	5.00E-02	0.50	0.25	2000
16	Interburden 8	1.00E-06	0.42	0.18	2000
17	Alluvium	1.00E+01	0.08	0.01	2000
18	Spoil	3.54E-01	0.45	0.20	2000
19	Underground	5.00E-01	0.50	0.25	2000

Table D- 2: COAL SEAM CONDUCTANCE MULTIPLIER FOR CELL-BY-CELL FIELD GENERATION STATISTICS

Parameter Zone	Parameter Name	Mean	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
1	Coal Seam	1.00	0.5	0.25	2000

Table D- 3: VERTICAL CONDUCTIVITY MULTIPIER FOR CELL-BY-CELL FIELD GENERATION STATISTICS

Parameter Zone	Parameter Name	Mean	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
1	Regolith	6.89E-04	0.58	0.33	2000
2	Interburden 1	1.00E-02	0.33	0.11	2000
3	Whybrow Seam	1.00E-02	0.33	0.11	2000
4	Interburden 2	4.12E-03	0.33	0.11	2000
5	Wambo Seam	1.00E-02	0.33	0.11	2000
6	Interburden 3	4.12E-03	0.33	0.11	2000
7	Blakefield Seam	1.00E-02	0.33	0.11	2000
8	Interburden 4	4.12E-03	0.33	0.11	2000
9	Woodlands Seam	1.00E-02	0.33	0.11	2000
10	Interburden 5	4.12E-03	0.33	0.11	2000
11	Bowfield Seam	1.00E-02	0.33	0.11	2000
12	Interburden 6	4.12E-03	0.33	0.11	2000
13	Mt Arthur Seam	1.00E-02	0.33	0.11	2000
14	Interburden 7	4.12E-03	0.33	0.11	2000
15	Vaux Seam	5.00E-03	0.25	0.06	2000
16	Interburden 8	1.00E-02	0.33	0.11	2000
17	Alluvium	8.35E-04	0.50	0.25	2000
18	Spoil	2.95E-02	0.25	0.06	2000

Table D- 3: VERTICAL CONDUCTIVITY MULTIPIER FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean	Standard Deviation	Variance	"a" of Exponential Variogram
			(log$_{10}$)	(log$_{10}$)	(m)
19	Underground	1.00E-03	0.25	0.06	2000

Table D- 4: SPECIFIC YIELD FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean	Standard Deviation	Variance	"a" of Exponential Variogram
			(log$_{10}$)	(log$_{10}$)	(m)
1	Regolith	2.00E-02	0.15	0.02	2000
2	Interburden 1	1.02E-04	0.50	0.25	2000
3	Whybrow Seam	4.74E-03	0.67	0.46	2000
4	Interburden 2	9.49E-04	0.58	0.33	2000
5	Wambo Seam	4.74E-03	0.67	0.46	2000
6	Interburden 3	9.49E-04	0.58	0.33	2000
7	Blakefield Seam	4.74E-03	0.67	0.46	2000
8	Interburden 4	9.49E-04	0.58	0.33	2000
9	Woodlands Seam	4.74E-03	0.67	0.46	2000
10	Interburden 5	9.49E-04	0.58	0.33	2000
11	Bowfield Seam	4.74E-03	0.67	0.46	2000
12	Interburden 6	9.49E-04	0.58	0.33	2000
13	Mt Arthur Seam	4.74E-03	0.67	0.46	2000
14	Interburden 7	9.49E-04	0.58	0.33	2000
15	Vaux Seam	4.74E-03	0.67	0.46	2000
16	Interburden 8	1.00E-03	0.58	0.33	2000
17	Alluvium	5.00E-02	0.29	0.09	2000
18	Spoil	1.98E-02	0.33	0.11	2000
19	Underground	1.00E-01	1.00	1.00	2000

Table D- 5: SPECIFIC STORAGE FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean (m^{-1})	Standard Deviation	Variance	"a" of Exponential Variogram
			(log$_{10}$)	(log$_{10}$)	(m)
1	Regolith	8.33E-04	0.33	0.11	2000
2	Interburden 1	4.68E-05	0.25	0.06	2000
3	Whybrow Seam	6.28E-06	0.42	0.18	2000
4	Interburden 2	6.28E-06	0.42	0.18	2000
5	Wambo Seam	6.28E-06	0.42	0.18	2000

Table D- 5: SPECIFIC STORAGE FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean (m^{-1})	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
6	Interburden 3	6.28E-06	0.42	0.18	2000
7	Blakefield Seam	6.28E-06	0.42	0.18	2000
8	Interburden 4	6.28E-06	0.42	0.18	2000
9	Woodlands Seam	6.28E-06	0.42	0.18	2000
10	Interburden 5	6.28E-06	0.42	0.18	2000
11	Bowfield Seam	6.28E-06	0.42	0.18	2000
12	Interburden 6	6.28E-06	0.42	0.18	2000
13	Mt Arthur Seam	6.28E-06	0.42	0.18	2000
14	Interburden 7	6.28E-06	0.42	0.18	2000
15	Vaux Seam	6.28E-06	0.42	0.18	2000
16	Interburden 8	1.00E-06	0.42	0.18	2000
17	Alluvium	6.03E-04	0.33	0.11	2000
18	Spoil	1.00E-04	0.42	0.18	2000
19	Underground	1.00E-04	0.50	0.25	2000

Table D- 6: RECHARGE FACTOR FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
1	Regolith	4.23E-03	0.17	0.03	2000
2	Alluvium	3.00E-02	0.13	0.02	2000
3	Spoil	7.45E-02	0.17	0.03	2000

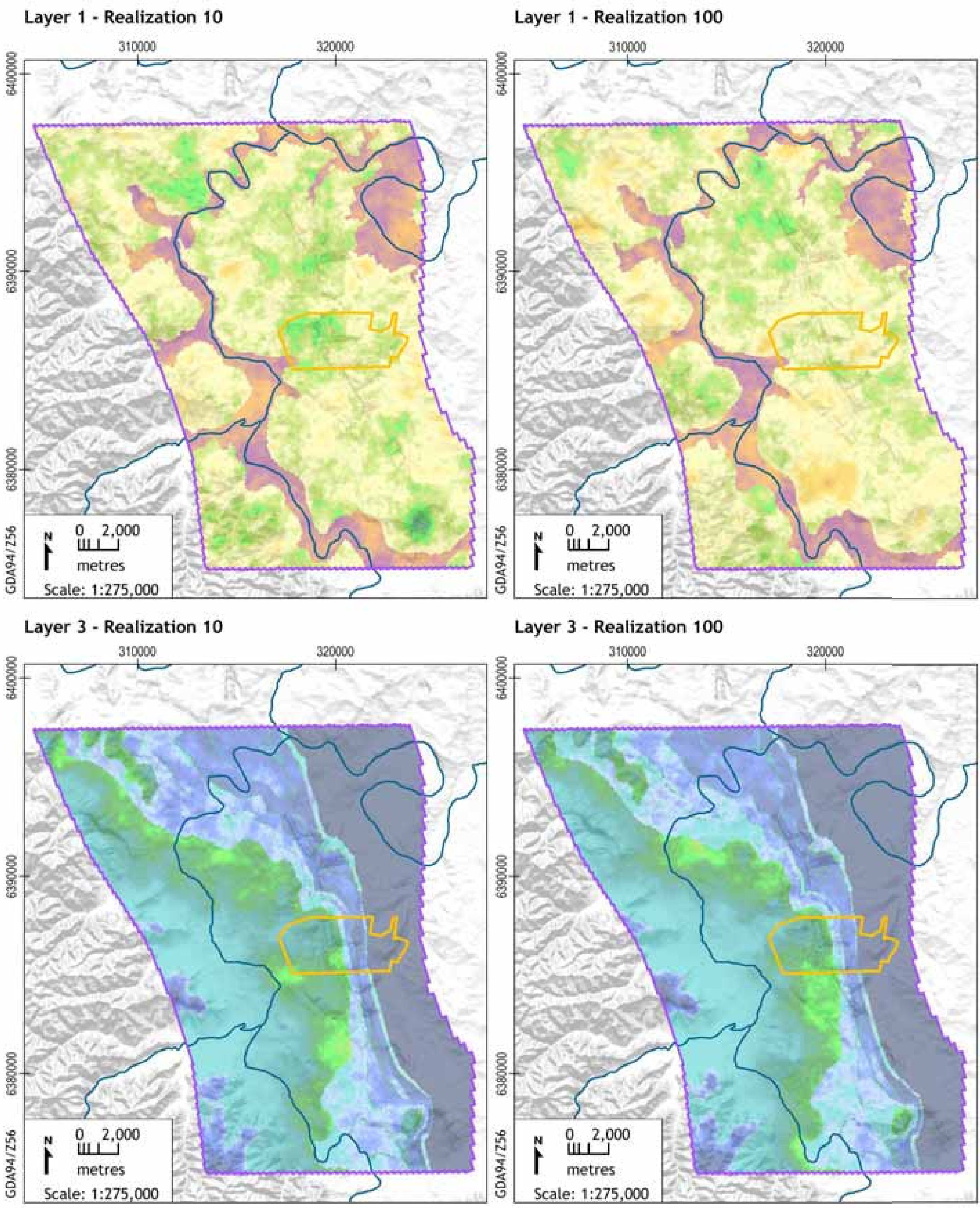
Table D- 7: VERTICAL RIVERBED CONDUCTIVITY FOR CELL-BY-CELL FIELD GENERATION STATISTICS					
Parameter Zone	Parameter Name	Mean (m/day)	Standard Deviation	Variance	"a" of Exponential Variogram
			(log_{10})	(log_{10})	(m)
1	Hunter	1.00E-01	0.58	0.33	2000
2	Wollombi	1.00E-02	0.58	0.33	2000
3	Minor drains	1.00E-01	0.58	0.33	2000

1.4 Application

Two hundred randomised realisations were generated with FIELDGEN using the parameters listed in Section 1.3.2. All 200 realisations were tested using PEST, and the objective function (sum of squared residuals) from each run was examined. The calibrated objective function[1] (Phi) was determined as 399,200 m^2, and a suitable cut off for “de-calibration” was set to be 200% of the calibrated Phi (i.e. 798,400 m^2). 127 realisations meet these criteria, and 73 realisations were rejected from further analysis. Of these 73 realisations, a total of 4 simulations failed to converge, meaning that the combination of varied parameters e.g. high recharge and low hydraulic parameters, caused numerical instability.

Figure D1 to Figure D-6 show a sample of the 127 realisations for the hydraulic conductivity, vertical conductivity, confined aquifer storage coefficient and specific yield for layers 1, 3, 6 and 13.

[1] The initial model calibration Phi used for uncertainty analysis.



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Major watercourse

Hydraulic Conductivity (m/day)

18	0.05
12	0.02
7	0.0003
2	0.0002
0.5	0.0001
0.2	0
0.1	

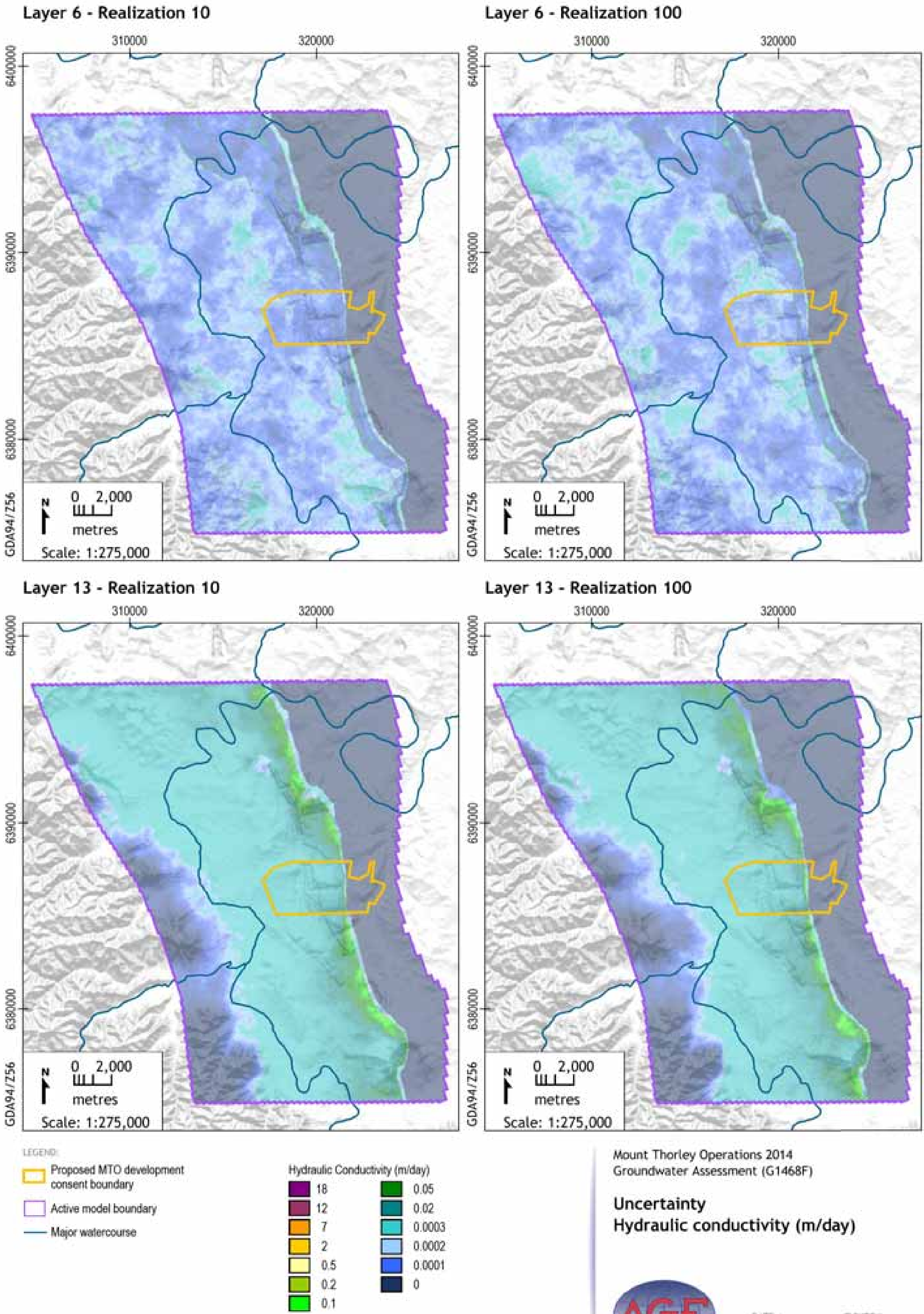
Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Hydraulic conductivity (m/day)

AGE

DATE: 3/4/2014

FIGURE No: **D-1**

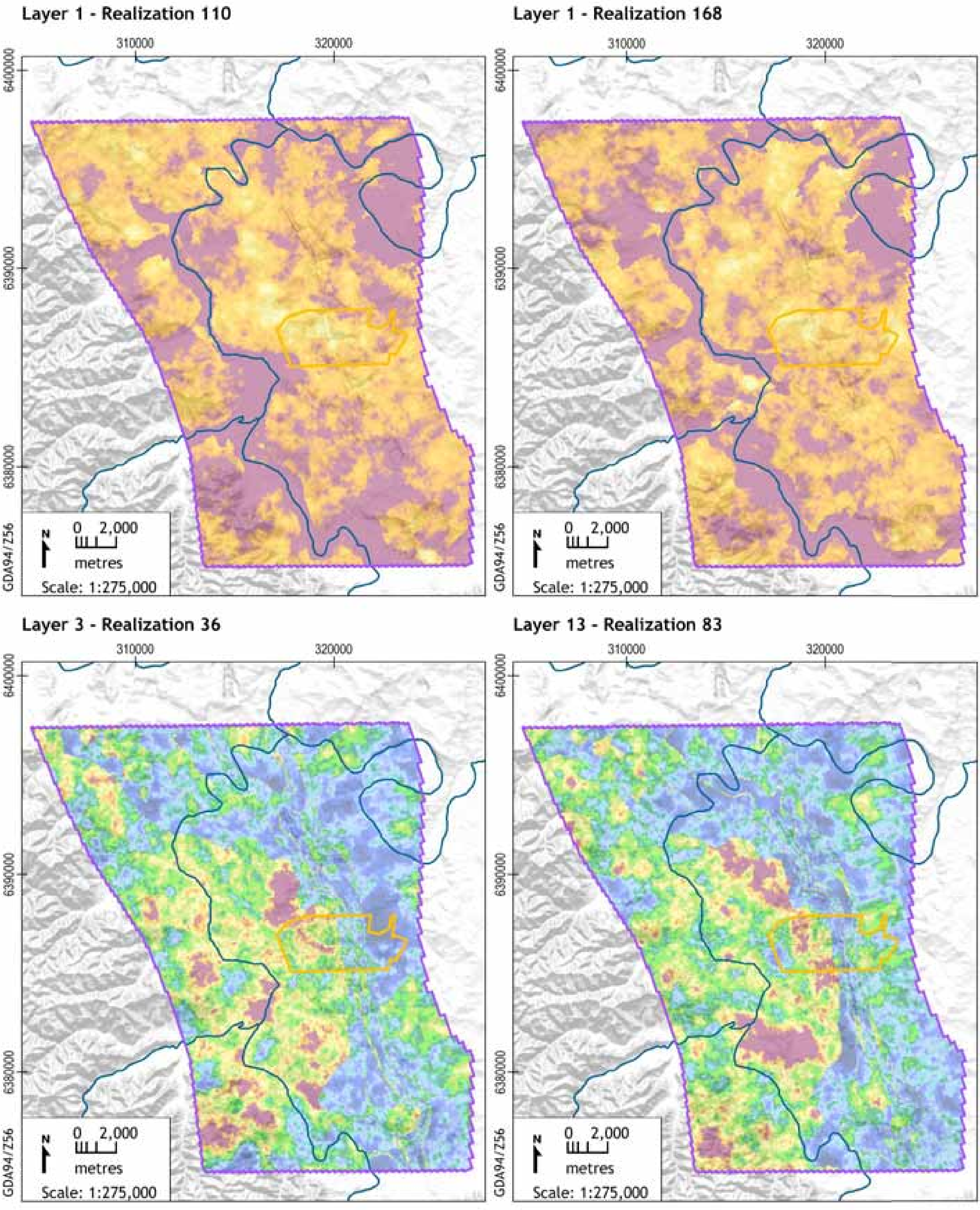


Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Hydraulic conductivity (m/day)

DATE: 3/4/2014

FIGURE No: **D-2**



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Major watercourse

Specific Yield

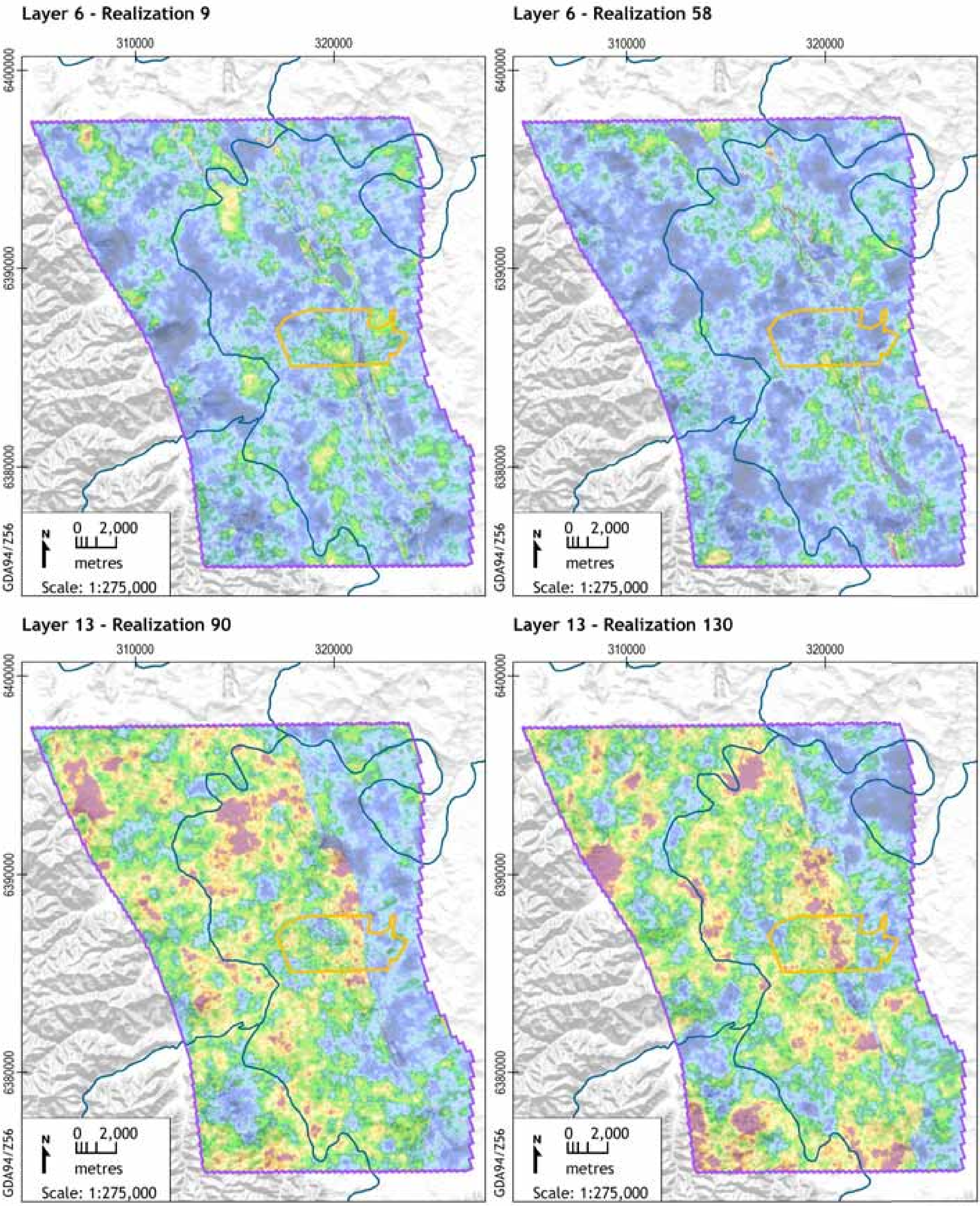
0.7	0.0025
0.025	0.002
0.02	0.0015
0.015	0.001
0.01	0.0005
0.005	0
0.003	

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Specific Yield

DATE: 3/4/2014

FIGURE No: **D-3**

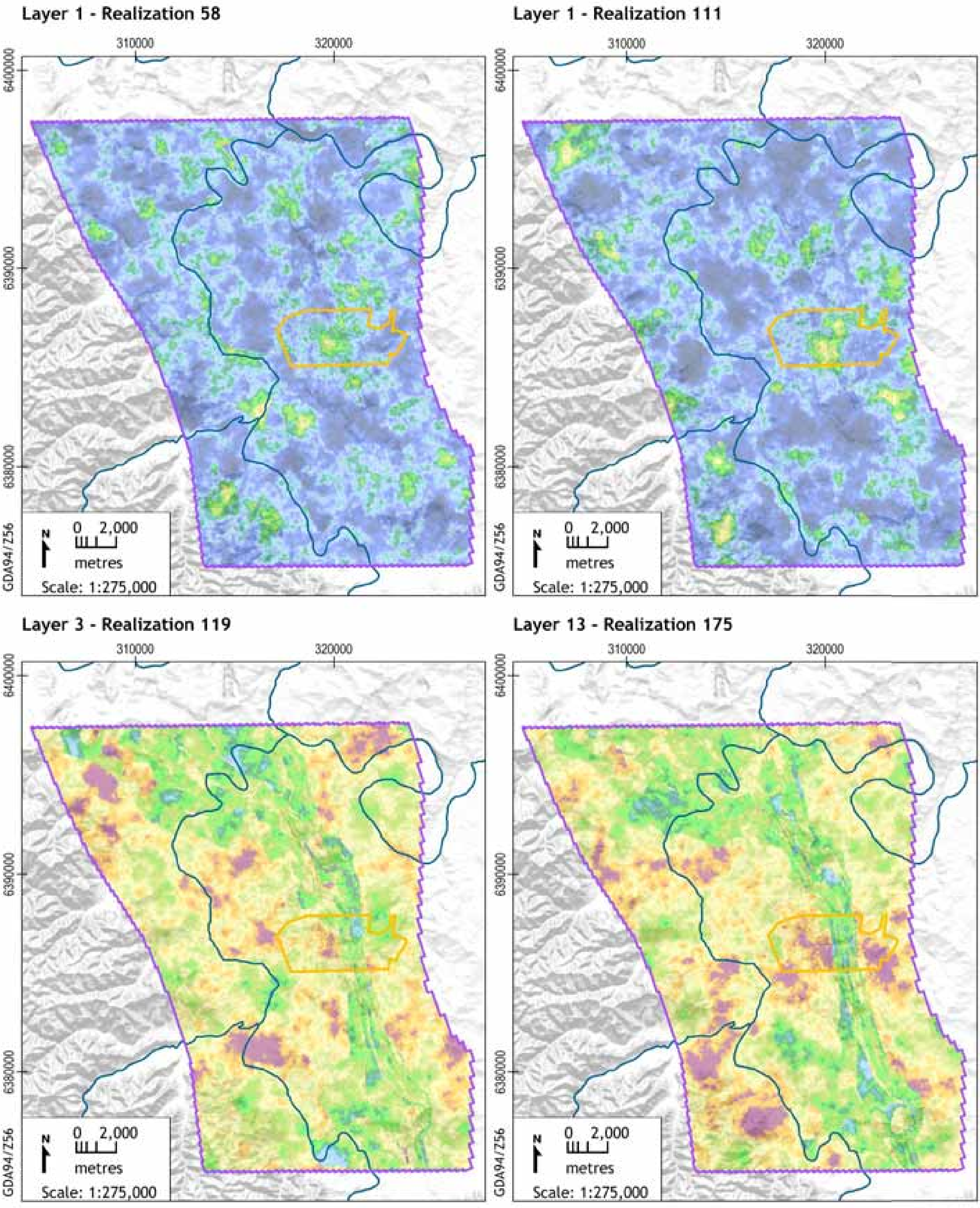


Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Specific Yield

DATE: 3/4/2014

FIGURE No: **D-4**



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Major watercourse

Vertical Hydraulic Conductivity Factor

0.1	0.0025
0.025	0.002
0.02	0.0015
0.015	0.001
0.01	0.0005
0.005	0
0.003	

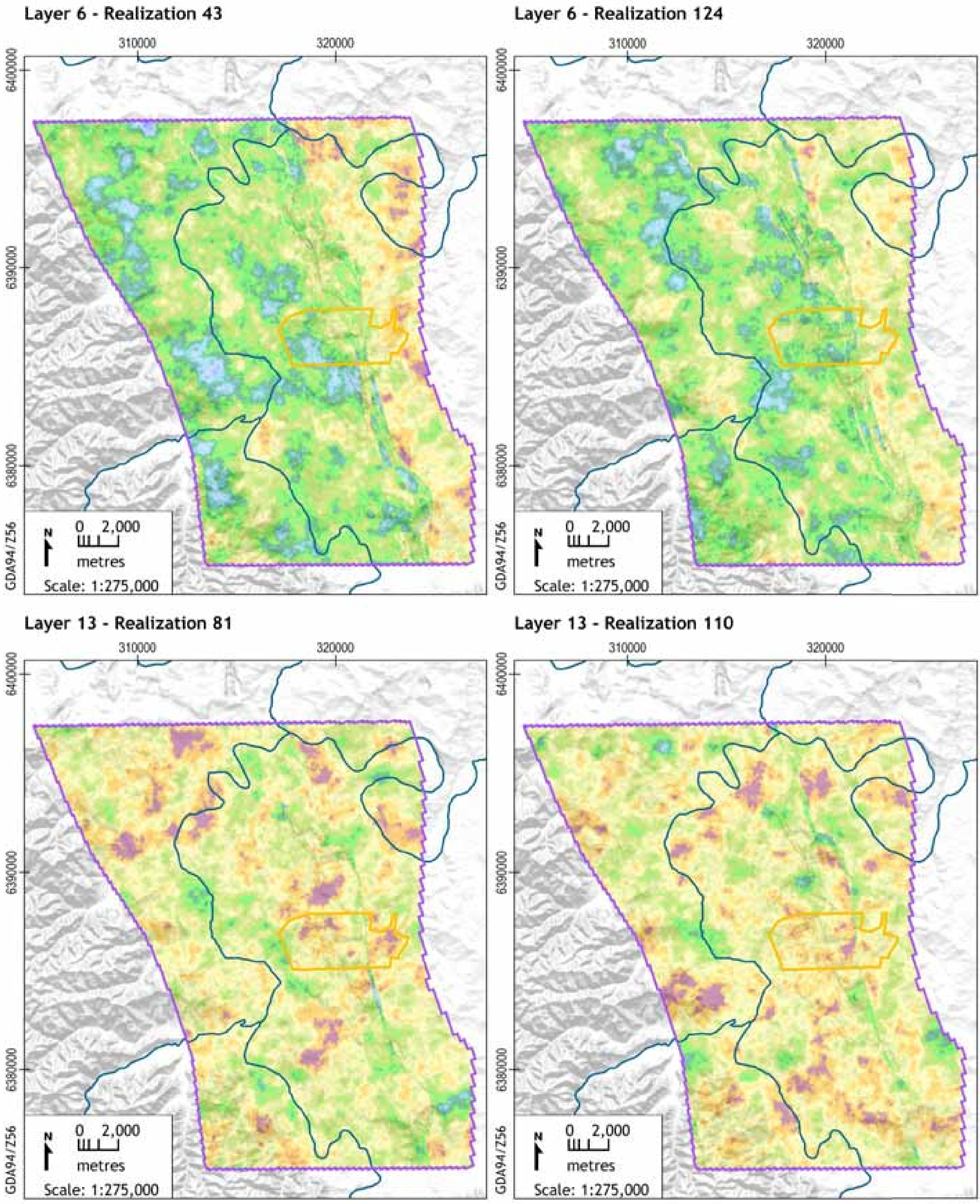
Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Vertical Hydraulic Conductivity Factor

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 3/4/2014

FIGURE No: D-5



LEGEND:

- Proposed MTO development consent boundary
- Active model boundary
- Major watercourse

Vertical Hydraulic Conductivity Factor

0.1	0.0025
0.025	0.002
0.02	0.0015
0.015	0.001
0.01	0.0005
0.005	0
0.003	

Mount Thorley Operations 2014
Groundwater Assessment (G1468F)

Uncertainty
Vertical Hydraulic Conductivity Factor

DATE: 3/4/2014

FIGURE No: **D-6**

Figure D- 7 shows the results from the calibration uncertainty analysis (Realisations), as well as the calibrated and cutoff levels for the objective function (Phi).

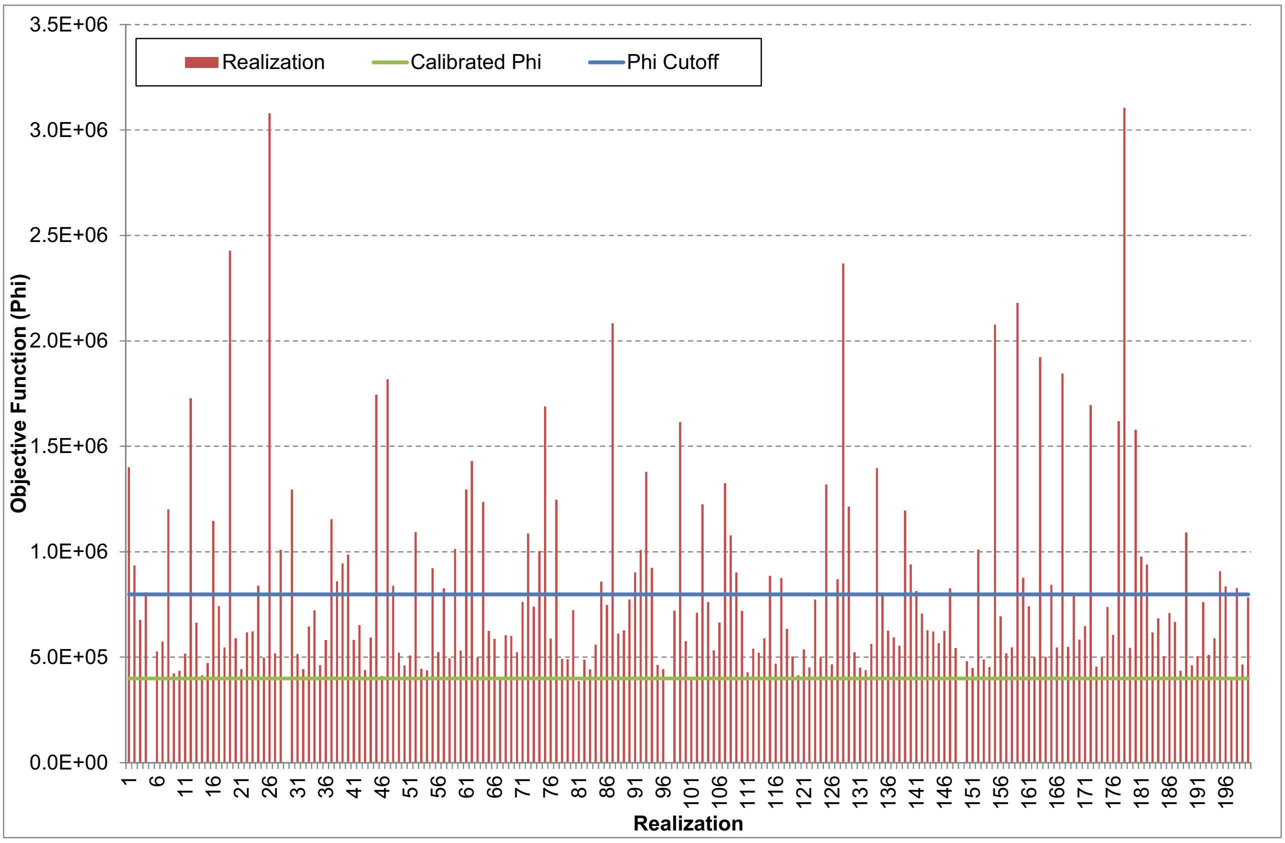


Figure D- 7: Ranking of Objective Function (Phi) from Calibration Runs

Appendix E

EXTERNAL REVIEW REPORT

KALF AND ASSOCIATES Pty Ltd
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23 May 2014

Mt Thorley Operations 2014
KA Final Peer Review of the AGE Groundwater Assessment

Background

The Peer Review presented herein is for the proposed completion of mining at the Mt Thorley mine site Upper Hunter Valley. The mine is seeking approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) have completed a report (AGE 2014) that describes the groundwater conditions at the site and used numerical model analysis to predict the impact of the proposed mining to completion on the surrounding groundwater system.

The KA peer review was completed in two parts: First a detailed preliminary review report was prepared of requested clarifications and also corrections, and error tabulation. AGE has in turn addressed most of these items in response. This report provides the final peer review documentation of the re-issued updated final AGE (2014) report.

In the following review the National Water Commission modelling guidelines have been taken into consideration.

Review

Overall the AGE (2014) report's hydrogeological description and assessment is comprehensive with suitable numerical modelling procedures applied together with uncertainty analysis. The AGE report provides a detailed description of the model development and calibration in an Appendix C.

The AGE 2014 model is based on previous models developed by MER (2002) and subsequently by AGE (2010) for the Warkworth mine site. The groundwater assessment based on the AGE 2010 work for the Warkworth mine was previously approved by both Commonwealth and NSW governments but overturned by the NSW Land and Environment Court. Since the 2010 work more monitoring bores have been installed that has allowed a much larger data base of groundwater levels to be established.

Hydrogeological Description

The hydrogeology of the site and surrounding area is described in detail and covers groundwater occurrence, monitoring, water levels, gradients, strata permeability and storage, recharge, discharge, water quality, users and ground water dependent ecosystems, policy and licensing requirements.

Conceptual Model

The area has had a long history of mining both on the Mt Thorley mine site and in adjacent mining zones and the geology and hydrogeology are well understood. The conceptual model used as the basis for the numerical model is considered suitable.

Model Software and Extent

The modelling software used for this project by AGE was MODFLOW-SURFACT (MS) which is entirely suitable for this kind of modelling assessment. The model covers an adequate area of 344 km^2 extending about 19 km from west to east and 24 km from north to south.

Model layers and cells

Model layering adopted is considered suitable with sixteen layers used to represent Permian coal bearing hydrogeological units both within the mining zone and below, as well as the overlying alluvial sediments of the drainage streams in the area, in particular Wollombi Brook and also the Hunter River. The layering has provided sufficient vertical resolution in the model and differs from the AGE (2010) model by including interburden as separate layers rather than as vertical conductances. Model cells used were 30m x 30m within the mining zone increasing up to 100m x 225m outside this zone. Higher resolution grid arrays were cantered on the Mt Thorley mining area.

Boundary conditions

Boundary conditions set for the model are suitable. Ephemeral streams were set initially using the ‘river package’ with very low stage but then with zero surface flow over an extended period as part of the uncertainty analysis. Recharge was applied as net recharge..

Model parameters

Initial model parameters were applied based on values used in previous modelling work and then subsequently calibrated using the new 2014 AGE model. Calibration was achieved by initial trial and error and then applying the PEST algorithm.

Calibration

Both steady state calibration using interpolated bore water level measurements and transient analysis calibration was conducted. Steady state calibration was problematic because of the considerable activity within the mining area over many years of operation both within the mine itself and in adjacent mines. Therefore the groundwater levels so obtained can only be considered to be a set of starting heads for the transient analysis.

Examination of the transient analysis scatter diagram indicates very good to poor fit. Statistically the results yielded an overall RMS value of 18% (and sRMS = 15%). This lies outside the range of 5% to 10% suggested in the modelling guidelines. There are some mitigation circumstances however. First is that the mining zones are highly disturbed and are also confounded by the lack of precise knowledge about the historical mining sequences in the region. The scatter diagram outliers also are over represented by having a longer duration of high frequency measurements.

KA in the preliminary review requested AGE to indicate the location of these outlier water levels. AGE has responded with a Figure 7.6. This puts those measurements in perspective. It shows that they relate to the deeper Permian model strata but not to the upper model layers that are more important in assessing any predicted drawdown influence both on the adjacent Wollombi Brook alluvium. That is, the drawdown residuals in layer 1 and 2 for example are relatively smaller and therefore would likely lie within the 5 to 10% suggested limits, but also that they over predict drawdown compared to that measured rather than under-predict.

Overall drawdown distributions depicted in Figure 7.5, that shows the regional extent of potentiometric heads at the end of the calibration period in both the alluvium and regolith and within the Mt Arthur coal seam, are consistent and appear plausible.

Predictions and Potential Impacts

Prediction of potentiometric heads and changes in head in Figures 8.1 to 8.3 also appear consistent and plausible.

Predicted inflows to the Loders pit and the influence to baseflows presented are considered to be plausible. Inflow from the high salinity Permian groundwater during the first year (2015) is 1064 m^3/day decreasing thereafter. Inflow from spoil is much higher at 2832 m3/day in 2015 increasing to a maximum of 3721 m3/day in 2017 decreasing thereafter. These inflows do not include losses due to direct evaporation from the high wall or pit floor.

Baseflow reduction from Wollombi Brook peaks at 300 m^3/day in 2020 with negligible loss to the Hunter River surface water flow. It should be noted that the baseflow reduction is due to the capture of brackish to saline groundwater from the Permian strata that would have otherwise entered Wollombi Brook alluvium and its stream channel.

Modelling indicates only four bores would be affected by the proposal with drawdowns in the Permian strata in the range 2.5 to 6.5m. However, these bores are not privately owned but belong to the Bulga Mine.

The main GDE in the area is the Warkworth Sands Woodland situated north-west of the Warkworth mine. However groundwater in these Sands comprise a perched system with limited hydraulic connection to the main regional watertable and therefore would not be significantly affected by mine drawdown.

The Southern Biodiversity Area (Valley Oak Forest and River Red Gum Woodland) are situated 4km from the proposed mining area in alluvium along the Wollombi eastern bank. These zones will not be influenced by mine drawdown.

There would be no significant increase in salinity created in the alluvium and Wollombi Brook stream flow during mining. On the contrary the reduction in groundwater flow from the Permian strata to the alluvium will be up to 532 m^3/day[1] and therefore correspondingly less brackish to saline groundwater would enter the alluvium and subsequently some as Wollombi baseflow.

Post Mining

Loders pit will be backfilled with spoil and tailings to 65m RL and a small depression 10m below pre-mine groundwater levels will remain that will fill with runoff and groundwater. There is potential of groundwater flow from the spoil post mining toward the Wollombi Brook alluvium due to the expected higher groundwater levels in the spoil than during pre-mining conditions. However, salinity of destination zones are reported to be in the range 15,000 to 20,000 microSeimens/cm with migrating groundwater salinity of about 10,000 microSeimens/cm. Hence there is unlikely to be undesirable degradation of groundwater salinity as a result of spoil groundwater migration.

Conclusion

[1] Of the 532 m^3/day groundwater flow reduction from the Permian to alluvium, 300 m^3/day of this rate is the baseflow component.

The AGE groundwater assessment report is comprehensive and has satisfactorily provided descriptions of the hydrogeological system of the Mt Thorley mine site. The model setup, calibration and predications are also considered to be suitable. Model analyses of the proposed continuation of mining indicate that the impacts will be minimal with respect to drawdown influence and beneficial to surface and groundwater quality. Simulations results are considered reasonable and plausible. Ongoing monitoring of water levels and a model update every 5 years during operations is recommended to compare model predicted with measured drawdown influence.

F. R. Kalf B.Sc, M.App.Sc., PhD

References

Australasian Groundwater and Environmental (AGE) 2010 *Warkworth Mine Extension, Groundwater Impact Assessment. Project No G1468. Feb.*

Australasian Groundwater and Environmental (AGE) 2014 *Mt Thorley Operatons 2014 Groundwater Assessment. Prepared for EMGA Mitchell McLennan. Project No G1468/F. May*

Mackie Environmental Research (2002) *Extension of Warkworth Coal Mine Assessment of Environmental Impacts Surface and Groundwater Systems in the Upper Hunter Valley of NSW. August .*

Appendix J

Surface water study

Appendix J — Surface water study

J

water + environment

MOUNT THORLEY OPERATIONS 2014 AND WARKWORTH CONTINUATION 2014 SURFACE WATER ASSESSMENT

Prepared for Coal & Allied Operations Pty Limited
June 2014

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REPORT TITLE: Mount Thorley Operations 2014 and Warkworth Continuation 2014 – Surface Water Assessment

CLIENT: Coal & Allied Operations Pty Limited

REPORT NUMBER: 0605-09-D7

Revision Number	Report Date	Description	Report Author	Reviewer
D7	2 June 2014	Final Report	TK	DN

For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

EXECUTIVE SUMMARY

WRM Water & Environment Pty Ltd was commissioned by EMGA Mitchell McLennan (EMGA), on behalf of Coal & Allied Operations Pty Limited (Coal & Allied), to undertake a surface water impact assessment to determine potential impacts on surface water resources due to the Mount Thorley Operations (MTO) and Warkworth Continuation 2014 Projects (the proposal).

The proposal involves an extension to the approved mining footprint at Warkworth Mine and completion of mining at MTO (among other things), for a period of 21 years.

MTO is an open cut coal mine approximately 15 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). Immediately to the north is Warkworth Mine, operated by Warkworth Mining Limited on behalf of MTJV. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for the operations.

MTW currently holds a high security Water Access Licence with an allocation of up to 1,012 mega Litres (ML) enabling extraction from the Hunter River, as well as two licenced discharge locations, operated in accordance with the Hunter River Salinity Trading Scheme (HRSTS) and existing Environmental Protection Licences (EPL) 1376 and 1976.

Under current catchment conditions (since the upgrade to the Glenbawn Dam in 1988), the Hunter River is perennial. The Hunter River water quality is characterised by low salinity and moderate alkalinity. However, numerous water quality parameters exceed water quality guidelines, particularly for nutrients and pH. Wollombi Brook is ephemeral, and has a high level of connectivity between surface water and the groundwater aquifer. Water quality in Wollombi Brook is characterised by low salinity and slight alkalinity. Parameters which exceed water quality guidelines include chloride and sodium.

The potential changes to surface water and water management during the life of the proposal that have been investigated include:

- Additional water demand from external third party sources (ie neighbouring mines or the Hunter River) to meet increased operational water requirements for the proposal;
- Loss of catchment area draining to Wollombi Brook and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Wollombi Brook and the Hunter River;
- Adverse impacts on the quality of surface runoff draining from the local site catchment to Wollombi Brook and the Hunter River;
- Change in downstream water quality associated with possible overflows from the mine water management system;
- Increase in saline water controlled discharges (HRSTS); and
- Interference with flood flows along Wollombi Brook and the Hunter River associated with changes in the respective flood plains.

A key component of the methodology for the surface water impact assessment has been the development of a detailed computer model of the mine water balance. The model was configured to represent the inflows to and outflows from the mine water management system as well as transfers of water between mine site storages. The mine water balance model was calibrated against observed system performance during 2012 to 2013. The mine water system model was simulated on a daily basis over the 21 year life of the proposal using 93 difference rainfall sequences based on recorded historical data.

The results of the water balance model indicate that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in production at Warkworth Mine and the decrease in groundwater inflows to at MTO. External water requirement from Year 3 to year 21 are generally consistent with:

- A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
- A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100% Available Water Determination (AWD)).

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (300ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of project life, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of project life; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of project life, and around 400ML from Warkworth Mine in any year of project life.

There is a maximum reduction of 0.56 per cent of the Wollombi Brook catchment to the Hunter River, and a maximum reduction of 0.19 per cent of the Hunter River (not including Wollombi Brook) during mining. Post-mining, the reduction in catchment area is 0.44 per cent and 0.04 per cent for Wollombi Brook and the Hunter River respectively. There is a median net runoff reduction to the Hunter River of up to 75ML/a during mining, and up to 104ML/a post-mining.

MTW currently undertakes an extensive surface water monitoring program, which will continue to be implemented for the proposal. Monitoring includes on site dams (both saline and sediment), receiving waters (upstream and downstream Hunter River, Wollombi Brook and their tributaries), and additional monitoring which is undertaken during periods of controlled release under the HRSTS. Additional saline storages and sediment dams constructed as part of the proposal will be monitored in accordance with the current monitoring program.

Overall, the impacts of the Project on surface water resources are unlikely to be significantly greater than those of the existing mining operation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

1 INTRODUCTION

1.1 OVERVIEW

WRM Water & Environment Pty Ltd (WRM) was commissioned by EMGA Mitchell McLennan Pty Limited (EMM), on behalf of Coal & Allied Operations Pty Limited (Coal & Allied), to undertake an assessment of surface water impacts due to the Mount Thorley Operations (MTO) 2014; as well as the Warkworth Continuation 2014.

As the water management systems at MTO and Warkworth Mine are significantly integrated, the surface water impact assessment has been based on the combined projects (the proposal). This assessment forms part of the environmental impact statement (EIS) for each project. Details of the proposal and the methodology and results of the surface water impact assessment are provided in this report.

1.2 MOUNT THORLEY OPERATIONS EIS

1.2.1 Background

Mount Thorley Operations (MTO) is an open cut coal mine approximately 15 kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Mount Thorley Joint Venture (MTJV). The site currently operates under Development Consent No. DA 34/95 (the MTO development consent) issued by the then Minister for Planning on 22 June 1996 under Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act).

Immediately to the north is Warkworth Mine. Since 2004, the two mines have integrated at an operational level and are known as Mount Thorley Warkworth (MTW), with a single management team responsible for all the operations. Equipment, personnel, water, rejects and coal preparation are all shared between the mines. The MTW operations involve employ approximately 1,300 persons, which includes full-time personnel and a small number of short-term contractors. Ownership of the two mines remains separate.

Mining activities approved under DA 34/95 have mostly been completed with the exception of Loders Pit and Abbey Green North Pit (AGN); rehabilitation is well-progressed on the east of the site. Run-of-mine (ROM) coal from MTO is transported to either the MTO or Warkworth Mine coal preparation plant (CPP) for processing. Extraction of coal from other pits has been completed; overburden emplacement is ongoing. Product coal from the CPPs is transported via conveyor to the Mount Thorley Coal Loader (MTCL). Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The proposal at MTO seeks an approval under Part 4, Division 4.1 of the EP&A Act to complete mining and rehabilitation activities within the current limits of approval.

1.2.2 Proposal Description

MTO has approval to mine until 22 June 2017 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in 2015, operations at MTO are forecast to continue to the end of 2035, an 18 year extension over the current approval. The proposal seeks a continuation of all aspects of MTO as it presently operates and extends or alters them, including:

- Mining in Loders Pit and AGN Pit. Mining in Loders Pit is expected to be completed in approximately 2020. Mining in AGN Pit is yet to commence; however, it is anticipated to take approximately two years and be completed before 2022;
- Transfer of overburden between MTO and Warkworth Mine to assist in rehabilitation and development of the final landform;
- Maintain existing extraction rate of 10 million tonnes per year (Mtpa) of ROM coal;
- Maintain and upgrade to the integrated MTW water management system (WMS), including:
  - upgrade to the approved discharge point and rate of discharge into Loders Creek from 100ML/d to 300ML/d via the Hunter River Salinity Trading Scheme (HRSTS);
  - ability to transfer and accept mine water from neighbouring operations (ie Bulga Coal Complex, Wambo Mine, Warkworth Mine and Hunter Valley Operations);
  - increase in the storage capacity of the southern out-of-pit (SOOP) dam from 1.6 giga litres (GL) to 2.2GL
- Maintain and upgrade the integrated MTW tailings management:
  - including use of the northern part of Loders Pit as a TSF after completion of mining; and
  - wall lift to Centre Ramp Tailings Facility to approximately RL150
- Upgrade to the MTO CPP to facilitate an increase in maximum throughput to 18Mtpa with the ability to receive this coal from Warkworth Mine;
- Acknowledge all approved interactions with Bulga Coal Complex; and
- Continuation of coal transfer between Warkworth Mine and MTO and transportation of coal via the MTCL to Port of Newcastle.

All activities, including coal extraction will be within disturbance areas approved under the existing development consent.

The proposal is shown in Figure 1.1.

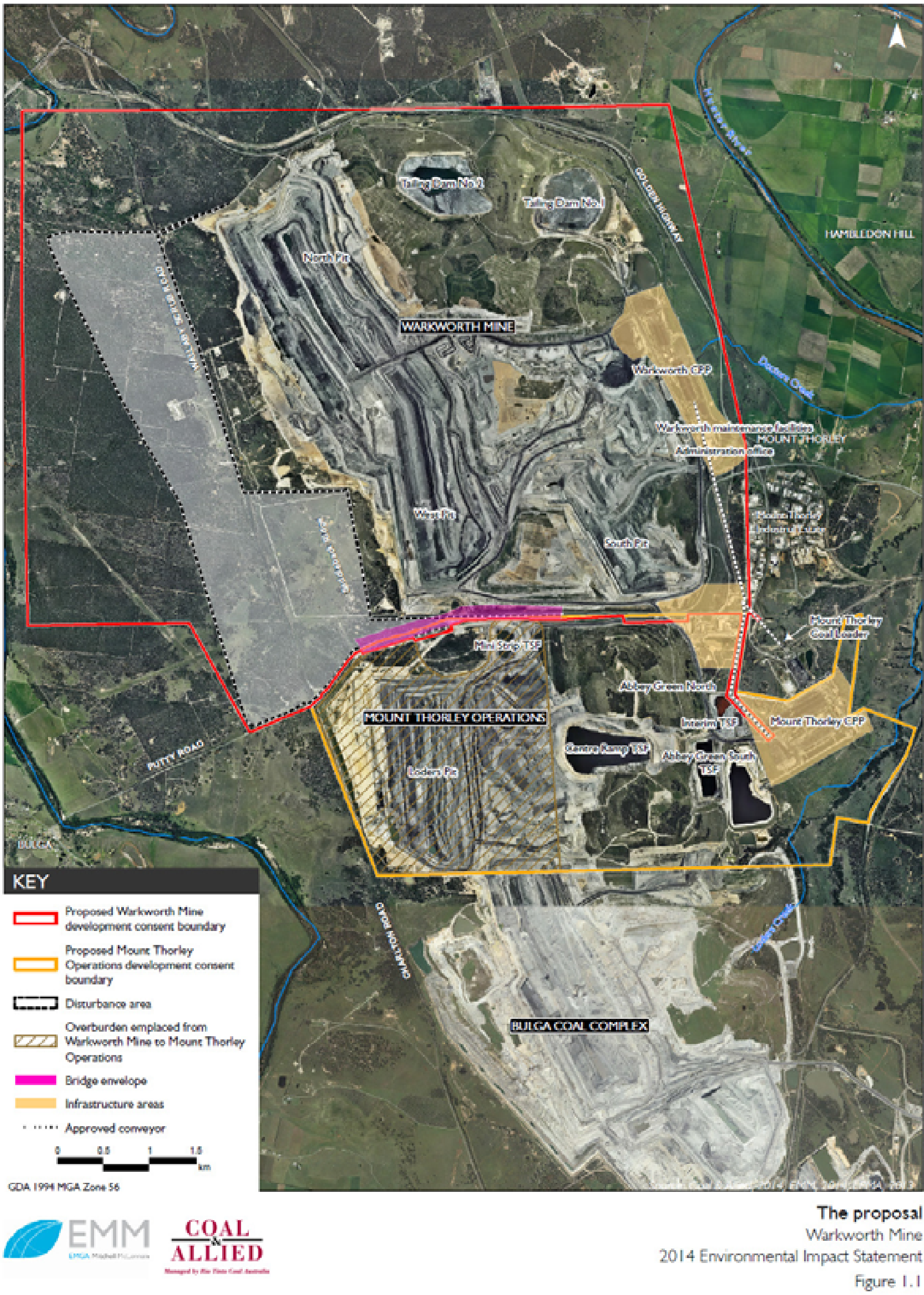

Figure 1.1 Proposal Site Layout

1.3 WARKWORTH MINE EIS

1.3.1 Background

Warkworth Mine is an open cut coal mine approximately eight kilometres (km) south-west of Singleton in the Hunter Valley, NSW. The mine is operated by Coal & Allied on behalf of Warkworth Mining Limited. The site currently operates under Development Consent No. DA 300-9-2002-i (the Warkworth Mine development consent) issued by the then Minister for Planning in May 2003 under Part 4 of the EP&A Act. The site also operates under two separate Commonwealth approvals (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)); EPBC 2002/629 and EPBC 2009/5081.

Warkworth Mine has been in operation since 1981 and the originally approved operation has been modified several times. Immediately to the south of Warkworth Mine is MTO. As noted in Section 1.2.1, the two mines have integrated at an operational level, however, ownership remains separate.

Warkworth Mine currently operates three integrated open cut mining areas, namely North, West and South pits with West and North pits being the focus of production. ROM coal from Warkworth Mine is transported to either the Warkworth or Mount Thorley CPP for processing. Product coal from the CPPs is transported via conveyor to either the MTCL or to the Redbank Power Station. Coal loaded onto trains at the MTCL is transported to the Port of Newcastle for export.

The proposal at Warkworth Mine seeks an approval under Part 4, Division 4.1 of the EP&A Act to extend mining beyond the current limits.

1.3.2 Proposal Description

Warkworth Mine has approval to operate until 19 May 2021 under its development consent. The proposal seeks a 21 year development consent period from the date of any approval. If approval is granted in late 2014, operations at Warkworth Mine are forecast to continue to 2035, a 14 year extension over the current approval. The proposal seeks a continuation of all aspects of Warkworth Mine as it presently operates together with:

- An extension of the approved mining footprint by approximately 698ha to the west of current operations (referred to herein as the proposed 2014 extension area);
- The ability to transfer overburden to MTO to complete MTO's final landform;
- The closure of Wallaby Scrub Road;
- An option to develop an underpass beneath Putty Road for the third bridge crossing yet to be constructed (while retaining the current approval for an overpass);
- Minor changes to the design of the Northern out-of-pit (NOOP) dam; and
- The continued use of secondary access gates to the mine site and offsets for activities such as drilling, offset management, equipment shutdown pad access amongst other things.

The proposal is shown in Figure 1.1.

1.4 DIRECTOR-GENERAL'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Section 78A(8A) of the EP&A Act states that a development application for a State Significant Development must be accompanied by an EIS prepared in accordance with the Environmental Planning & Assessment Regulation 2000 (EP&A Regulation). Clause 3 of Schedule 2 of the EP&A Regulation states that prior to the preparation of an EIA, the applicant must make a written application to the Director-General for Environmental Assessment Requirements (DGRs). A request for DGRs was made by Coal & Allied on 1 April 2014. This assessment, which forms part of the EIS, addresses the DGRs concerning surface water.

1.5 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the existing surface water environment in the vicinity of the proposal;
- Section 3 provides an overview of the relevant legislation and guidelines relating to surface water resources;
- Section 4 details the assessment of the potential surface water impacts from the proposal;
- Section 5 details the flooding impacts from the proposal;
- Section 6 provides more detail on the site water balance used for the assessment of impacts;
- Section 7 describes the management and monitoring which will be undertaken as part of the proposal; and
- Section 8 summarises the outcomes of the study.

2 EXISTING SURFACE WATER ENVIRONMENT

2.1 RAINFALL AND EVAPORATION

Summary details of existing Bureau of Meteorology (BOM) rainfall stations in the vicinity of MTW are shown in Table 2.1. Bulga (Down Town) is the closest open BOM rainfall station to MTW, whereas Jerrys Plains has the longest period of record (130 years). Table 2.2 shows mean monthly rainfalls for the Jerrys Plains and Bulga (Down Town) rainfall stations, over the entire period of record as well as coincident periods of record (1960 to 2013). The mean annual rainfall over the long term (1884 to 2013) at Jerrys Plains station is 645mm. The mean annual rainfall over the coincident period is 668mm and 695mm at Jerrys Plains and Bulga Down Town, respectively. This indicates that rainfalls are around four per cent higher at Bulga than Jerrys Plains.

Table 2.1 BOM Rainfall Stations – Open (Australian Government Bureau of Meteorology, 2014)

Station Name	Station No.	Lat.	Long.	Opened	Elevation	Distance from MTW
Jerrys Plains Post Office	061086	32.50°	150.91°	1884	87 m	17 km NW
Bulga (South Wambo)	061191	32.61°	150.98°	1959	80 m	7.2 km W
Bulga (Down Town)	061143	32.65°	151.02°	1960	69 m	4 km W
Singleton STP	061397	32.59°	151.17°	2002	45 m	8.5 km E
Mibrodale (Hillsdale)	061309	32.69°	150.97°	1963	120 m	9.7 km SW
Mibrodale School	061422	32.70°	151.00°	2010	88 m	7.4 km SW

Long term daily rainfall for the MTW site from January 1889 to December 2012 (124 years) has been obtained from the DSITIA Data Drill service. Table 2.2 shows the Data Drill rainfall long term (124 years) monthly averages. The Data Drill rainfall is filtered to reduce anomalies such as missing data or accumulated rainfall totals and has been adopted for the water balance modelled for this study.

Table 2.2 also shows mean monthly pan evaporation (based on Class A evaporation pan) recorded by the BOM at Jerrys Plains over the period 1957 to 1972. Mean annual evaporation is 1,641mm, with significant seasonal variation, as shown in Figure 2.1. Table 2.2 shows a comparison of the long term monthly averages of Morton's lake evaporation. Average annual lake evaporation is more than double the average annual rainfall.

Table 2.2 Mean Monthly Rainfall and Evaporation (mm/month)

Month	Rainfall					Pan Evaporation	Lake Evaporation
	Jerrys Plains		Bulga Down Town	Data Drill Rainfall		Jerrys Plains	Data Drill
	1884-2013	1960-2013	1960-2013	1960-2012	1889-2012	1957-1972	1889-2012
Jan	77.7	84.5	85.2	76.2	73.0	220.1	186.1
Feb	73.1	82.8	91.3	83.6	77.8	169.5	150.9
Mar	59.1	60.1	73.3	62.5	66.8	155.0	135.2
Apr	44.0	40.6	45.6	46.7	49.1	120.0	92.0
May	40.7	46.1	49.4	44.9	43.9	89.9	59.3
Jun	48.3	44.9	46.3	45.2	50.0	60.0	40.8
Jul	42.7	35.8	27.2	29.6	38.8	71.3	48.3
Aug	36.1	36.7	34.9	34.1	35.1	80.6	74.3
Sep	41.7	43.1	39.0	38.8	40.1	111.0	105.1
Oct	52.1	57.6	56.9	53.4	52.4	164.3	143.4
Nov	62.3	68.4	69.7	62.8	59.7	195.0	165.5
Dec	68.1	70.3	75.1	72.3	70.9	204.6	89.2
Total	**645**	**668**	**695**	**650**	**658**	**1,641**	**1,390**

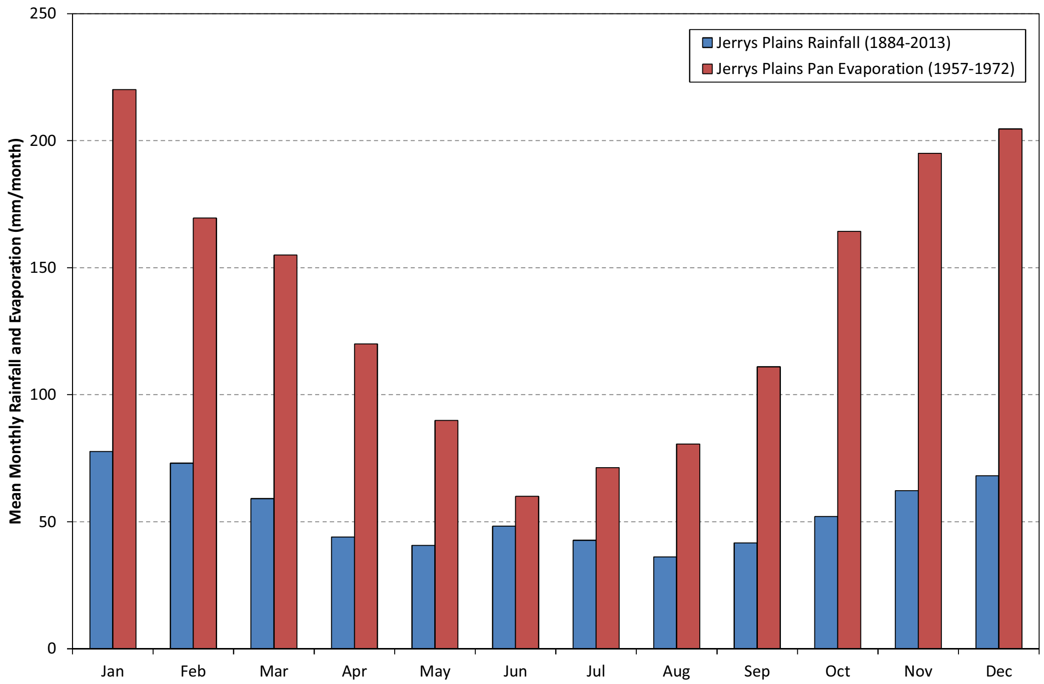

Figure 2.1 Distribution of Monthly Rainfall and Pan Evaporation at Jerrys Plains Post Office (Australian Government Bureau of Meteorology, 2014)

2.2 REGIONAL DRAINAGE NETWORK

The regional drainage network in the area of interest is shown in Figure 2.2. MTW is located on the southern side of the Hunter River, and the eastern side of Wollombi Brook. The Hunter River has a catchment area of approximately 16,400km^2 to Singleton.

The Hunter River catchment upstream of MTW includes Glennies Creek Dam (located 25km north of Singleton) and Glenbawn Dam (located 22km north of Muswellbrook), which command catchment areas of approximately 233km^2 and 1,300km^2 respectively, or a combined nine per cent of the total river catchment to Singleton. Glennies Creek Dam was completed in 1983 with a total storage capacity of 283,000ML. Glenbawn Dam was commissioned in 1957 with a storage capacity of 300,000ML. The Glenbawn Dam was raised in 1988 to a total storage capacity of about 750,000ML.

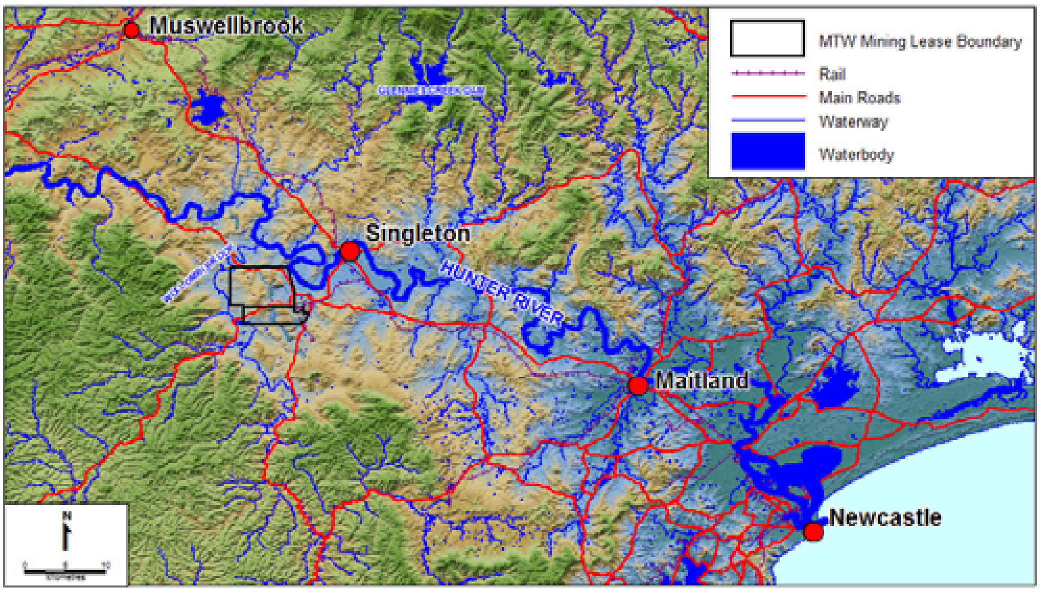

Figure 2.2 MTW Regional Drainage

2.3 LOCAL DRAINAGE NETWORK

Figure 2.3 shows the local drainage network in the vicinity of MTW. Wollombi Brook drains in a north-easterly direction around the site and joins the Hunter River approximately 3.5km north of MTW.

North and West Pit at Warkworth Mine are surrounded by natural landforms that slope inwards towards the active mining areas, however in the proposed extension area of Warkworth mine the natural landform generally slopes westwards towards Wollombi Brook. Clean water diversions (Dam 6N) have been constructed to divert clean water away from the active pits. Doctors Creek diversion protects West Pit, and Sandy Hollow Creek diversion protects North Pit. The catchment areas and the diversion structures are progressively changing with the westward advancing highwall.

At MTO, the clean catchment west of Loders Pit (Salt Pan Creek) drains westward towards Wollombi Brook. Doctors Creek and Loders Creek capture runoff from undisturbed areas east of the mining operations, and are the receiving waterways for controlled site discharges under the HRSTS (refer Section 3.5).

Other drainage lines within the mining lease mostly drain westward or north-westward to Wollombi Brook. All are ephemeral and first or second order watercourses as identified from 1:25,000 topographic maps.

There are no surface water bodies in the disturbance area of the proposal.

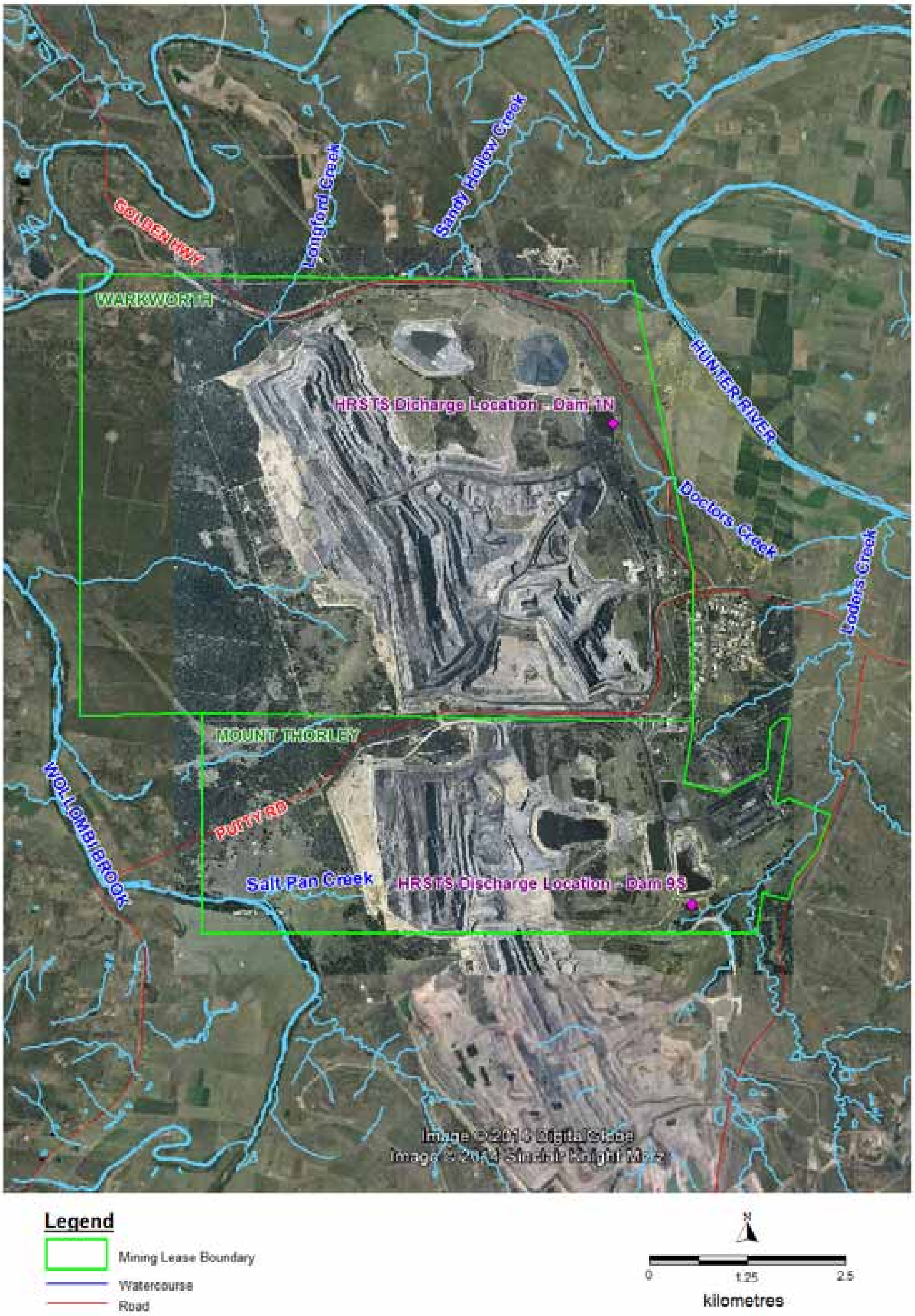

Figure 2.3 MTW Local Drainage (Background Aerial Photography: Coal & Allied, Google Earth)

2.4 STREAMFLOW

Figure 2.4 shows the New South Wales Office of Water (NOW) stream gauging locations in the vicinity of MTW. Flow data is presented for the following three locations:

- Station No. 210001 - Hunter River at Singleton 210001 (approximately 28km downstream of Wollombi Brook confluence). The catchment area of the river to the gauge is approximately 16,400km^2.
- Station No. 210004 - Wollombi Brook at Warkworth (approximately 7km upstream of the Hunter River confluence). The catchment area of the brook to the gauge is approximately 1,848km^2.
- Station No. 210028 – Wollombi Brook at Bulga (20km upstream of the Hunter River confluence). The catchment area of the brook to the gauge is approximately 1,672km^2.

The following sections present the recorded flow information for Wollombi Brook and the Hunter River.

2.4.1 Hunter River

The recorded flow-duration relationship for the Hunter River at Singleton (Station No. 210001) is shown in Figure 2.5 for the periods 1913 to 1957, 1958 to 1987, and 1988 to 2013. Glenbawn Dam was completed in 1958 and upgraded in 1987. Under current catchment conditions (since the upgrade to Glenbawn Dam in 1987), the river is perennial, with a minimum flow rate of about 10 Megalitres / day (ML/d). The median (50th percentile) flow rate is about 300 ML/d and the 95th percentile flow rate is greater than 100ML/d. Comparison of the three flow-duration curves indicates that the upgraded Glenbawn Dam has increased the frequency of low flows (due to regulation) and moderately reduced the frequency of high flows.

2.4.2 Wollombi Brook

Figure 2.6 shows the recorded flow-duration relationship for Wollombi Brook at Warkworth (Station No. 210004), for the periods 1908 to 2013 and 1949 to 2013. Figure 2.6 also shows the recorded flow-duration relationship for Wollombi Brook at Bulga (Station No. #210028) for the period 1949 to 2013. The flow-duration relationship indicates the brook is ephemeral, with an 80th percentile flow rate of about 2ML/d at Warkworth, and about 0.2ML/d at Bulga. The median (50th percentile) flow rate is about 40ML/d at Warkworth, and about 30ML/d at Bulga. During significant flood events, water levels at the Warkworth stream gauge may be affected by backwater from the Hunter River.

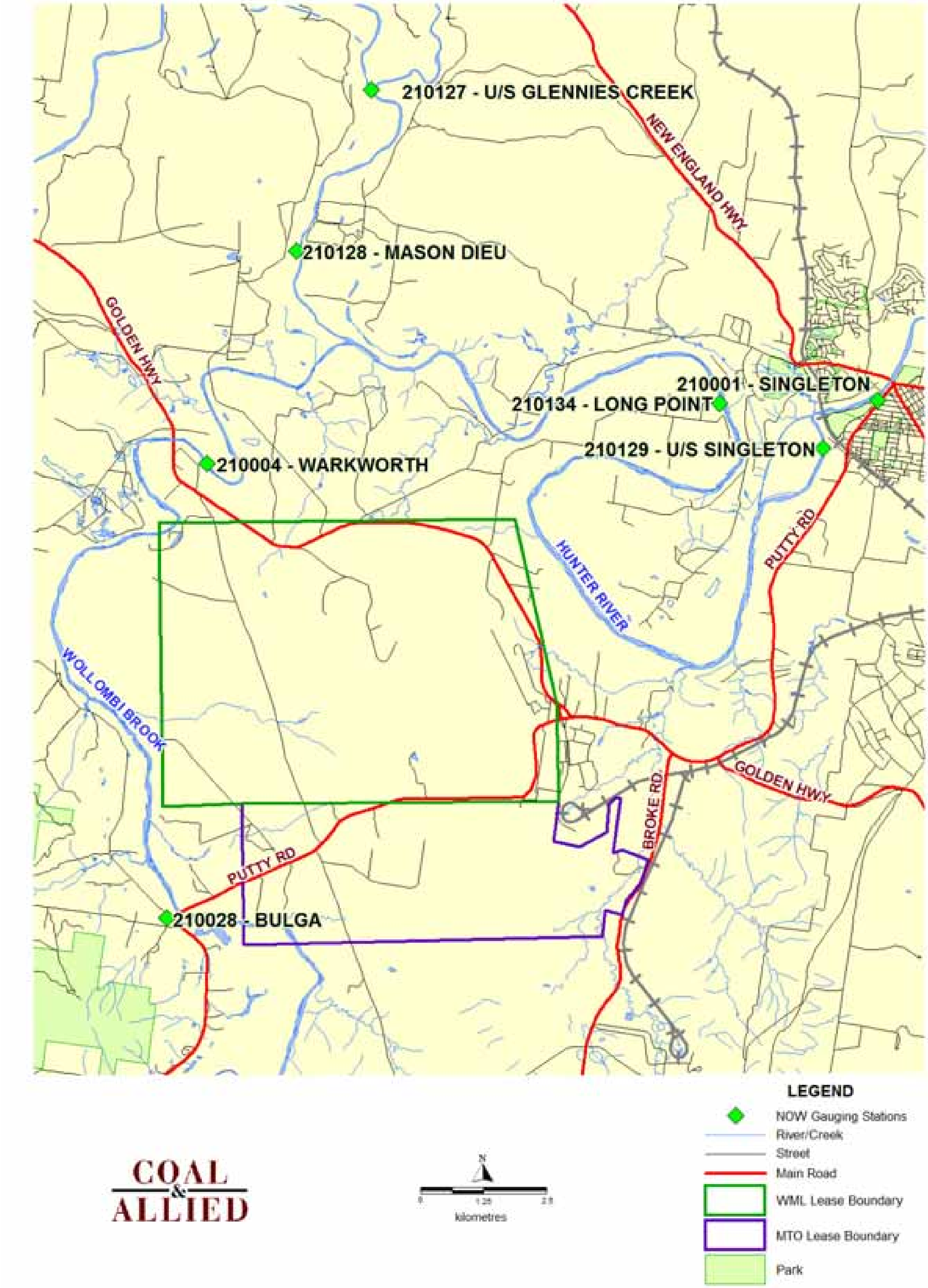

Figure 2.4 NOW Stream Gauging Locations

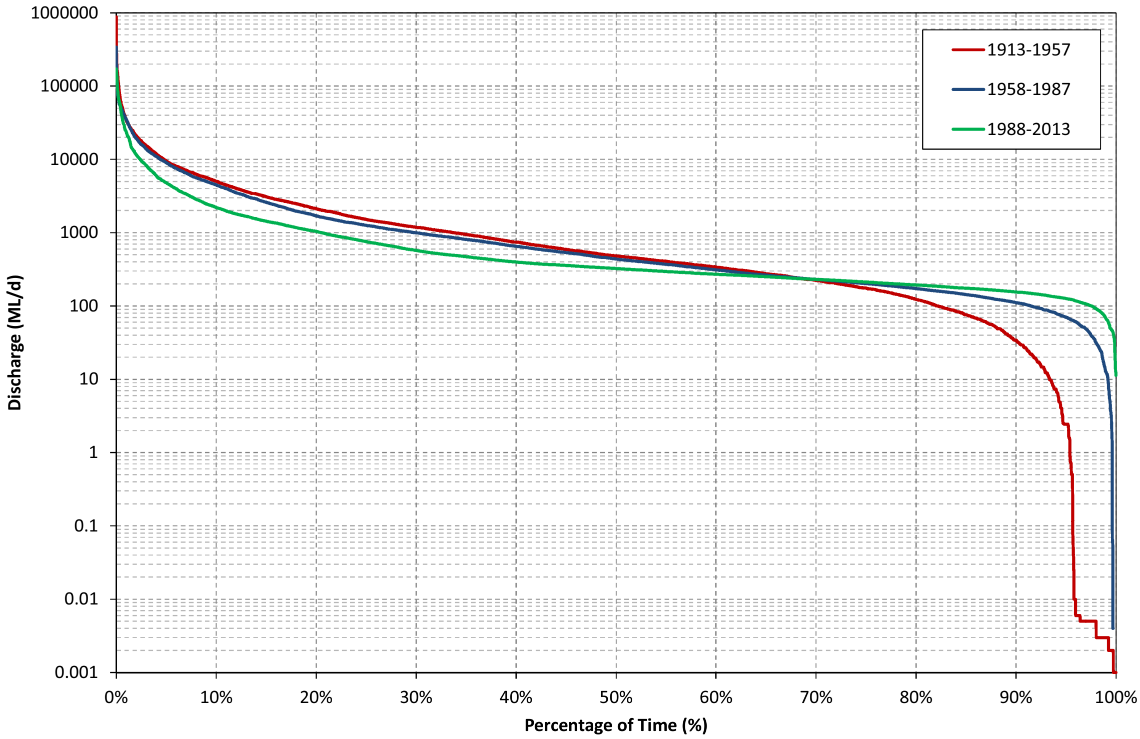

Figure 2.5 Stream Discharge Duration Curve #210001 Hunter River at Singleton

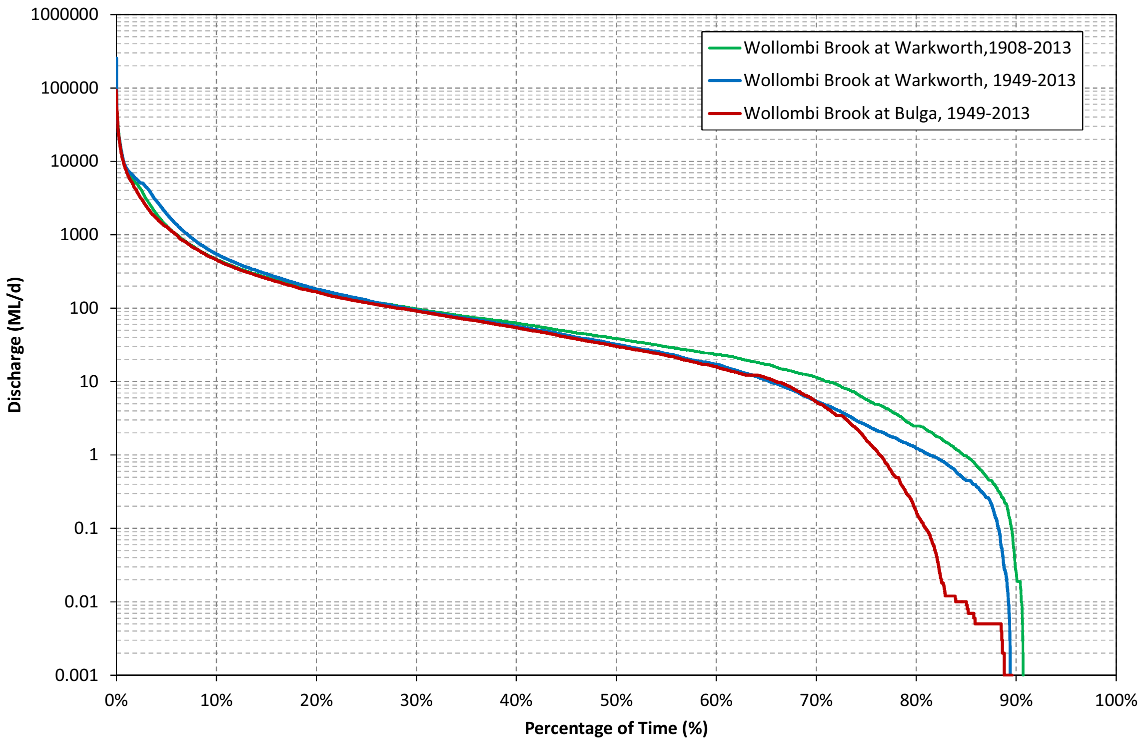

Figure 2.6 Stream Discharge Duration Curve #210004 Wollombi Brook at Warkworth, #210028 Wollombi Brook at Bulga

Table 2.3 shows the estimated annual runoff volume for the Wollombi Brook catchment to the Bulga gauge. The volumetric runoff coefficient is relatively high, with a mean value of about 11 per cent. There are no significant water storages on Wollombi Brook, however there is a high level of connectivity between surface water and the groundwater aquifer (ref. *Water sharing in the Lower Wollombi Brook water source*, http://www.hcr.cma.nsw.gov.au/water_sharing/macro_hunter_lowerwollombibrook.pdf).

Figure 2.7 shows a plot of annual runoff versus rainfall for the Wollombi Brook catchment at Bulga. Very little runoff is generated by the catchment when annual rainfall is less than about 400mm. Once annual rainfall exceeds this value, the volume of surface runoff increases substantially.

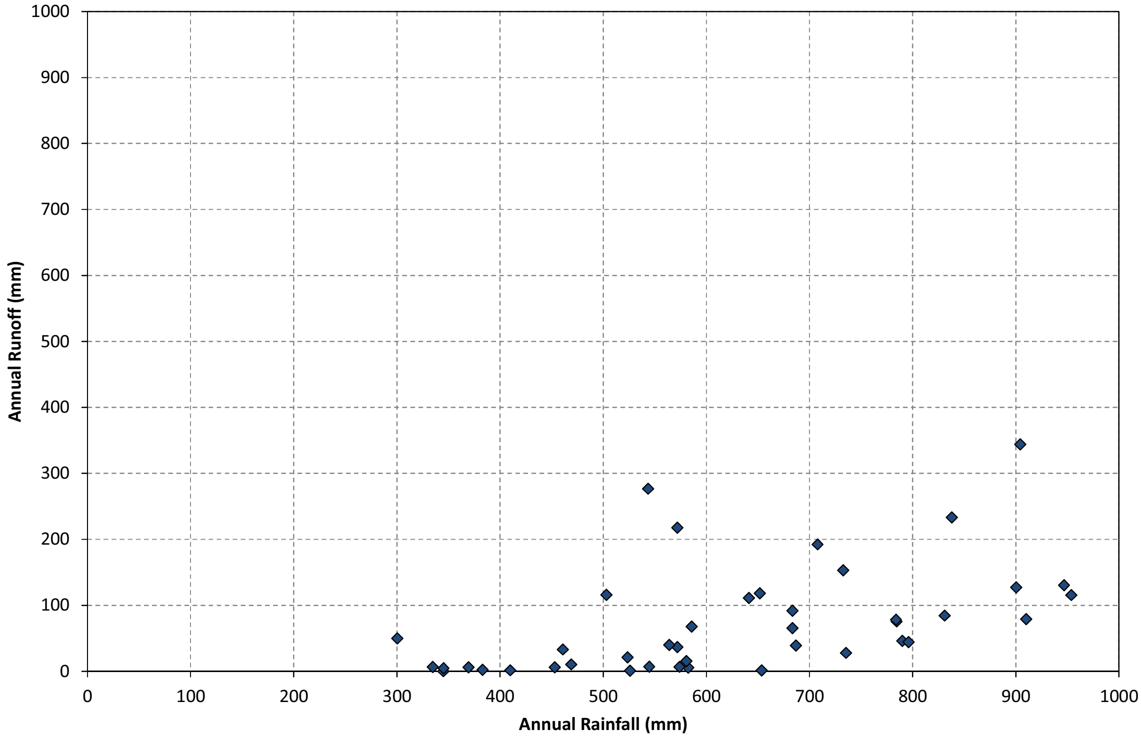

Figure 2.7 Annual Runoff versus Rainfall for Wollombi Brook at Bulga Gauging Station

Table 2.3 Annual Rainfall and Runoff Volumes for Wollombi Brook to Bulga Gauging Station

Year	Annual Rainfall [a] (mm)	Annual Runoff Volume		Volumetric Runoff Coefficient
		(GL)	(mm)	
1953	544	463	277	0.509
1954	831	141	84	0.101
1955	572	364	217	0.380
1956	708	322	192	0.272
1957	335	11	6	0.019
1958	582	9	6	0.010
1963	904	575	344	0.380
1964	503	194	116	0.230
1965	383	4	2	0.006
1966	410	3	1	0.004
1967	586	113	68	0.116
1968	735	47	28	0.038
1969	790	77	46	0.058
1970	574	11	7	0.012
1971	641	186	111	0.173
1972	785	126	75	0.096
1973	796	74	44	0.055
1974	733	256	153	0.209
1975	572	61	37	0.064
1976	838	390	233	0.278
1977	652	197	118	0.181
1978	947	218	130	0.138
1979	581	26	15	0.026
1980	345	0	0	0.000
1981	784	131	78	0.100
1982	564	66	40	0.070
1983	545	12	7	0.013
1984	900	212	127	0.141
1985	687	65	39	0.057
1986	524	35	21	0.040
2001	684	153	92	0.134
2002	461	55	33	0.072
2003	526	2	1	0.002
2004	654	2	1	0.002
2005	369	10	6	0.016
2006	345	7	4	0.012
2007	954	193	116	0.121
2008	684	109	65	0.096
2009	469	17	10	0.022
2010	453	10	6	0.014
2011	910	132	79	0.087
2012	300	84	50	0.167
Mean	**623**	**123**	**73**	**0.108**

[a] Based on rainfall for the Broke (Harrowby) Station which has been adopted as representative of rainfall over the Wollombi Brook catchment.

An analysis of flow data for Wollombi Brook at the Bulga and Warkworth stream gauges indicates that a loss of flow is sometimes observed along the reach of Wollombi Brook adjacent to MTW, despite an additional catchment area of 176km^2 between the two stations. The magnitude of flow losses is difficult to quantify due to the potentially large impact of inaccuracies in the rating curves at both stream gauges. Since the accuracy of flow rating curves typically decreases as flow rate increases, periods that include moderate to high flows can sometimes indicate a large loss of flow which may be an artefact of the site rating curves rather than an actual loss of flow. For this reason, estimates of flow losses were made for periods that excluded high flows.

Table 2.4 shows the minimum, mean and maximum loss of monthly flow between the two stations. Results are shown for three cases, which each exclude flows above a threshold mean monthly flow. Note that months that showed an increase in flow were assigned a flow loss of zero. The analysis is based on 489 months from 1954 to 2013 over which corresponding flow data was available for both the Bulga and Warkworth stations.

The results of the low flow analysis, summarised in Table 2.4, show that the estimated loss of flow is sensitive to the adopted threshold of high flows that are excluded from the analysis. However, it is apparent that a measureable loss of flow from Wollombi Brook, perhaps of the order of 10 to 50ML per month, occurs adjacent to MTW under existing conditions.

Given the significant surface and groundwater entitlements in the area, some loss of flow along this reach is not unexpected. However, due to the large number of potential locations for extraction of flow, it is not possible to accurately determine where the flow loss is occurring.

Table 2.4 Assessment of Low Flow Losses, Wollombi Brook

	Flow Loss, Bulga to Warkworth (ML/month)		
Adopted Threshold Mean Monthly Flow [a]	Minimum	Mean	Maximum
30th percentile = 90 ML/d (2,740 ML/m)	0	70	1725
50th percentile = 29 ML/d (882 ML/m)	0	16	733
70th percentile = 6 ML/d (183 ML/m) b	0	3	156

[a] Months with mean monthly flow above the threshold value were not included in the analysis

2.5 EXISTING MINE WATER MANAGEMENT SYSTEM

The MTW water management system is a network of infrastructure (ie dams, pipelines, contour drains) to control the movement of water around the site and prevent unscheduled release of water off site. Water is managed according to its type. Water type is determined by catchment area, quality and use. The main types of water managed at MTW include mine water , sediment water and clean water.

Figure 2.8 shows the main elements of the water management system. Figure 2.9 shows a schematic diagram of the conceptual configuration of the existing mine water management system. The existing MTW mine water management system is described in detail in MTW's Water Management Plan (Coal & Allied, 2012).

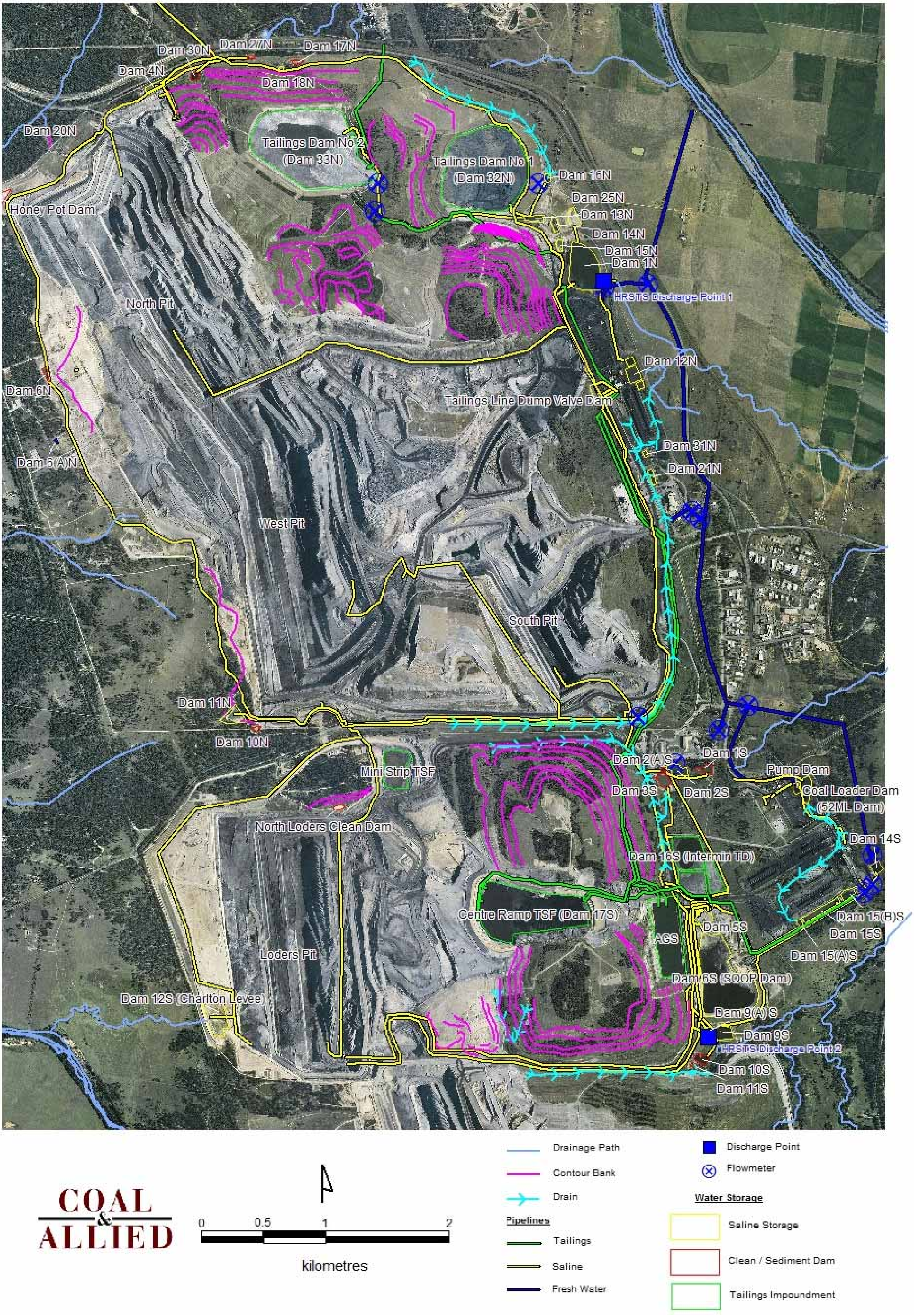

Figure 2.8 MTW Water Management System Infrastructure - Existing

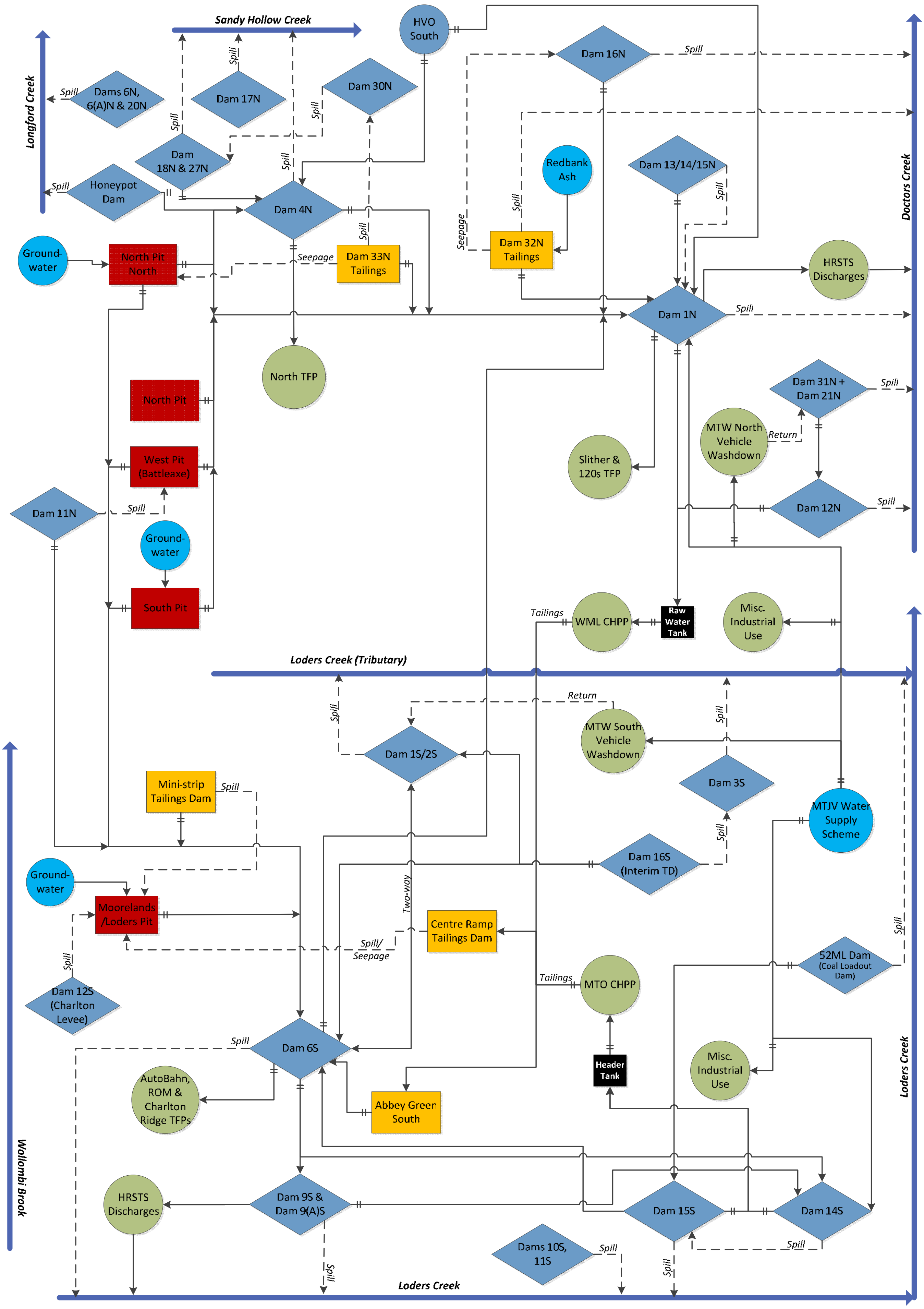

Figure 2.9 MTW Water Management System Schematic - Existing

2.6 SURFACE WATER QUALITY

2.6.1 New South Wales Office of Water (NOW) Monitoring

Hunter River water quality data has been collected by NOW since the 1970s. Discrete data collected in the Hunter River at Singleton (#210001) and Wollombi Brook at Warkworth (#210004) is summarised in Table 2.5 and compared to the trigger values in the Australia and New Zealand Environment Conservation Council (ANZECC) water quality guidelines (2000). Additionally, electrical conductivity (EC) has been monitored continuously at Wollombi Brook at Warkworth (#210004) since 1992, and Hunter River Upstream of Singleton (#210129) since 1993. Locations of the water quality gauging stations are shown in Figure 2.4. Note that the trigger value for mercury (ecosystem protection) is less than the Limit of Reporting; therefore it cannot be determined if the mercury values measured are higher or lower than the ANZECC trigger value for ecosystem protection.

Review of the NOW water quality data indicates the Hunter River:

- Is moderately alkaline, with a median pH of 8.24;
- Is fresh, with a median EC of 621µS/cm;
- Has a median value greater than the ANZECC guideline trigger value for pH (ecosystem protection), total nitrogen (ecosystem protection) and total phosphorus (ecosystem protection); and
- Has a median value lower than the ANZECC guideline trigger value for all other monitored parameters.

Review of the NOW water quality data indicates Wollombi Brook:

- Is slightly alkaline, with a median pH of 7.56;
- Is fresh, with a median EC of 595µS/cm;
- Has a median value greater than the ANZECC guideline trigger values for chloride (irrigation) and sodium (irrigation); and
- Has a median value lower than the ANZECC guideline trigger value for all other monitored parameters.

2.6.2 Coal & Allied Monitoring

Receiving Waters

Controlled discharges from Dam 1N and Dam 9S are directed to Doctors Creek and Loders Creek respectively, which are tributaries of the Hunter River. Runoff from undisturbed areas and small areas of disturbed catchment is treated via sediment dams on the site. Overflows from these sediment dams discharge to Wollombi Brook and Longford Creek (a tributary of Wollombi Brook), as well as Sandy Hollow Creek, Loders Creek and Doctors Creek (which are tributaries of the Hunter River). A tabular summary of the MTW surface water quality monitoring data for watercourses is detailed in Appendix A. Sampling locations are shown in Figure 2.10. Review of the site water quality monitoring results for receiving waters indicates:

- The Hunter River upstream of the Loders Creek confluence has a median EC of 645µS/cm and a median pH of 8.0. The Hunter River downstream of the Loders Creek confluence has a median EC of 630µS/cm and a median pH of 8.1.

- Loders Creek (water quality impacted by controlled discharges under the HRSTS) has a median EC of approximately 4,200µS/cm and a median pH of 8.1. Pre-mining water quality data (BHP Ltd, 1980) at Loders Creek indicated ECs varying between 2,000µS/cm and 14,200µS/cm, with an average of 7,100µS/cm. The salinity was attributed to seepage from the Saltwater Creek coal measures which sub-crop in areas of Loders Creek (MER, 2012).
- It is difficult to determine the Doctors Creek catchment runoff water quality characteristics, as the water quality is impacted by controlled discharges under the HRSTS. The water quality monitoring results indicate a median EC of 4,695µS/cm and a median pH of 8.2;
- Longford Creek has a median EC of 288µS/cm and a median pH of 7.4;
- Sandy Hollow Creek has a median EC of 270µS/cm and a median pH of 7.7;
- Wollombi Brook has a median EC of 680µS/cm and a median pH of 7.5; and
- Salt Pan Creek has a median EC of 16,810µS/cm and a median pH of 8.1.

Site Dams

The primary saline water storages at MTW (Dam 6S, Dam 1N and Dam 9S) are routinely monitored for EC, pH and turbidity. Additionally, a comprehensive analysis of water quality in a number of saline and sediment dams is undertaken on a quarterly basis. A tabular summary of the results of the MTW site water quality monitoring program for site dams is detailed in Appendix A. Locations of site dams are shown in Figure 2.8. Review of the site water quality monitoring results for the site dams indicates:

- The primary mine water storages at MTW (Dam 1N, Dam 6S and Dam 9S) are characterised as brackish and strongly alkaline, with median ECs of approximately 7,000µS/cm and median pH values of 8.7 to 9.0;
- Water quality of sediment dams varies considerably in salinity from fresh to brackish, with median ECs of between 300µS/cm and 8,400µS/cm. The sediment dams' water quality ranges from moderately alkaline to very strongly alkaline, with median pH values between 7.9 and 9.8.

2.6.3 Water Quality Monitoring Results Analysis

Box and whisker plots have been used to graphically depict water quality in the Hunter River to illustrate the spread of data at four locations:

- Upstream of Glennies Creek;
- Upstream of Loders Creek;
- Downstream of Loders Creek; and
- Upstream of Singleton.

Figure 2.11 and Figure 2.12 show box and whisker plots for EC and Total Suspended Solids (TSS) as measured in the Hunter River from both NOW and site monitoring locations over the period 2003 to 2013. Note that the monitoring frequency of samples by MTW and NOW are different (quarterly versus daily), and therefore results are not directly comparable and are to provide an indication only. Review of the results indicates that there is a slight decrease in EC downstream of the Loders Creek confluence. Additionally, the median EC downstream of Loders Creek is lower than upstream of Glennies Creek, indicating the releases from MTW do not appear to be adversely affecting salinity in the Hunter River. TSS levels increase slightly across the Loders Creek confluence.

wrm water + environment

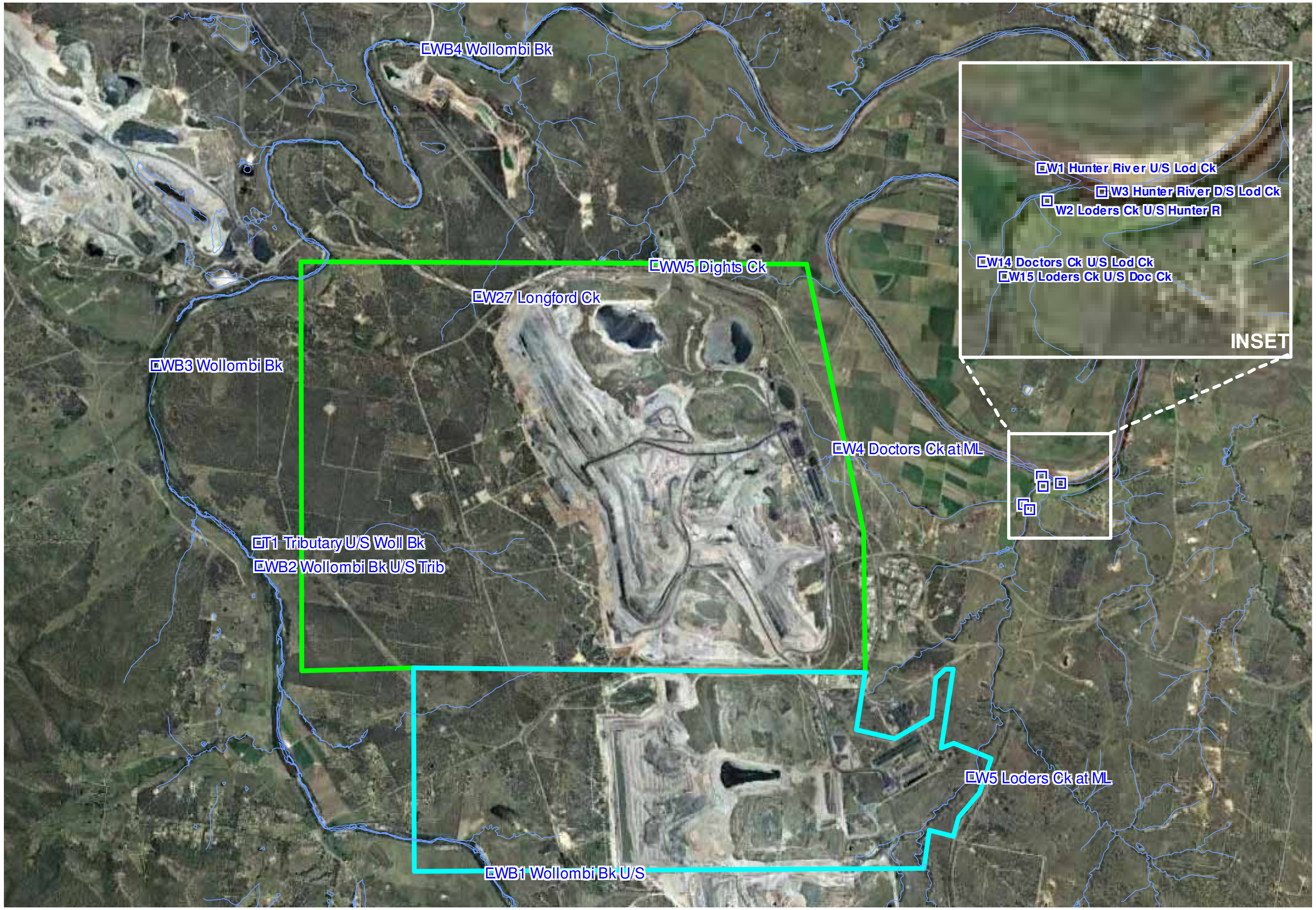

Figure 2.10 MTW Receiving Water Monitoring Locations

Table 2.5 Summary of Discrete NOW Water Quality Data - Hunter River at Singleton and Wollombi Brook at Warkworth (New South Wales Office of Water, 2011) and ANZECC Trigger Values

		ANZECC Trigger Value				Hunter River at Singleton			Wollombi Brook at Warkworth		
Parameter	Unit	Irrigation	Livestock drinking	Eco-system^^	Recreational	90%ile	Median	Count	90%ile	Median	Count
Aluminium as Al	mg/L	5 (LTV) 20 (STV)	5	0.055^^^^	0.2						
Arsenic as As	mg/L	0.1 (LTV) 2.0 (STV)	0.5	0.024 (As III) 0.013 (As V)	0.05						
Barium as Ba	mg/L				1						
Bicarbonate (HCO_3)	mg/L					275	221	70	232	513	9
Boron (Total)	mg/L	0.5	5	0.37	1	0.13	<LOR	38	0.13	<LOR	38
Calcium (Ca)	mg/L		1,000			50.0	37.0	70	26.0	19.9	9
Chloride as Cl	mg/L	175***			400	153	100	71	459	260	9
EC (uncompensated)	µS/cm	950***		125-2,200		820	621	687	1,172	595	64
EC (25C)	µS/cm					1,014	730	65	2,307	804	500
Iron as Fe (Soluble)	mg/L	0.2			0.3	0.121	0.004	8			
Iron as Fe (Total)	mg/L					0.711	0.035	52	0.83	0.25	6
Fluoride (Soluble)	mg/L	1 (LTV) 2 (STV)	2			0.52	0.22	39	0.39	0.39	1
Lead as Pb (Total)	mg/L	2 (LTV) 5 (STV)		0.0034		0.011	0.003	8	0.011	0.003	8
Lithium as Li	mg/L	2.5									
Magnesium as Mg	mg/L		2,000**			43.0	30.7	70	45.2	24.2	9
Manganese as Mn (Total)	mg/L	0.2 (LTV) 10 (STV)		1.9	0.1	0.155	0.057	10	0.155	0.057	10
Mercury as Hg (Total)	mg/L	0.002		0.0006		0.005	0.001	6			
Nitrite and nitrate as N	mg/L		30	0.7^^^	1	0.26	0.03	107	0.12	0.01	144
pH	pH	6.0 - 9.0		6.5 - 8^	6.5 - 8.5	8.51	8.24	483	8.08	7.56	276
Potassium as K (soluble)	mg/L					4.4	3.1	69	8.2	5.2	9
Selenium as Se (total)	mg/L	0.02 (LTV) 0.05 (STV)	0.02	0.011	0.01						
Silicon as Si	mg/L										
Sodium as Na (soluble)	mg/L	115***			300	100.3	71.6	70	265.4	171.6	9
Sulphate as SO_4	mg/L		1,000		400	80.0	38.2	70	53.8	29.0	9

		ANZECC Trigger Value				Hunter River at Singleton			Wollombi Brook at Warkworth		
Parameter	**Unit**	**Irrigation**	**Livestock drinking**	**Eco-system^^**	**Recreational**	**90%ile**	**Median**	**Count**	**90%ile**	**Median**	**Count**
Total Dissolved Solids (TDS)	mg/L		2,000*		1,000						
Total Nitrogen (Total N)	mg/L	5		0.5^		1.10	0.56	105	0.89	0.47	143
Total Phosphorus (Total P)	mg/L	0.05		0.05^		0.152	0.060	240	0.035	0.013	297
Total Suspended Solids (TSS)	mg/L					47	21	72	16	6	71
Turbidity	NTU										
Zinc as Zn (Total)	mg/L	2 (LTV) 5 (STV)	20	0.008	5	0.09	<LOR	23	0.09	<LOR	23

* Lowest recommended value.
** Cattle (insufficient information on other livestock).
*** Sensitive crops.
^ Lowland river (<150m altitude).
^^ 95 per cent of species protected.
^^^ Nitrate only.
^^^^ pH greater than 6.5.

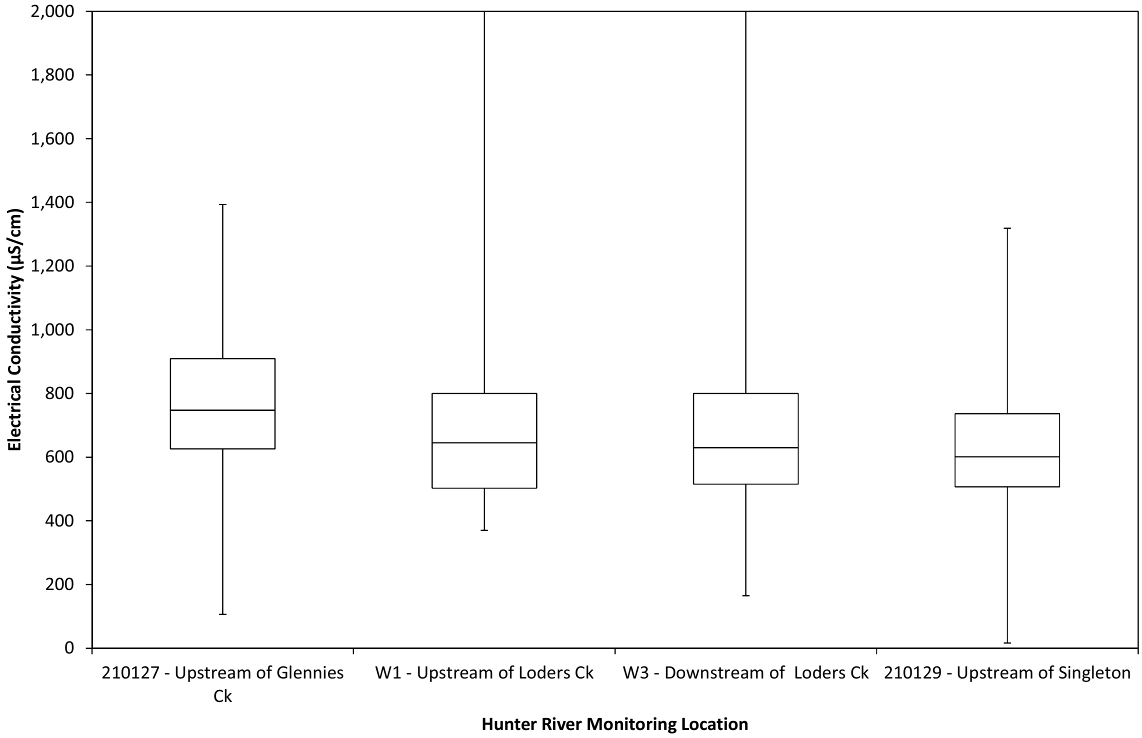

Figure 2.11 Hunter River EC Monitoring Data – Box and Whisker Plot

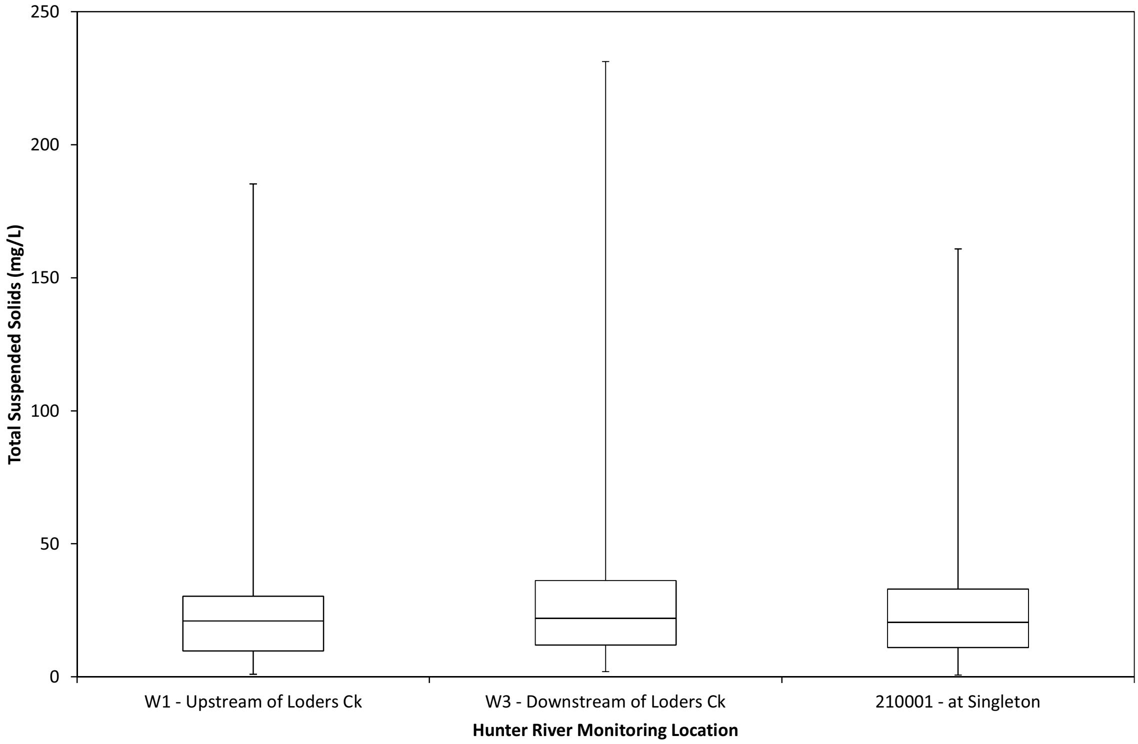

Figure 2.12 Hunter River TSS Monitoring Data – Box and Whisker Plot

3 RELEVANT LEGISLATION AND GUIDELINES

3.1 OVERVIEW

The following legislation, plans, policies and regulations are relevant to this assessment:

- *Protection of the Environment Operations Act 1997*;
- *Water Management Act 2000* and applicable Water Sharing Plans;
- State Water Management Outcomes Plan (SWMOP) and Hunter and Central Rivers Catchment Action Plan (CAP);
- Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002; and
- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) (refer Section 2.6).

The relevance of key legislation is briefly outlined in the following sections.

3.2 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

Warkworth Mine and MTO are licensed under the *Protection of the Environment Operations Act 1997.* The existing licences (EPL 1976 for MTO and EPL 1376 for Warkworth Mine) make provision for release of water from the sites at Dam 1N and Dam 9S. Licence discharge limit conditions are the same for each EPL, as shown in Table 3.1.

Table 3.1 MTO & Warkworth Mine Discharge Conditions (EPL 1376 & 1976)

Pollutant	Unit	Limit
pH	pH units	Lower: 6.5 Upper: 9.0
Total suspended solids	mg/L	120
Volume	ML/d	100 (at each discharge location)

(NSW Government Office of Environment & Heritage, 2011)

3.3 WATER MANAGEMENT ACT 2000

3.3.1 Water Sharing Plans

The *Water Management Act 2000* applies to surface waters within the MTW area and the Hunter River itself through the following Water Sharing Plans:

1. **Hunter Unregulated and Alluvial Water Sources Water Sharing Plan 2009.** Surface water in Wollombi Brook and its tributaries is regulated under this plan. Water volumes extracted from these catchments require a water entitlement (an unregulated river access licence). The plan limits annual extraction to provide for no new growth in water entitlements.
2. **Hunter Regulated River Water Sharing Plan 2003.** All water extractions from the Hunter River will be managed under appropriate Water Access Licences (WALs). MTW holds approximately 1,012 ML/a of high security units of Hunter River water shares under the MTJV Supply Scheme. Water will continue to be extracted from existing licences and therefore, there will be no cumulative impact on water supplies in the Hunter River catchments caused by the proposal.

3.4 STATE WATER MANAGEMENT OUTCOMES PLAN (SWMOP) AND HUNTER AND CENTRAL RIVERS CATCHMENT ACTION PLAN (CAP)

The SWMOP (established under the *Water Management Act 2000*) and CAP (established under the *Catchment Management Authorities Act 2003*) set out the broad targets and strategic directions for the state and for the catchment. Natural resources features to be protected and enhanced are identified, along with actions to achieve key outcomes. The proposal is consistent with the SWMOP and CAP objectives because:

- Surface disturbance is restricted to the area covered by the application (the Site). Impacts will be mitigated within MTW's water management system described in Section 3. Erosion and sediment controls for the proposal will be designed and operated in accordance with 'Managing urban stormwater: soils and construction' requirements (Landcom, 2004);
- Any extraction of water will be in accordance with licensing provisions; and
- Discharges under the proposal will only occur in accordance with the site EPL and where applicable, the Hunter River Salinity Trading Scheme (HRSTS).

3.5 PROTECTION OF THE ENVIRONMENT OPERATIONS (HUNTER RIVER SALINITY TRADING SCHEME) REGULATION 2002

The HRSTS was introduced by the NSW Government to reduce salinity levels in the Hunter River, and operates under the Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002.

Releases of mine water to the Hunter River can be made in compliance with the conditions of an EPL and in accordance with credits purchased under the HRSTS. The HRSTS limits the quantity of salt that may be discharged through a cap and trade system that also restricts discharge to periods of high flow.

Under the HRSTS, credit holders are permitted to discharge saline water to the Hunter River on a managed basis. The aim is to maintain river salinity levels below 600µS/cm at Denman and 900µS/cm at Singleton. This is achieved through:

- Discharge scheduling that allows discharge only at times when the river flow and salinity level are such that salt can be discharged without breaching the salinity targets; and
- Sharing the allowable discharge according to licensed holdings of tradeable salinity credits.

The discharge schedule prohibits discharges during low flow periods. Discharges are regulated in proportion to credit holdings during high flow periods and unlimited discharges are permitted during flood flow periods, subject to tributary protection limits and the overarching requirement to achieve the upper limit salinity levels at Denman and Singleton.

A total of 1,000 credits are available for allocation through the scheme. Consequently, a holding of one credit entitles the owner to discharge 0.1 per cent of the total allowable discharge for the period.

If discharge of further excess water to the Hunter River system is required, under the scheme, credits may be obtained on a day to day basis through trade between licensed users, or, for long term use, through public auction.

Under the HRSTS, the Hunter River is separated into three sectors upstream of Singleton: Upper, Middle and Lower. MTW lies in the Lower Sector (downstream of Glennies Creek confluence). The HRSTS flow and river salinity thresholds for the Lower Sector are presented in Table 3.2.

Table 3.2 HRSTS Flow & River Salinity Thresholds, Lower Sector

Hunter River Flow Rate (ML/d)	Block Classification	River Target Salinity (EC)	Discharge Procedure
<2,000	Low	n/a	No discharges allowed
2,000 – 10,000	High	900µS/cm	Limited discharges allowed, controlled by salt credits and Total Allowable Discharge (TAD)
>10,000	Flood	900µS/cm	Unlimited discharges

(Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*)*

The water in the river is divided into numbered blocks. The scheme operators monitor the flow and salinity in each block, and calculate the Total Allowable Discharge (TAD) of salt to meet the salinity target. Credit holders are notified via a dedicated website of the TAD and the start and end times for each release.

MTW is currently a Licence Holder and Scheme Participant of the HRSTS. Warkworth Mine currently hold 68 credits and MTO holds 78 credits, totalling 146 credits, which entitles MTW to discharge 14.6 percent of the TAD for a given period.

4 IMPACT ASSESSMENT

4.1 OVERVIEW

The potential changes to surface water and water management during the life of the proposal that have been investigated in the following sections comprise:

- Additional water demand from external third party sources (ie neighbouring mines or the Hunter River) to meet increased operational water requirements for the proposal;
- Loss of catchment area draining to Wollombi Brook and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Wollombi Brook and the Hunter River;
- Change in the quality of surface runoff draining from the local site catchment to Wollombi Brook and the Hunter River;
- Adverse impacts on downstream water quality associated with possible overflows from the mine water management system;
- Increase in saline water controlled discharges (HRSTS); and
- Interference with flood flows along Wollombi Brook and the Hunter River associated with changes in the respective flood plains.

4.2 MINE SITE WATER REQUIREMENTS

A significant proportion of mine site water requirements will be sourced from water collected on the site, including rainfall runoff and groundwater inflows to the open cut pits (Year 0 and Year 3) which will be transferred to the mine water management system for recycling.

The results of the water balance modelling (see Section 6.6) show that external water may be required to meet all site demands. Total external water requirements are characterised as:

- A minimum of 140ML/a of external raw water (from the Hunter River) will be required for the life of the proposal. This is consistent with site demands of industrial use and vehicle wash of around 140ML/a which are supplied from raw water sources only;
- There is a 90 per cent chance that at least 450ML of external water will be required in any year of project life.
- A step change in external water requirement occurs in around Year 2 which is consistent with the decrease in pit inflows at MTO, and an increase in production at Warkworth Mine. External water requirement from Year 3 to Year 21 is generally consistent with:
  - A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
  - A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

MTW has identified the following possible sources of additional water for the proposal, which will be negotiated on an as-needed basis when mutually beneficial:

- Water sharing with Hunter Valley Operations (directly to the north of Warkworth Mine). This strategy has been successfully adopted in the past;
- Water sharing with Bulga Coal Complex (directly to the south of MTO); and
- Water sharing with Wambo Mine.

If required, additional water licences would be sought and purchased by Coal & Allied over the life of the project to meet external water demands. As all off-site water supplies for the project would be obtained from licensed sources, there will be no adverse impact on other licensed users who will still have access to their entitlement (subject to climatic conditions and the operation of the water supply scheme).

4.3 LOSS OF CATCHMENT AREA

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to Wollombi Brook or the Hunter River. The indicative mine plans are shown in Figure 6.4 to Figure 6.11 for Years 3 to 21. A breakdown of the catchment areas reporting to the mine storages is provided in Appendix B.

Table 4.1 shows the total catchment area captured within the MTW mine water management system over the life of the proposal, including sediment dam areas. The maximum captured Wollombi Brook area of 10.5km^2 occurs during Year 14 to Year 22 of the proposal, representing 0.56 per cent of the Wollombi Brook catchment to the confluence of the Hunter River. Note that although the catchment area of sediment dams is included in the catchment loss calculations, these sediment dams may overflow to Wollombi Brook during periods of rainfall, reducing the volume of water lost from the downstream catchment. Refer to Section 4.6.2 for further information on the Hunter River flow volume.

Table 4.1 also shows the catchment area captured in the final landform (including the South Pit void). The final landform restored the Hunter River catchment area (excluding the Wollombi Brook catchment) to 99.96 per cent of its pre-mining catchment area. The final landform captures 8.6km^2 or 0.44 per cent of the Wollombi Brook catchment to the confluence of the Hunter River.

Table 4.1 Receiving Waters Catchment Area during and after MTW Mining Operations

Mine Stage	Wollombi Brook to Hunter River confluence		Hunter River (excluding Wollombi Brook) to Singleton	
	Area (km^2)	Proportion of Pre-mining Area (%)	Area (km^2)	Proportion of Pre-mining Area (%)
Pre-Mining	1,888	100%	16,400	100%
Existing (2013)	1,885	99.84%	16,371	99.82%
Proposal				
Year 0	1,885	99.84%	16,371	99.82%
Year 3	1,881	99.79%	16,368	99.81%
Year 9	1,878	99.60%	16,368	99.81%
Year 14	1,878	99.44%	16,368	99.81%
Year 21	1,878	99.44%	16,368	99.81%
Final Landform	1,879	99.54%	16,394*	99.96%

Notes: * Includes South Pit final void.

4.4 SURFACE WATER QUALITY

The MTW water management plan has the following key objectives in relation to surface water quality of receiving waters:

- Preferential re-use of poor quality mine water in preference to clean water;
- Minimise the use of fresh water; and
- Protect clean water systems.

Potential impacts on surface water quality in the receiving waters will be managed by implementation of the following measures:

- MTW site water management system (detailed in Section 6.5);
- Compliance with HRSTS discharge limits (detailed in Section 6.5.8);
- Sediment and Erosion Control Plan (detailed in Section 7.3); and
- Surface water monitoring program (detailed in Section 7.5).

The results of the water balance modelling show that no uncontrolled release of saline water occurs over the life of the proposal. Excess saline water is released in accordance with the existing rules of the HRSTS. Downstream impacts on surface water quality as salinity will be in accordance with the acceptable limits under the HRSTS. Refer to Section 4.6.4 for impacts on other water quality parameters.

4.5 UNCONTROLLED OFFSITE RELEASES

The results of the water balance modelling indicate that under the current model assumptions and configuration, there is a low risk of the MTW water management system accumulating water over the 21 year project life. The results show that the system recovers well after each wet season. The model results show no uncontrolled spills of saline water from the saline water storages.

Overflows of water from sediment dams will occur during wet periods that exceed the design standard of the sediment control system (as per the design intent). Monitoring of sediment dams' water quality will continue, as described in Section 7.5.

4.6 IMPACTS OF CONTROLLED RELEASES UNDER HRSTS

4.6.1 Overview

MTW is a current participant of the HRSTS, which provides the opportunity to discharge saline water without exceeding salt concentration limits in the Hunter River. Further details of the HRSTS are provided in Section 3.5. Under the proposal, MTW will continue to be a Scheme participant. Controlled discharges are currently made from Dam 9S at MTO, and Dam 1N at Warkworth Mine. The proposal seeks an increase in the maximum release rate at MTO to 300ML/d (currently 100ML/d); however, the release rate of Warkworth Mine will remain unchanged. The water balance has modelled a discharge rate of 200ML/d at MTO, to be conservative with regards to mine water containment performance.

Figure 4.1 and Figure 4.2 show the simulated annual controlled discharges to the Hunter River under the HRSTS from MTO and Warkworth Mine, respectively. Review of the results shows that:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharge structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

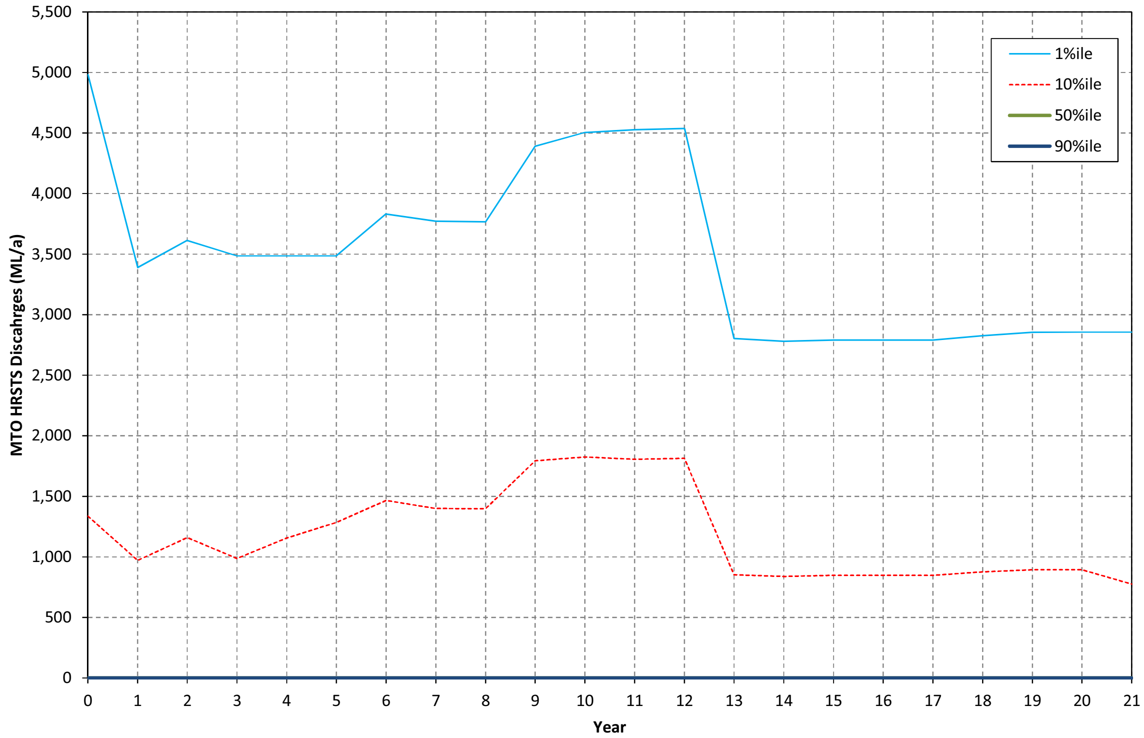

Figure 4.1 MTO Discharges to Hunter River

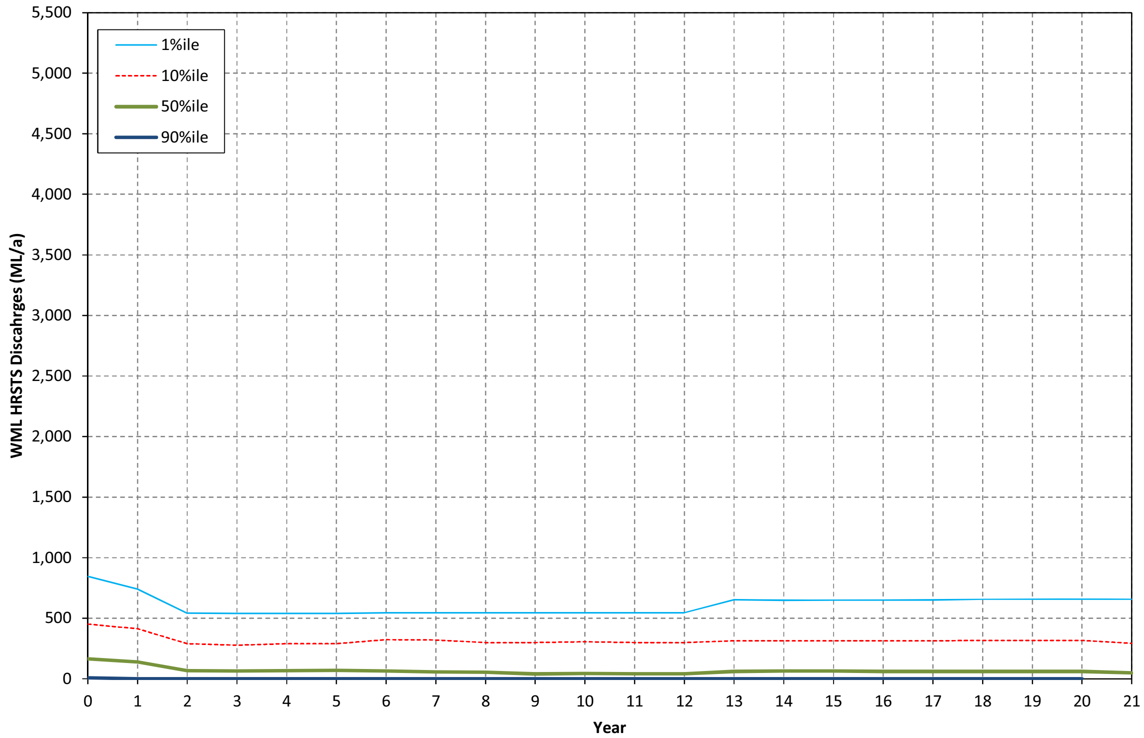

Figure 4.2 Warkworth Mine Discharges to Hunter River

Controlled releases of saline water under the HRSTS have the following potential impacts:

- Impacts on the total flow volume in the Hunter River;
- Impacts on stream condition, including bank erosion; and
- Water quality impacts.

These potential impacts are discussed in the following sections.

4.6.2 Hunter River Flow Volume

Table 4.2 shows the net impact of the MTW water management system on Hunter River flow volumes over the life of the proposal. The median runoff captured in the system is based on the captured catchment areas (see Appendix B), and the harvestable rights runoff coefficient (0.07ML/ha). The simulated median controlled discharges (HRSTS) and simulated median sediment dam overflows to the Hunter River are used to estimate the median net reduction in runoff in the Hunter River. The HRSTS discharges and sediment dam overflows offset the reduction in Hunter River flows caused by the loss of catchment area. The results show that the median annual reduction in flows to the Hunter River varies between 16 and 75ML/a during the life of the proposal, and the median annual reduction is 104ML/a post-mining. This is approximately 0.02 per cent of the median annual Hunter River discharge to Singleton (estimated from NOW's IQQM model - full development case with 2004 water sharing plan rules).

Table 4.2 Net Impact of Mine Water Management System on Hunter River Flow Volumes over Project Life

Mine Stage	Median Runoff Captured (ML/a)	Median Discharge to Hunter River (ML/a)	Median Sedimentation Dam Overflows (off-site)	Median Net Runoff Reduction (ML/a)
Year 0 (existing)	225	181	25	19
Year 3	215	81	118	16
Year 9	231	40	116	75
Year 14	246	66	151	29
Year 21	243	48	154	41
Post-Mining	104	0	0	104

Figure 4.3 shows the impact of MTW HRSTS discharges on the Hunter River flow characteristics (IQQM simulated). Flow characteristics are shown for the wettest and driest realisations (defined by the total flow in the Hunter River over the simulated 22 year period of the life of the proposal), for scenarios both with and without MTW HRSTS discharges. Note that under the rules of the HRSTS, discharges only occur when flows in the Hunter River are greater than 2,000ML/d, and a maximum total discharge rate from MTW of 300ML/d has been simulated. Results show that the impacts of HRSTS discharges on the Hunter River flow characteristics are negligible during both wet periods and dry periods.

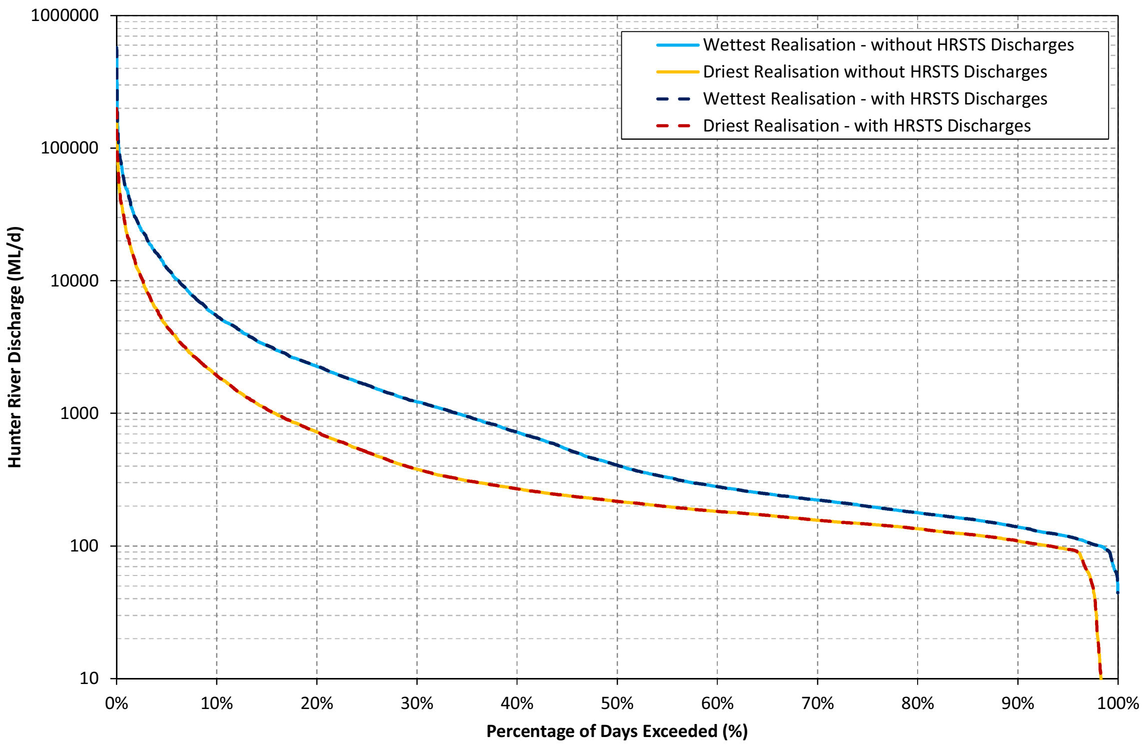

Figure 4.3 Hunter River Discharges (IQQM Simulated) Flow Characteristics – Impact of MTW HRSTS Discharges

4.6.3 Stream Condition

The proposed flow rate of the controlled discharge will be less than 300ML/d (3,500L/s) from Dam 9S to Loders Creek (increased rate of discharge from current approval), and less than 100ML/d (1,160L/s) from Dam 1N to Doctors Creek (no change to approved rate of discharge). It is possible that controlled discharges may occur at times when there is no natural flow in Loders Creek or Doctors Creek. Note that current MTW operations have discharged flows of this magnitude to Doctors Creek in the past when required and it is not expected that discharges under the proposal will have an additional impact on the stream condition of Doctors Creek to that already experienced under the current operations.

The mine directly adjacent to MTO to the south (Bulga Coal Mine (BCM)) is also currently seeking approval for an increased controlled discharge rate to Loders Creek. The Bulga Optimisation Project (Umwelt, 2014) has estimated a maximum sustainable discharge to the Loders Creek system with considerations of potential cumulative impacts of discharges from both MTO and BCM. The results of the analysis are summarised as:

- There is one area of erosion risk identified in Loders Creek downstream of MTO discharges;
- Hydraulic analysis indicates that limited the peak discharge rate to 60 per cent of the bank full capacity will most likely ensure a low risk of erosion during discharges;
- Bank full capacity in Loders Creek upstream and downstream of the Northern Dam tributary (a dam proposed in the BOP) is $23.6m^3/s$ and $43.4m^3/s$, respectively. Therefore the maximum discharge at 60% of the bank full capacity is $14.2m^3/s$ (1,200ML/d) and $26.0m^3/s$ (2,250ML/d), respectively.

- Due to the locations of the discharge points at BCM, the BCM discharge rates are limited by the upstream creek capacities. The BCM proposed discharge rates are therefore much less than the 60% bank full flows for the downstream reaches of Loders Creek.
- The BCM proposed maximum discharge rate upstream of the Northern Dam tributary is 300ML/d; and 800ML/d downstream of the Northern Dam tributary.

The MTO and BCM combined maximum discharges rates of 600ML/d upstream of the Northern Dam tributary and 1,100ML/d downstream of the Northern Dam tributary are significantly less than the 60% bank full capacity of Loders Creek. Therefore it is considered that there is a low potential risk of erosion during discharges in Loders Creek downstream of the MTO discharge location.

As specified under the rules of the HRSTS, controlled discharges may only occur when the 'high' or 'flood' flow block is passing MTW. Therefore, controlled releases from the proposal will only occur when the Hunter River is in an increased state of flow (at least 2,000ML/d). Based on the comparatively low controlled discharge rate, it is not expected that controlled discharges would result in adverse hydraulic impacts on the Hunter River, such as increased bed and bank erosion.

4.6.4 Water Quality Impacts

Discharges under the HRSTS are controlled so that the salt concentration in the Hunter River Lower Sector (downstream of Glennies Creek confluence) does not exceed 900µS/cm. An important component of meeting the salinity goal is to discharge the salt load evenly throughout the discharge period to avoid short periods of elevated salinity in the Hunter River (DECCW, 2010).

Controlled discharges from the proposal will continue to be released in accordance with HRSTS and EPL 1376 and 1976 requirements.

Table 4.3 shows a comparison of site and NOW water quality monitoring data in the Hunter River in the vicinity of MTW, with ANZECC (2000) guideline trigger values and site water quality monitoring at the discharge dams. The comparison shows:

- Discharge dam water quality (median) is better than Hunter River water quality and the lowest recommended ANZECC guidelines trigger value for the following parameters:
  - Manganese, selenium, phosphorus (total) and zinc.
- Discharge dam water quality (median) is better than the lowest recommended ANZECC trigger value, but worse than the Hunter River water quality for the following parameters:
  - Arsenic, boron, barium, calcium, calcium carbonate, iron (filtered), potassium, lithium, magnesium, rubidium, and strontium.
- Discharge dam water quality (median) is poorer than the lowest recommended ANZECC trigger value but better than the Hunter River water quality for the following parameter:
  - Aluminium.
- Discharge dam water quality (median) is poorer than the lowest recommended ANZECC trigger value and the Hunter River water quality for the following parameters:
  - Chloride, sodium and sulphate.

It is likely that the elevated sodium and chloride concentrations are the main salt component of the salts generated on site, discharges of which are controlled by the HRSTS. The ANZECC guideline trigger value of 115mg/L for sodium and 175mg/L for chloride applies to irrigation of sensitive crops. A trigger value of 300mg/L for sodium and 400mg/L for chloride applies for recreational use. There are no sodium or chloride trigger values for livestock drinking or ecosystem protection.

The median sulphate levels in the discharge dams exceed the ANZECC guideline trigger value for recreational use (400mg/L), and are equal to the ANZECC guideline trigger value for livestock drinking use (1,000mg/L).

As controlled discharges occur during high flow events in the Hunter River, significant dilution of discharges is expected. The 'worst case' dilution ratio for MTW discharges to Hunter River flows is 1:5 (400ML/day discharge rate to 2,000ML/day minimum flow required in the Hunter River flow for discharge under HRSTS). In the immediate vicinity of the Loders Creek confluence with the Hunter River, inside a mixing zone, contaminant concentration will be elevated compared to adjacent areas. However, secondary velocity currents induced by the nearby channel bends and turbulence induced by the riparian vegetation will promote mixing of the discharge water with the Hunter River flow. It is therefore likely that complete mixing of the discharge water with the river flow will occur within a few hundred metres of the outlet.

Table 4.3 Water Quality - Hunter River and MTW Discharge Dams

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Al - Total (mg/l)	10%ile	0.055	0.33	-	0.09	0.26
	Median	(Ecosystem)	0.52	-	0.16	0.38
	90%ile		5.73	-	10.06	0.71
	N		5	-	5	9
As - Total (mg/l)	10%ile	0.013	0.001	-	0.001	0.002
	Median	(Ecosystem)	0.001	-	0.013	0.007
	90%ile		0.001	-	0.017	0.025
	N		10	-	10	13
B (mg/l)	10%ile	0.37	0.00		0.06	0.08
	Median	(Ecosystem)	0.04	<LOR	0.08	0.10
	90%ile		0.05	0.13	0.11	0.12
	N		9	38	10	13
Ba (mg/l)	10%ile	1	0.022	-	0.015	0.027
	Median	(Recreational)	0.031	-	0.033	0.051
	90%ile		0.085	-	0.114	0.085
	N		9	-	9	12
Ca - Total (mg/l)	10%ile	1,000	27		15	7
	Median	(Livestock	39	37.0	40	13
	90%ile	drinking)	44	50.0	50	17
	N		7	70	18	8
$CaCO_3$ - Total Hard (mg/l)	10%ile		77	-	502	200
	Median		163	-	590	200
	90%ile		249	-	848	200
	N		2	-	13	1
Cl- (mg/l)	10%ile	175	132		-	856
	Median	(Irrigation)	136	100	-	946
	90%ile		140	153	-	964
	N		2	71	0	3

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Fe - Filtered (mg/L)	10%ile	0.2 (Irrigation)	0.03		0.02	0.01
	Median		0.12	0.004	0.05	0.01
	90%ile		0.21	0.121	0.09	0.01
	N		3	8	4	1
K - Total (mg/l)	10%ile	-	3		23	27
	Median		4	3.1	36	30
	90%ile		4	4.4	44	34
	N		7	69	5	8
Li (mg/l)	10%ile	2.5 (Irrigation)	0.002	-	0.131	0.197
	Median		0.005	-	0.275	0.212
	90%ile		0.030	-	0.358	0.294
	N		5	-	5	9
Mg - Total (mg/l)	10%ile	2,000 (Livestock drinking)	23		25	13
	Median		28	30.7	36	19
	90%ile		35	43.0	67	25
	N		7	70	6	9
Mn - Total (mg/l)	10%ile	0.1 (Recreational)	0.056		0.004	0.005
	Median		0.110	0.057	0.008	0.011
	90%ile		0.352	0.155	0.046	0.030
	N		9	10	9	12
Na - Total (mg/l)	10%ile	115 (Irrigation)	42	-	1,306	1,720
	Median		73	-	1,800	1,860
	90%ile		80	-	1,900	2,197
	N		7	-	5	8
P - Total (mg/l)	10%ile	0.05 (Irrigation & Ecosystem)	0.06		0.01	0.01
	Median		0.09	0.060	0.02	0.02
	90%ile		2.35	0.152	0.48	0.03
	N		6	240	6	9
Rb - Total (mg/l)	10%ile	-	0.001	-	0.043	0.048
	Median		0.002	-	0.061	0.055
	90%ile		0.004	-	0.063	0.060
	N		5	-	5	9
Se (mg/l)	10%ile	0.01 (Recreational)	0.00	-	0.00	0.00
	Median		0.00	-	0.01	0.01
	90%ile		0.05	-	0.01	0.01
	N		9	-	10	13
Si (mg/l)	10%ile	-	3.01	-	5.62	5.30
	Median		12.20	-	6.25	6.40
	90%ile		14.82	-	7.65	9.24
	N		4	-	4	5
SO_4 - Total (mg/l)	10%ile	400 (Recreational)	26		444	730
	Median		34	38.2	1,011	939
	90%ile		145	80.0	1,304	1,290
	N		8	70	10	11

Water Quality Parameter		ANZECC (2000)	Hunter River		Discharge Dam	
		Trigger Value (Lowest)	W1 – U/S Loders Ck (Site monitoring)	At Singleton (NOW monitoring)	Dam 1N	Dam 9S
Sr - Total (mg/l)	10%ile	-	0.125	-	0.316	0.382
	Median		0.380	-	0.640	0.648
	90%ile		0.490	-	0.833	0.882
	N		5	-	5	9
Zn - Total (mg/l)	10%ile	0.008	0.005		0.005	0.005
	Median	(Ecosystem)	0.005	<LOR	0.005	0.005
	90%ile		0.019	0.09	0.036	0.021
	N		10	23	10	13

4.7 FLOODING AND STREAM GEOMORPHOLOGY

The potential interactions between the proposed operations and the 1 in 100 year Average Recurrence Interval (ARI) design flood event for the Hunter River to the east and Wollombi Brook to the west has been investigated. The proposal will not result in any additional flood risk to infrastructure adjacent to the Hunter River along the eastern side of the mining lease (see Section 5).

The results of a flood study for Wollombi Brook (see Section 5) indicate that the proposal is located outside the 100 year ARI flood extent for Wollombi Brook. Hence, the proposal will not impact on flooding behaviour in Wollombi Brook and will not have any measurable effect on the geomorphology of Wollombi Brook.

4.8 WATER ALLOCATIONS

The water management system for the proposal has been designed to minimise the capture of clean runoff wherever possible.

Dams solely for the capture, containment and recirculation of mine affected water consistent with best management practice to prevent the contamination of a water source are “excluded works” and are exempt from the requirement for water supply works approvals and WALs under the Water Management Act 2000. On this basis, water captured in the site water management structures, with the exception of rainfall runoff from undisturbed natural catchments, is not subject to licensing.

The capture of runoff from undisturbed natural catchment draining to any of the proposal’s water management dams and mining areas may require a Water Access Licence (WAL). Figure 4.4 shows the clean water catchment areas requiring a WAL for runoff capture. Table 4.4 shows the estimated average volume of water captured within the water management system over the life of the proposal.

The intercepted average and maximum annual runoff has been estimated using average and maximum annual rainfalls at Jerrys Plains (Station No. 061086) of 644.5mm and 1,191.2mm respectively. A volumetric runoff coefficient of 0.108 has been used based on the runoff coefficient utilised for harvestable rights calculations at MTW (10 per cent of runoff =

0.07ML/ha = 7mm runoff. 100 per cent of runoff = 70mm. 70mm/644.5mm average annual rainfall = 10.8 per cent).

The total unregulated river access entitlement for the Hunter Unregulated and Alluvial Water Sources is 80,619 units (ML/a). The proposal is located on the boundary of the Singleton Water Source and the Lower Wollombi Brook Water Source, which have unregulated river access component shares of 960 units (ML/a) and 6,663 units (ML/a), respectively.

The predicted average annual impacts on the share components for the Singleton Water Source (67.3 ML/a) and for the Lower Wollombi Brook Water Source (10.0ML/a) under the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan is approximately 8 per cent and 0.1 per cent, respectively, on an annual average basis for the life of the proposal.

MTW holds approximately 1,012ML/a of high security units of Hunter River water shares under the Mount Thorley Joint Venture (MTJV) Supply Scheme.

The total surface water entitlement (general and high security access licences) for the Hunter Regulated River water source is 151,792 units (ML/a). The proposal is located in Management Zone 2, which has an entitlement of 57,094 units (ML/a).

The MTW contiguous land holdings for the harvestable rights calculation are 4,007 ha in the Hunter River catchment and 2,667 ha in the Wollombi Brook catchment. At a harvestable right of 0.07ML/a, this equates to a volume of 280ML and 187ML in the Singleton and Lower Wollombi Brook Water Sources respectively.

Table 4.4 Surface Water Allocations

Water Sharing Plan		**Hunter Unregulated and Alluvial Water Sources**		**Hunter Regulated River**
Water Source		**Lower Wollombi Brook**	**Singleton**	**Hunter Regulated River**
Predicted annual take (ML/a)	Average	10	73	1,876
	Maximum	18	135	4,410
Predicted annual impact on water source (%)	Average	0.1	8	3.3
	Maximum	0.3	14	7.7
MTW current licences/ Harvestable Right		187 ML/a	280 ML/a	1,012 units
Additional water potentially required for the integrated operation (ML/a)	Average	0	0	864*
	Maximum	0	0	3,398*

Notes: * These volumes may be obtained from surplus mine water from nearby mining operations under water sharing agreements - refer Section 4.2.

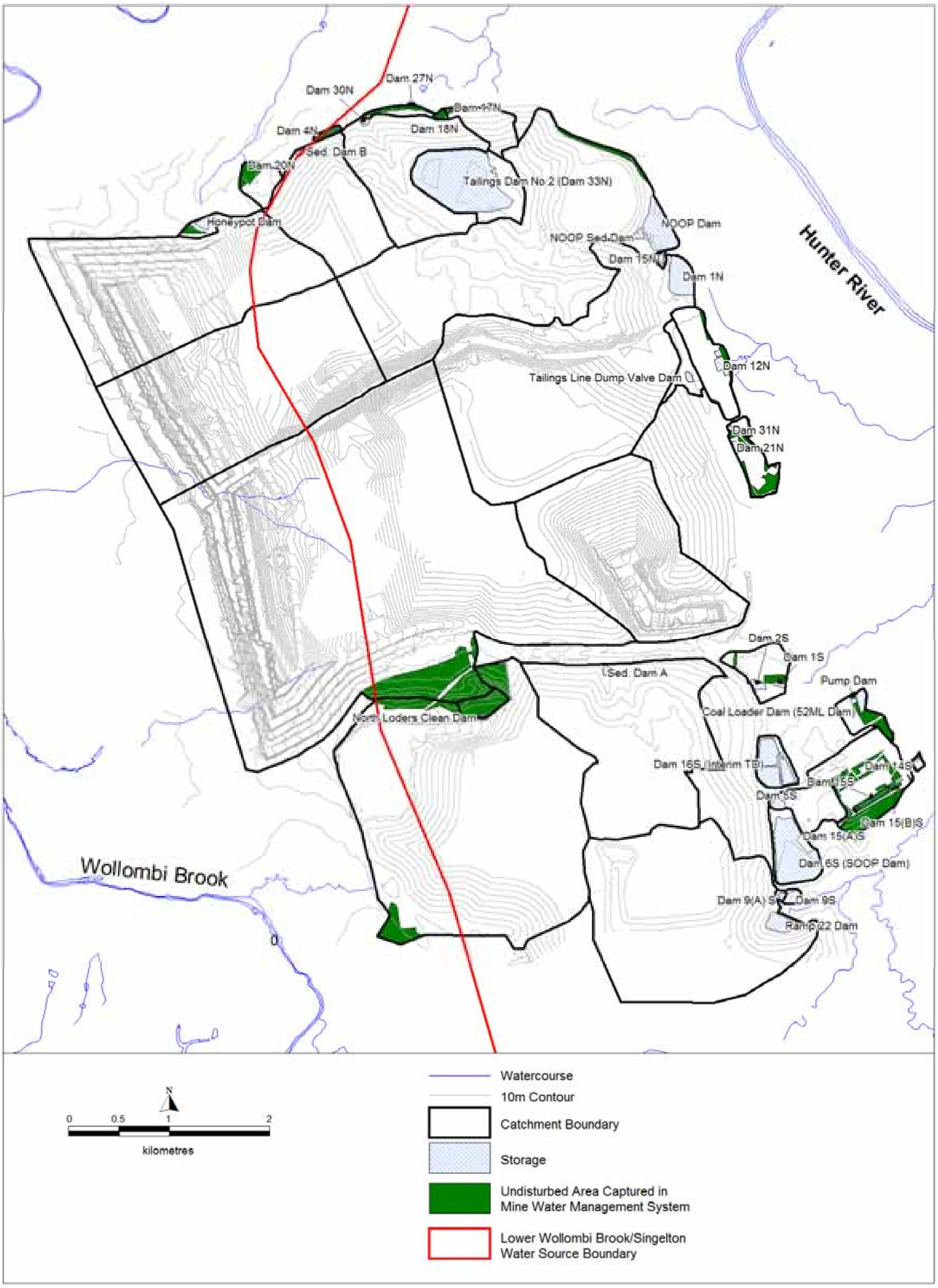

Figure 4.4 Undisturbed Catchment Areas Requiring Water Allocation Licence for Runoff Capture

5 FLOODING

5.1 OVERVIEW

The proposal may potentially impact on flooding in the Hunter River to the east and Wollombi Brook to the west. Since the proposal involves the advancement of mining to the west, there will be no increase in flood risk to infrastructure along the eastern side of the mining lease from the Hunter River. A desktop assessment was undertaken to assess flood levels along the Hunter River adjacent to the mine. For Wollombi Brook, a flood study was undertaken to estimate design flood levels adjacent to the mine. The methodology and results of the flood investigations are described below.

5.2 HUNTER RIVER FLOODING

Water level data for the Hunter River is available adjacent to the mine site at Mason Dieu (Station No. 210128), Long Point (Station No. 210134), Upstream Singleton (Station No. 210129) and Singleton (Station No. 210001). The locations of these stations are shown in Figure 2.4. Of these stations, only gauge levels from Long Point and Singleton can be translated into Australian Height Datum (AHD) levels. The peak levels recorded at these stations and at the two stations on Wollombi Brook (Bulga and Warkworth) for the June 2007 event are shown in Table 5.1. The June 2007 event was the largest flood event in the Hunter River at Singleton since the February 1955 event, and the third largest on record.

The minimum ground level along the eastern boundary of the MTW mining leases is approximately 50mAHD, which is about 1m higher than the maximum June 2007 flood level recorded at Long Point, located about 5km to the north-east. The proposal will not increase the Hunter River flood risk to infrastructure along the eastern side of the mining lease.

Table 5.1 Peak Recorded Levels for June 2007 Event

Station Number	River	Station Name	Peak Water Level (mAHD)
210134	Hunter River	Long Point	48.98
210001	Hunter River	Singleton	41.67
210028	Wollombi Brook	Bulga	63.48
210004	Wollombi Brook	Warkworth	56.30

5.3 WOLLOMBI BROOK FLOODING

5.3.1 Previous Flood Investigations

Two previous flood studies for Wollombi Brook have been undertaken: the first by the University of New South Wales Water Research Laboratory in April 1996 for an EIS prepared by Sinclair Knight Merz for the South Lemington open cut mine (SKM 1997), and the second by BMT WBM for Cessnock City Council in December 2010

The SKM (1997) study performed a frequency analysis on peak flood level data from the Warkworth gauge to determine design flood levels which were correlated to design discharges at Bulga. The study estimated a 100 year ARI design discharge of 2,700 m^3/s for Wollombi Brook at Bulga.

The BMT WBM (2010) study performed a flood frequency analysis (FFA) on a “synthetic” data series, which was a manipulated annual series which included gap filling and adjustment of recorded peak flow values to provide consistency in the annual flow records between the gauges. A flood frequency analysis was performed on the adjusted annual peak flows at Paynes Crossing, Bulga and Warkworth to determine the return period of a certain magnitude event. The FFA estimated a 100 year ARI design discharge of around 2,500m^3/s for Wollombi Brook at Bulga. The design flood discharges adopted for the study were based on an interactively calibrated hydrologic and hydraulic model using IFD design rainfall estimates. As the study was focussed on flood management at Wollombi Village, design discharges at Bulga using the calibrated hydrologic model have not been provided in the report.

5.3.2 Design Flood Discharges

For this study, a flood frequency analysis (FFA) of available data for the Bulga gauge was used to estimate design discharges. The available data at the Warkworth stream gauge includes a greater number of years, however the station is frequently affected by backwater flooding from the Hunter River and hence, the estimated discharges at the Warkworth gauge are unreliable. Annual recorded peak flood discharges for the Bulga gauge were available for the years 1949-1959, 1963-1987 and 2000-2013 totalling 50 years of data.

The methodology recommended in Book 4, Section 2 of Australian Rainfall and Runoff (ARR, 1998) was used to fit a Log-Pearson Type III distribution to the annual series of recorded peak flood discharges for the Bulga gauge. Figure 5.1 is a flood frequency plot for Wollombi Brook at Bulga. Design discharges estimated from the FFA are shown in Table 5.2 and are compared with the design discharges used in the SKM (1997) study, and the BMT WBM (2010) study. Discharges from this study are slightly higher than those in the BMT WBM (2010) study for the larger ARI events, and are therefore considered to be more conservative. Note that the recorded peak flood discharge for the June 2007 event at Bulga was 875m^3/s. Comparing this recorded discharge with the results shown in Table 5.2 indicates that the June 2007 event was between a five to ten year ARI event in Wollombi Brook at Bulga.

Table 5.2 Design Discharges for Wollombi Brook

ARI (years)	Design Discharge from FFA (m³/s)	SKM (1997) Design Discharge	BMT WBM (2010) Design Discharge
5	470	600	750
10	880	1,400	1,000
20	1,400	1,900	1,500
50	2,100	2,500	2,000
100	2,700	2,700	2,500

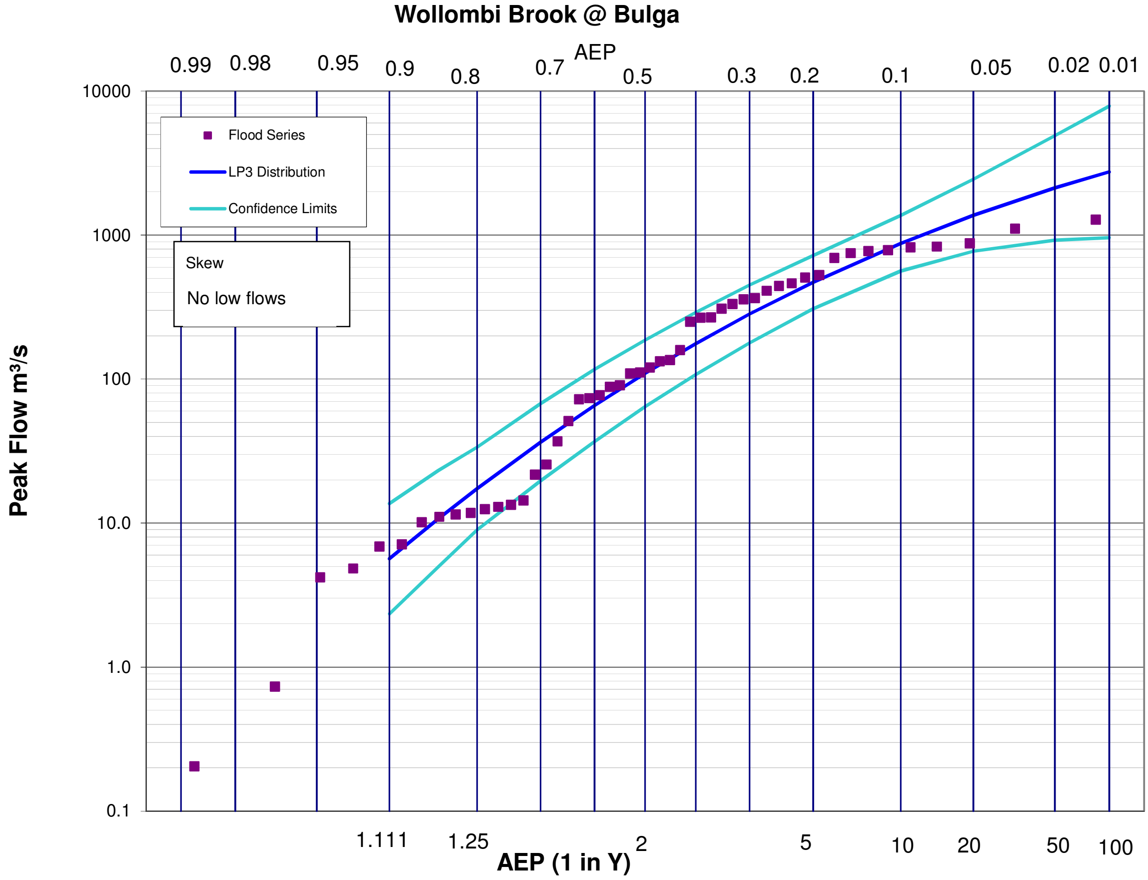

Figure 5.1 Flood Frequency Analysis Plot, Wollombi Brook at Bulga

5.3.3 Design Flood Levels

Methodology

The HEC-RAS steady state hydraulic model was used to estimate the 100 year ARI design flood levels in Wollombi Brook adjacent to the mine site. The model was calibrated to recorded flood levels and discharges for the June 2007 event.

Model Configuration

Figure 5.2 shows the location of the cross-sections used in the HEC-RAS model. A total of 23 cross-sections were used in the study. Cross-section data was based on 2m contours obtained from aerial survey undertaken by AAMHatch in September 2008. The vertical accuracy of the data is +/- 2m, which was considered adequate for this study given the significant available freeboard between estimated flood levels and the proposed pit extent.

Downstream Boundary Condition

The adopted downstream boundary condition was a fixed water level which was selected to match a selected level at the Warkworth stream gauge. A frequency analysis was performed on available peak water level data for the Warkworth stream gauge to estimate design water levels. Annual recorded peak flood levels for the Warkworth gauge were available for the years 1908-2013 (except 1953) totalling 105 years of data. The predicted water level for the 100 year ARI event from the analysis was 59.0mAHD which is slightly lower than the 59.4mAHD estimated by the SKM (1997) study. The slightly higher value of 59.4mAHD was adopted as the target starting water level at the Warkworth gauge.

Model Calibration

The HEC-RAS model was calibrated to match recorded peak discharges and water levels for the June 2007 flood event. A uniform friction loss coefficient (Manning's 'n') value of 0.045 was adopted for all cross-sections in the model based on calibration to recorded flood levels. A comparison of the recorded and calculated flood levels for the calibration event is included in Table 5.2.

Table 5.3 Recorded and Estimated Flood Levels for June 2007 Event

Water Level (mAHD)	Bulga Station	Warkworth Station
Recorded value	63.48	56.30
Estimated value	63.50	56.31

Estimated Flood Levels

Estimated flood levels for the 100 year ARI design event vary from 59.4mAHD at Warkworth to 65.7mAHD at Bulga. Note that the 100 year ARI design flood level at Bulga is about 2.2m higher than the June 2007 peak flood level (63.5mAHD). Although the estimated 100 year ARI design discharge for this study is similar to the previous SKM study (SKM, 2007), the estimated design flood level at Bulga from this study is 1.2m higher than the SKM study.

Figure 5.2 shows the 100 year ARI design flood extent and flood level at each cross-section. Note that the proposal is outside the 100 year ARI extent of flooding from Wollombi Brook. An existing levee across Salt Pan Creek prevents flood waters from Wollombi Brook entering Loders Pit at MTO.

5.3.4 Flood Impacts

As shown in Figure 5.2 the proposal is located outside the 100 year ARI design flood extent. Figure 5.3 shows a cross-section of Wollombi Brook adjacent to the proposal, indicating that the 100 year ARI design flood level is about 11m below the top of the extended pit high wall. Hence, the proposal will have no impact on flood flows, velocities or flood levels along Wollombi Brook for events up to and including the 100 year ARI flood event. For this reason, the proposal does not require measures to mitigate flood impacts on Wollombi Brook.

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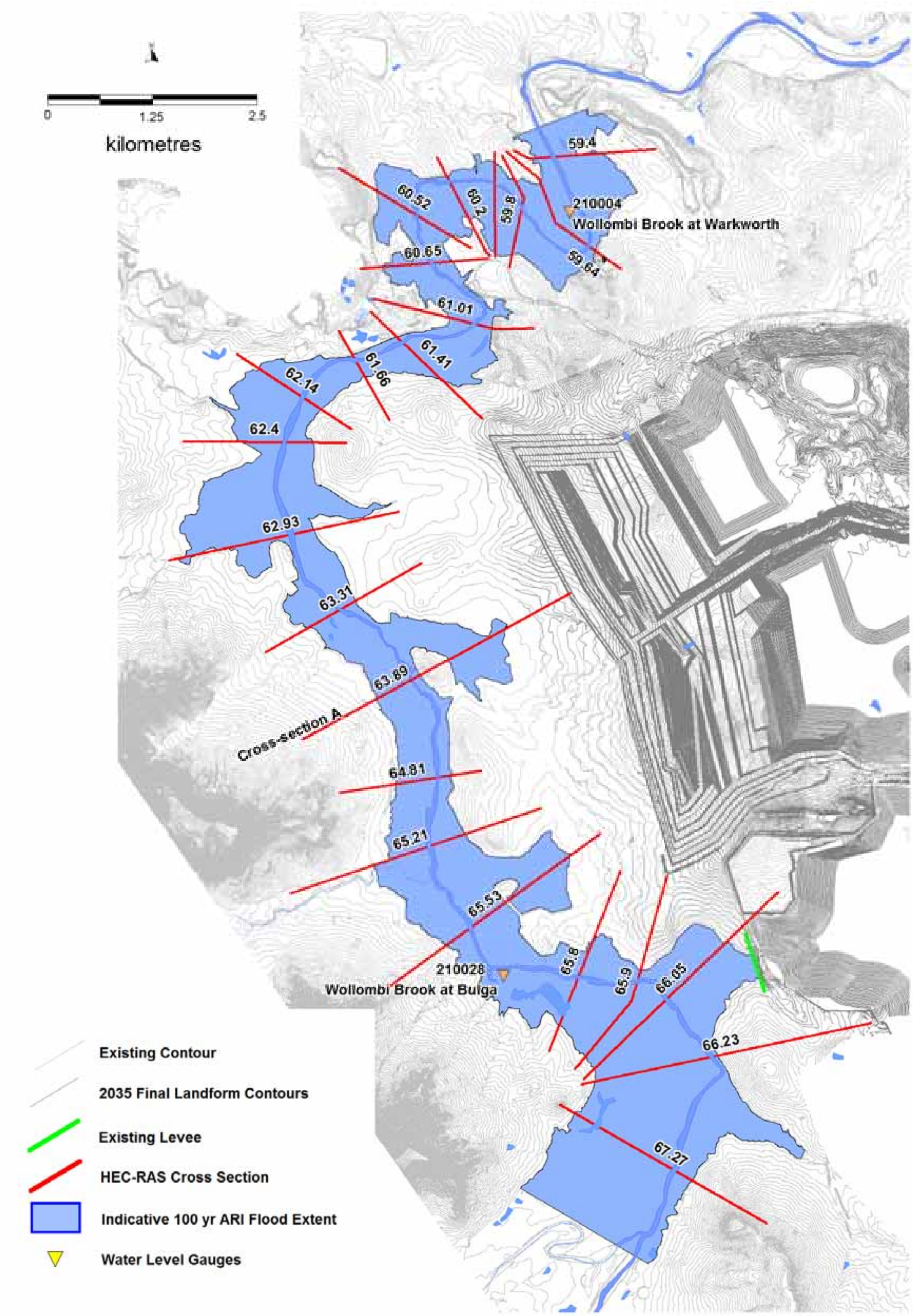

Figure 5.2 HEC-RAS Model Configuration and 100 Year ARI Design Flood Extent

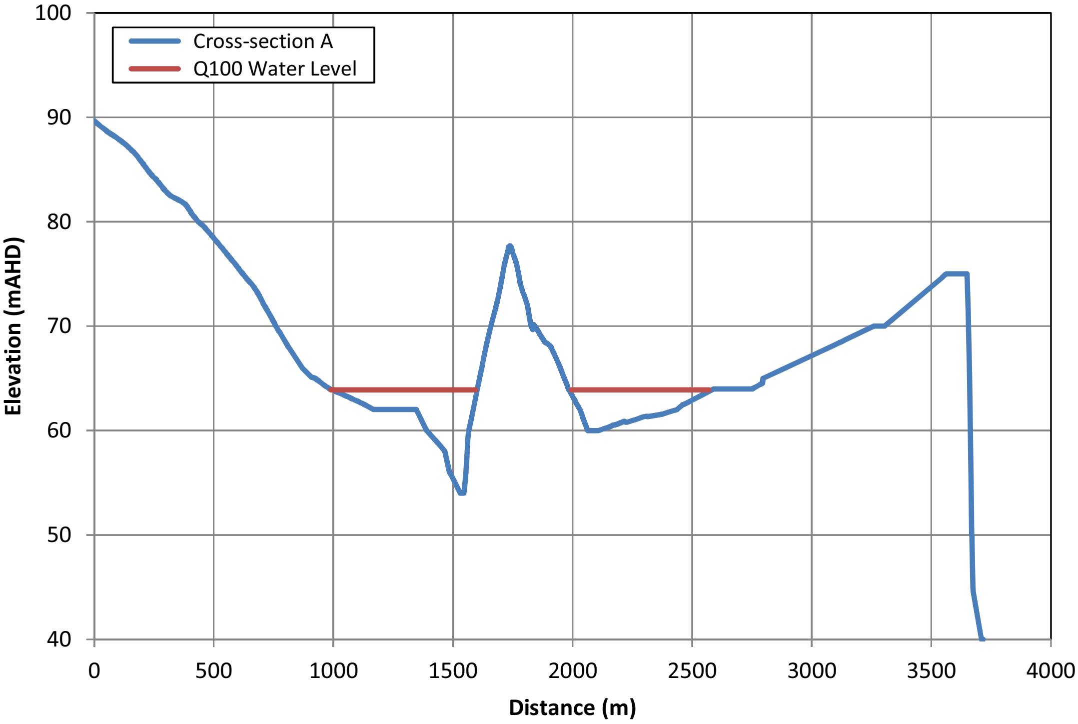

Figure 5.3 Flood Level at Cross-Section A, Adjacent to Extended Pit Highwall

6 MINE WATER BALANCE

6.1 OVERVIEW

The computer based OPSIM model was used to simulate the site water balance for the proposal. The model simulates the operations of all major components of the proposed water management system, including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff;
- Controlled discharges (under the HRSTS) and uncontrolled overflows;
- Groundwater inflows; and
- Site water usage (CHPP, haul road dust suppression and stockpile dust suppression, vehicle wash).

6.2 SIMULATION METHODOLOGY

The water balance model has been run for the 'forecast' simulation methodology.

The forecast water balance results are generated by running multiple climate sequences through the model and taking a statistical representation of the results for the different climate cases modelled. These results more accurately reflect the actual performance of the system because they take into account the dynamic nature of the mine staging, groundwater inflows, and CHPP throughputs. In these runs the model configuration changes over time, to reflect the changes due to mine development.

The forecast water balance model has been run on a daily time-step for a 22 year period, corresponding to the period of operation of the proposal (21 years) plus one year of the existing system (total 22 years). The model was run for multiple climate sequences, each referred to as a "realisation". Each realisation is based on a 22 year sequence extracted from the historical rainfall data. The first of 93 realisations is based on rainfall data from 1893 to 1914. The second is based on data from 1894 to 1915, and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record.

The model configuration changes over the 21 year project life, reflecting changes in the water management system over time. The different stages of the mine life are linked in the model to reflect variations over time such as catchments, ROM coal production and groundwater inflows. Five different representative stages of mine life were modelled (Years 0, 3, 9, 14 and 21). Although the catchment areas will continuously change as mining under the proposal progresses, the adopted approach of modelling discrete stages will provide a reasonable representation of conditions over the 21 year period.

The operational rules and physical layout for each representative stage of mine progression are applied to a range of years given in Table 6.1.

Table 6.1 Application of Representative Mine Stage to Full Mine Life

Representative Mine Stage	Applied Range of Mine Life	Period (years)
Year 0	Year 0 – 1	2
Year 3	Year 2 – 5	4
Year 9	Year 6 – 12	7
Year 14	Year 13 – 17	5
Year 21	Year 18 - 21	4

6.3 SIMULATION OF RAINFALL RUNOFF

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate daily runoff from daily rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evapotranspiration. Simulated surface runoff occurs when the storages fill and overflow. Figure 6.1 shows a conceptual configuration of the AWBM model.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area.

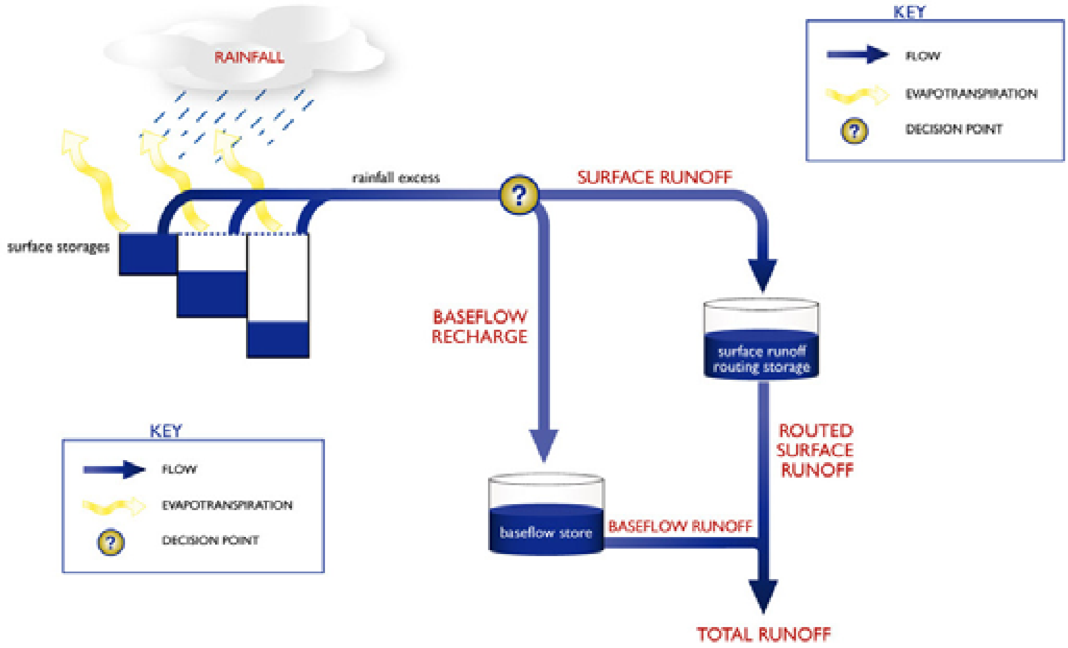

Figure 6.1 AWBM Model Configuration

The model parameters define the storage depths, the proportion of the catchment draining to each of the storages, and the rate of flux between them (Boughton, 2003).

The AWBM model parameters selected have been derived from the previous water balance modelling undertaken at MTW (WRM, 2014). Table 6.2 presents the calibrated AWBM model parameters and long term runoff coefficients over the period 1893 to 2006.

Table 6.2 MTW Catchment Yield (AWBM) Parameters

Parameter	Natural/ Undisturbed	Cleared/ Prestrip	Mining Pit	Tailings	Rehabilitated Spoil	Unrehabilitated Spoil	Roads/Industrial/ Hardstand
A1	0.2	0.1	0.1	0.1	0.1	0.1	0.1
A2	0.4	0.9	0.9	0.9	0.9	0.9	0.9
A3	0.4	0	0	0	0	0	0
S1	30	1	2.3	1	9.4	12.5	2.3
S2	50	11	6.9	11	94	125	6.9
S3	90	0	0	0	0	0	0
BFI	0.15	0	0	0	0.15	0.7	0
K_b	0.98	0	0	0	0.98	0.99	0
K_s	0.96	0	0	0	0.96	0.96	0
Long term Runoff Coefficient, C_v	12.5 %	40.4 %	46.1 %	40.4 %	9.9 %	7.2 %	46.1 %

6.4 WATER BALANCE MODEL CALIBRATION

The MTW OPSIM model was last updated and calibrated as part of the 2013 water balance model update (WRM Water & Environment Pty Ltd, 2014). The model was calibrated over the period May 2012 to June 2013 to the recorded total site inventory (see Figure 6.2). It was determined that the difference between recorded and simulated storage inventories in January and February 2013 is due to one or a combination of factors:

- Inaccurate recorded inventories in the pits; and/or
- Water stored in storages which are not recorded being pumped back into the recorded storage inventory system over time after rainfall events.

Nevertheless, the 2013 MTW OPSIM water balance model is considered to provide a reasonable representation of the response of the site's water management system to a range of climatic scenarios. The MTW 2013 OPSIM water balance model has been used as a basis for the proposed surface water investigations.

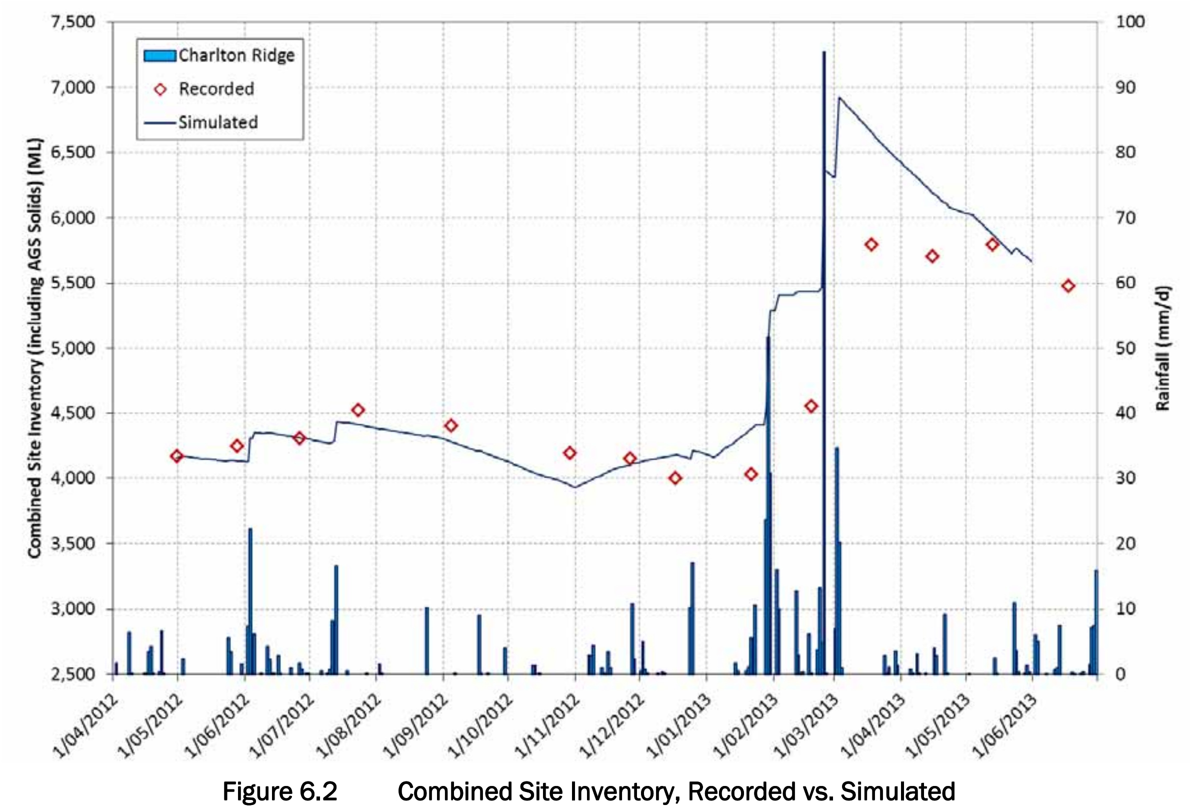

Figure 6.2 Combined Site Inventory, Recorded vs. Simulated

6.5 PROPOSED WATER MANAGEMENT SYSTEM

6.5.1 Proposed Mine Water Storages

A number of new storages or upgrades to existing storages are proposed at MTW in this proposal and are described below:

- North-Out-of-Pit Dam (NOOP Dam): Saline water storage located directly to the north of Dam 1N at Warkworth Mine. NOOP Dam has a proposed capacity of 740ML.

- SOOP Dam: Primary water storage for MTO (existing), also referred to as Dam 6S. Increase in storage capacity to 2.2GL within the same footprint.
- Ramp 22 Dam: Sediment dam situated at the current Dam 10S and Dam 11S location at MTO. Joint sediment dam with Bulga Coal Mine to the south. Runoff from both MTW and Bulga will be directed to this dam.
- Sediment Dam A: Sediment dam located at MTO to capture runoff from future spoil and rehabilitated areas. Exact location yet to be confirmed.
- Sediment Dam B: Sediment dam location at Warkworth Mine to capture runoff from future spoil and rehabilitation areas. Exact location yet to be confirmed.

Note also that a new pit/tailings storage facility (Abbey Green North) will be mined in approximately 2018 and 2019, however does not form part of this proposal. AGN is the designated tailings storage facility during Years 9 to 12.

6.5.2 Water Management System Layout and Operating Rules

The changes to the approved mine under the proposal will result in a number of potential changes to the water management system layout. The proposed water management system is shown in the schematic in Figure 6.3, with proposed changes highlighted. The mine stage layouts are presented in Figure 6.4 to Figure 6.10. Table 6.3 details the proposed OPSIM model operating rules.

The water management system will evolve as the mine develops, simulated as follows:

- Year 3: Tailings are directed to both the Centre Ramp Tailings Storage Facility (CRTSF) and AGS. Construction of the North-Out-of-Pit (NOOP) Dam is complete. Construction of Ramp 22 Dam is complete, replacing Dam 10S and 11S. Dam 32N (TD1) has been capped and rehabilitated. Dam 6N and Dam 12S have been mined out.
- Year 9: Tailings are directed to the CRTSF and Abbey Green North (AGN) TSF. Mining has been completed in Loders Pit, which has been partially backfilled. Mini-strip TSF has been rehabilitated. Sediment Dam A has been constructed. AGS is covered and rehabilitated.
- Year 14: Tailings are directed to the partially backfilled Loders Pit. CRTSF has been capped and rehabilitated. Sediment Dam B has been constructed. AGN is covered and rehabilitated.
- Year 21: Tailings Dam 2 (Dam 33N) has been capped and rehabilitated. Considerable areas of the site have now been rehabilitated.

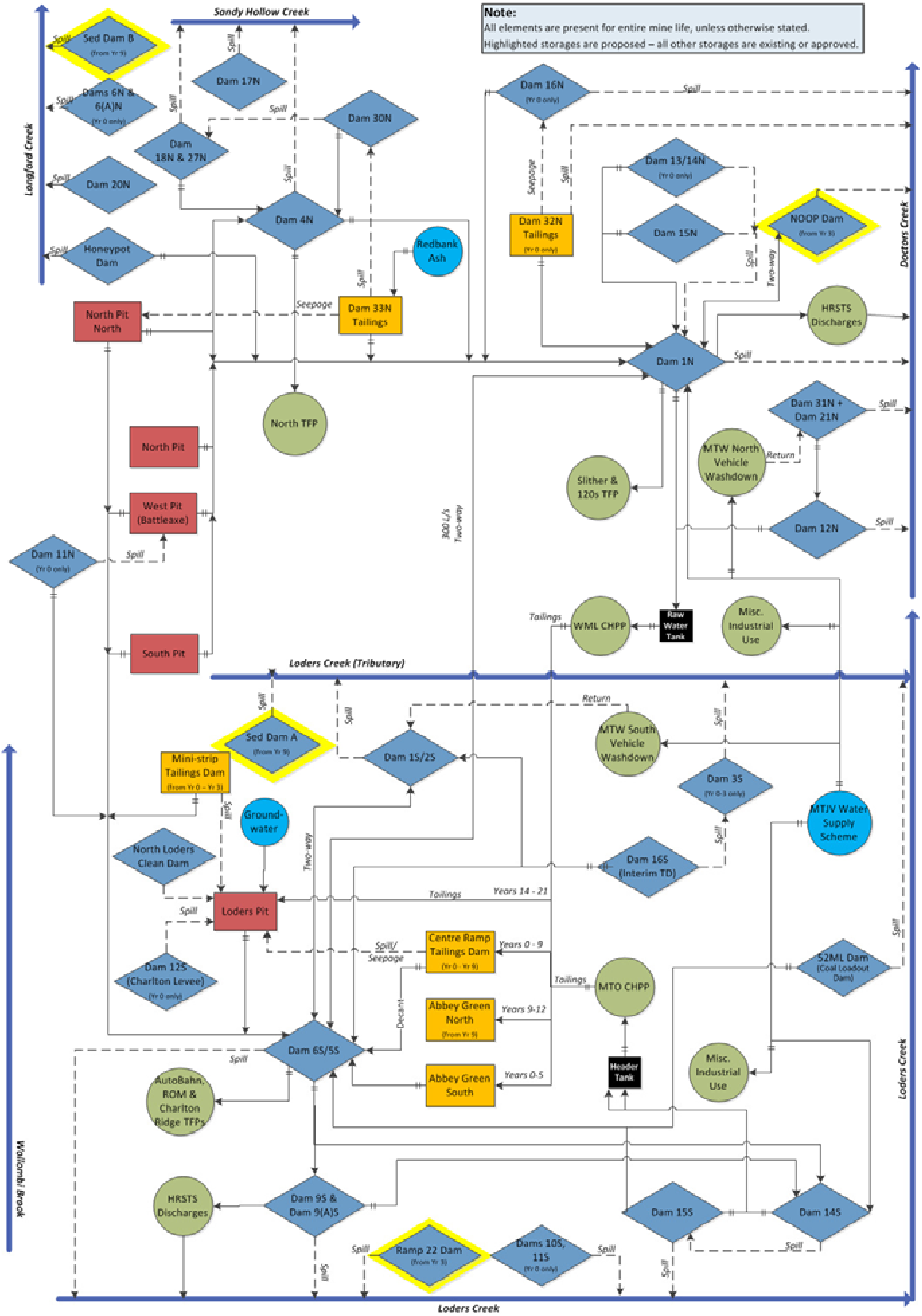

Figure 6.3 Proposed Water Management System Schematic

Table 6.3 Proposal OPSIM Model Operating Rules

Node No.	Node Name	Operating Rules
Water Supply		
161	MTJV Water Supply Scheme	▪ Supplies to the following locations as required: ▫ Dam 14S ▫ Dam 1N ▫ MTW South Vehicle Washdown ▫ MTW North Vehicle Washdown ▫ MTW South Misc. Industrial Use ▫ MTW North Misc. Industrial Use
Controlled Discharges		
311	Dam 1N HRSTS Discharge	▪ Warkworth controlled release point from Dam 1N under the following conditions: ▫ >70% of MOL capacity ▫ Maximum 100ML/d ▫ Under 'High' flows – releases so that downstream EC does not exceed 900µS/cm. ▫ Under 'Flood' flows – not limited by salts. ▪ Discharged to Hunter River via Doctor's Creek. ▪ Storage overflows to Doctor's Creek.
313	Dam 9S HRSTS Discharge	▪ Mount Thorley controlled release point from Dam 9S under the following conditions: ▫ >70% of MOL capacity ▫ Maximum 100ML/d ▫ Under 'High' flows – releases so that downstream EC does not exceed 900µS/cm. ▫ Under 'Flood' flows – not limited by salts. ▪ Discharged to Hunter River via Loders Creek. ▪ Storage overflows to Loders Creek.
Water Demands		
150	MTW North CHPP (Warkworth Mine)	▪ Supplied from Dam 1N via the Raw Water Tank ▪ Tailings directed to Abbey Green South/ CRTSF/Abbey Green North/Loders Pit – depending on stage.
250	MTW South CHPP (MTO)	▪ Supplied from the following locations (via the Header Tank): ▫ Dam 14S ▫ Dam 15S ▪ Tailings directed to Abbey Green South / CRTSF/Abbey Green North/Loders Pit – depending on stage.
181	MTW South Vehicle Washdown	▪ Supplied from MTJV Supply Scheme as per Table 6.11. ▪ 85% loss assumed. ▪ Return directed to Dam 1S/2S.
183	MTW South CHPP Miscellaneous Industrial Use	▪ Suppled from MTJV Supply Scheme as per Table 6.11. ▪ 100% loss assumed.
281	MTW North Vehicle Washdown	▪ Supplied from MTJV Supply Scheme as per Table 6.11. ▪ 85% loss assumed. ▪ Return directed to Dam 31N/21N.
283	MTW North CHPP Miscellaneous Industrial Use	▪ Suppled from MTJV Supply Scheme as per Table 6.11. ▪ 100% loss assumed.

Node No.	Node Name	Operating Rules
307	AutoBahn, ROM and Charlton Ridge Truck Fill Points (TFPs)	▪ Supplied from Dam 6S at a maximum rate of 3,481kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
308	Slither and 120s Truck Fill Points (TFPs)	▪ Supplied from Dam 1N at a maximum rate of 2,320kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
	North Truck Fill Point	▪ Supplied from Dam 4N at a maximum rate of 1,610kL/d on a 'non-rain day'. ▪ Reduction in demand for days of rain. ▪ 100% loss assumed.
Operational Pits		
190	Loders Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam). ▪ Receives seepage from Dam 17S (Centre Ramp TD) at a rate of 12,000kL/d. ▪ Receives pumped transfers from the following locations for Years 14-21: ▫ MTW North CHPP (tailings) ▪ MTW South CHPP (tailings)Receives spillway overflows from the following locations: ▫ Mini-strip TSF ▫ Dam 12S (Charlton Levee) ▫ Dam 17S (CRTSF) ▪ Receives groundwater inflows as per Table 6.4.
290	North Pit North	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 4N, Dam 1N, Dam 6S. ▪ Receives seepage from Dam 33N at a rate of 50kL/d. ▪ Receives groundwater inflows as per Table 6.4.
291	West Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 280L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam) or Dam 1N. ▪ Receives spillway overflows from Dam 11N.
293	South Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 280L/s. ▪ Pit dewatering directed to Dam 6S (SOOP Dam) or Dam 1N. ▪ Receives groundwater inflows as per Table 6.4.
295	North Pit	▪ Continuous dewatering from pit dewatering pumps (when required) at a nominal maximum rate of 100L/s. ▪ Pit dewatering directed to Dam 1N.
Water Storages		

Node No.	Node Name	Operating Rules
102	Dam 1S/2S	▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam). ▫ Dam 16S (Interim TD). ▪ Receives return from MTW South Vehicle Washdown. ▪ Pump transfers to Dam 6S when >12ML. ▪ Storage overflows to Loders Creek Tributary.
103	Dam 3S	▪ Rehabilitated area sediment dam (clean catchment). ▪ Receives storage overflows from Dam 16S. ▪ Storage overflows to Loders Creek Tributary. ▪ Mined out from Yr 9 onwards.
104	Sediment Dam A	▪ Present for Yr 9 onwards. ▪ Storage overflows to Loders Creek tributary.
105	Dam 5S	▪ Storage overflows to Dam 6S (SOOP Dam).
106	Dam 6S (SOOP Dam)	▪ Primary mine water storage for Mount Thorley. ▪ Receives pumped transfers from the following locations: ▫ Loders Pit ▫ Mini-strip TSF ▫ Dam 1S/2S ▫ Dam 15S (South CPP) ▫ Dam 16S ▫ Dam17S (Centre Ramp TSF) ▫ Dam 1N ▫ Dam 11N ▫ North Pit North ▫ West Pit ▫ South Pit ▫ Abbey Green South ▫ Coal Loader Dam (52ML Dam) ▪ Receives storage overflows from Dam 5S. ▪ Supplies to the following locations: ▫ Dam 2S ▫ Dam 14S ▫ Dam 1N ▫ Dam 9S ▫ AutoBahn TFP ▫ ROM TFP ▫ Charlton Ridge TFP ▪ Storage overflows to Loders Creek.
107	Ramp 22 Dam	▪ Present from Yr 3 onwards. ▪ Storage overflows to Loders Creek.
109	Dam 9S	▪ Mount Thorley HRSTS controlled release point (max. 200ML/d). ▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam) ▫ Dam 9(A)S ▪ Supplies to Dam 14S as required. ▪ Storage overflows to Loders Creek.
110	Dam 10S	▪ Present for Yr 0 only. ▪ Rehabilitated area sediment dam (clean catchment). ▪ Storage overflows to Dam 11S.

Node No.	Node Name	Operating Rules
111	Dam 11S	▪ Present for Yr 0 only. ▪ Rehabilitated area sediment dam (clean catchment). ▪ Receives storage overflows from Dam 10S. ▪ Storage overflows to Loders Creek.
112	Dam 12S (Charlton Levee)	▪ Present for Yr 0 only. ▪ Storage overflows to Loders Pit.
113	Dam 9(A)S	▪ Rehabilitated area sediment dam. ▪ Pump transfers to Dam 9S. ▪ Storage overflows to Loders Creek.
114	Dam 14S	▪ Receives pumped transfers from the following locations: ▫ Dam 6S (SOOP Dam) ▫ Dam 9S ▫ MTJV Water Supply Scheme (as required) ▪ Supplies to Header Tank as required. ▪ Storage overflows to Dam 15S.
115	Dam 15S (South CHPP)	▪ Receives overflows from Dam 14S. ▪ Supplies to Header Tank as required. ▪ Pump transfers to Dam 6S when >10ML. ▪ Storage overflows to Loders Creek.
116	Dam 16S (Interim TD)	▪ Pump transfers to Dam 2S or Dam 6S to maintain empty. ▪ Storage overflows to Dam 3S.
117	Dam 17S (Centre Ramp TSF)	▪ Receives pumped transfers from the following locations for Years 0-9: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Seeps to Loders Pit at a rate of 12,000kL/d. ▪ Storage overflows to Loders Pit (no spillway). ▪ Rehabilitated from Yr 14 onwards.
118	Coal Loader Dam (52ML Dam)	▪ Pump transfers to Dam 6S to maintain empty. ▪ Storage overflows to Loders Creek Tributary.
119	Loders Pit North Clean Water Dam	▪ Clean water catchment. ▪ Storage overflows to Loders Pit.
191	Mini-strip TSF	▪ Supplies to Dam 6S as required. ▪ Storage overflows to Loders Pit.

Node No.	Node Name	Operating Rules
201	Dam 1N	▪ Primary mine water storage for Warkworth. ▪ Warkworth HRSTS controlled release point (max 100ML/d). ▪ Receives pumped transfers from the following locations: ▫ Dam 6S ▫ Dam 4N ▫ North Pit North ▫ North Pit ▫ West Pit ▫ South Pit ▫ Dams 13/14/15N ▫ NOOP Dam ▫ Dam 16N ▫ Dam 32N ▫ Dam 33N ▫ MTJV Water Supply Scheme ▪ Receives storage overflows from Dams 13/14/15N. ▪ Supplies to the following locations: ▫ MTW North CHPP & miscellaneous industrial use via Raw Water Tank ▫ NOOP Dam ▫ Slither and 120s TFPs ▪ Transfers to Dam 6S @ 300L/s when > 240ML. ▪ Storage overflows to Doctor's Creek.
204	Dam 4N	▪ Receives pumped transfers from the following locations: ▫ North Pit North ▫ Dam 27N ▫ Honeypot Dam ▫ Dam 30N ▪ Pump transfers to Dam 1N to maintain empty. ▪ Supplies to North Pit TFP. ▪ Storage overflows to Sandy Hollow Creek.
205	Sediment Dam B	▪ Present for Yr 9 onwards. ▪ Storage overflows to Longford Creek.
206	Dam 6N	▪ Present for Yr 0 only. ▪ Clean water catchment. ▪ Receives storage overflows from Dam 6(A)N. ▪ Storage overflows to Longford Creek.
207	Abbey Green South	▪ Tailings storage facility. ▪ Receives pumped transfers from the following locations for Years 0-5: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Pump transfers to the following locations at a nominal rate of 100L/s: ▫ Dam 6S ▫ Capped and rehabilitated from Yr 9 onwards.
208	Abbey Green North	▪ Present for Yr 9 onwards. ▪ Receives pumped transfers from the following locations for Years 9-12: ▫ MTW North CHPP (tailings) ▫ MTW South CHPP (tailings) ▪ Capped and rehabilitated from Yr 14 onwards.

Node No.	Node Name	Operating Rules
211	Dam 11N	▪ Present for Yr 0 only. ▪ Clean water catchment. ▪ Pump transfers to Dam 6S (SOOP Dam) to maintain empty. ▪ Storage overflows to West Pit.
212	Dam 12N	▪ Receives pumped transfers from Dam 31N (CC8). ▪ Supplies to Raw Water Tank as required. ▪ Storage overflows to Doctor's Creek.
215	Dams 13/14/15N	▪ Supplies to Dam 1N as required. ▪ Storage overflows to Dam 1N. ▪ (Dams 13N & 14N not present from Yr 3 onwards)
216	Dam 16N	▪ Present for Yr 0 only. ▪ Receives seepage from Dam 32N (Tailings Dam 1). ▪ Pump transfers to the Dam 1N to maintain empty. ▪ Storage overflows to Doctor's Creek.
217	Dam 17N	▪ Rehabilitated area sediment dam (clean catchment). ▪ Storage overflows to Sandy Hollow Creek.
218	Dam 18N	▪ Storage overflows to Dam 27N.
220	Dam 20N	▪ Clean water catchment. ▪ Storage overflows to Longford Creek.
227	Dam 27N	▪ Receives storage overflows from the following locations: ▫ Dam 18N ▫ Dam 30N ▪ Pump transfers to Dam 4N at a rate of 25L/s to maintain empty. ▪ Storage overflows to Sandy Hollow Creek.
228	NOOP Dam	▪ Present from Yr 3 onwards. ▪ 2-way transfer with Dam 1N. ▪ Storage overflows to Doctors Creek.
230	Dam 30N	▪ Receives storage overflows from Dam 33N (Tailings Dam 2). ▪ Transfers to Dam 4N to maintain empty (50L/s). ▪ Storage overflows to Dam 27N.
231	Dam 31N (CC8) + Dam 21N	▪ Pump transfers to Dam 12N at a rate of 70L/s. ▪ Receives return from MTW North Vehicle Washdown. ▪ Storage overflows to Doctor's Creek,
232	Dam 32N (Tailings Dam 1)	▪ Present for Yr 0 only (rehabilitated from Yr 3 onwards). ▪ Seeps to Dam 16N at a rate of 50kL/d. ▪ Pump transfers to Dams 1N to maintain empty. ▪ Storage overflows to Doctor's Creek.
233	Dam 33N (Tailings Dam 2)	▪ Seeps to North Pit North at a rate of 50kL/d. ▪ Receives moisture in ash from Redbank Power Station at a rate of 68kL/d. ▪ Pump transfers to Dams 1N to maintain empty. ▪ Storage overflows to Dam 30N.
306	Dam 6(A)N	▪ Clean water catchment. ▪ Storage overflows to Dam 6N.
381	Honeypot Dam	▪ Pump transfers to Dam 1N to maintain empty. ▪ Storage overflows to Longford Creek.
Receiving Waters		

Node No.	Node Name	Operating Rules
174	Loders Creek (including Tributary)	▪ Receives controlled HRSTS discharges from Dam 9S. ▪ Receives storage overflows from the following locations: ▫ Sediment Dam A ▫ Dam 1S/2S ▫ Dam 3S ▫ Dam 6S (SOOP Dam) ▫ Dam 9S ▫ Dam 9(A)S ▫ Ramp 22 Dam ▫ Dam 11S ▫ Dam 15S (South CPP) ▫ Coal Loader Dam (52ML Dam)
175	Wollombi Brook	▪ Not linked to MTW water management system.
176	Hunter River	▪ Receives controlled releases from the following locations: ▫ Dam 1N (via Doctors Creek) ▫ Dam 9S (via Loders Creek)
275	Doctor's Creek	▪ Receives controlled HRSTS discharges from Dam 1N. ▪ Receives storage overflows from the following locations: ▫ Dam 1N ▫ Dam 12N ▫ Dam 16N ▫ Dam 31N (CC8) + 21N ▫ Dam 32N ▫ NOOP Dam
276	Longford Creek	▪ Receives storage overflows from the following locations: ▫ Dam 6N/6(A)N ▫ Honeypot Dam ▫ Sediment Dam B ▫ Dam 20N
277	Sandy Hollow Creek	▪ Receives storage overflows from the following locations: ▫ Dam 4N ▫ Dam 17N ▫ Dam 27N

6.5.3 Groundwater Inflows

Groundwater inflows into the proposed operation are not expected to be significant. The groundwater impact assessment (AGE 2014a, AGE 2014b) has predicted total groundwater inflow rates to Warkworth Mine and MTO from two sources: Permian inflows and spoil inflows. The predicted inflows from spoil to the open cut pits include rainfall runoff baseflow and seepage from tailings dams, both of which are already simulated in the surface water balance model. Comparison of the surface water balance estimates and the groundwater model estimates indicate flows are of the same order of magnitude. However, the surface water balance model simulates rainfall runoff baseflow on a daily basis whereas the groundwater model uses annual average rainfall. Therefore the spoil inflow estimates from the surface water balance model are considered more suitable for the purposes of the surface water balance modelling than the spoil inflows from the groundwater model.

The Permian inflows to the open cut pits were reduced to account for evaporation from the pit faces and the entrained moisture losses due to mining. These water losses were estimated as follows:

- Evaporation from the open cut pits was based on pit face lengths estimated from the indicative mine plans and actual coal seam heights (36m at Warkworth, and 21m at Mount Thorley). An evaporation rate of 2.63mm/d was adopted based on a Morton's Lake Average rate of 3.8mm/d, an evapotranspiration factor of 0.99 and a shading factor for deep pits of 0.7.
- The entrained losses due to mining were calculated from production schedule and an assumption that the raw feed to the CHPP has a moisture content of 5 per cent.

At Warkworth Mine, the losses from coal moisture entrainment and evaporation resulted in a predicted nil 'pumpable' Permian groundwater inflows for the life of the project. This is consistent with the existing operation, which has very little groundwater inflow. At MTO, groundwater inflows occur for Years 1 to 5. After Year 6, inflows are nil as mining has finished and Loders Pit has been filled in.

The groundwater inflow rates were averaged over the years covered by each mine state, as detailed in Table 6.4.

Table 6.4 Adopted Groundwater Inflows (ML/a)

Year	Warkworth	Mount Thorley
Year 0 (2 years)	0	186
Year 3 (4 years)	0	10
Year 9 (7 years)	0	0
Year 14 (5 years)	0	0
Year 21 (4 years)	0	0
Total	**0**	**413 ML**

An uncertainty analysis of the groundwater model inputs was undertaken (AGE, 2014) to put potential error bars around predictive results. The predictive groundwater model simulation for the uncertainty analysis showed 95th percentile worst case inflows resulted in an increase of 'pumpable' Permian groundwater inflows by 157ML/a in Year 15. This equates to approximately 2.6% of the total inflows to MTW (refer Table 6.13), and is therefore not expected to greatly impact on the performance of the MTW water management system. It is likely that the only significant impact of increased groundwater inflows of this magnitude on the site water balance would be to reduce the external water requirement by an equal amount.

6.5.4 Catchments and Land Use Classifications

The changes in the physical layout are represented in the indicative mine plans given in Figure 6.4 to Figure 6.11 for Years 3, 9, 14 and 21 respectively. Catchment areas (separated by the different land use types) reporting to the mine site storages are provided in Appendix B.

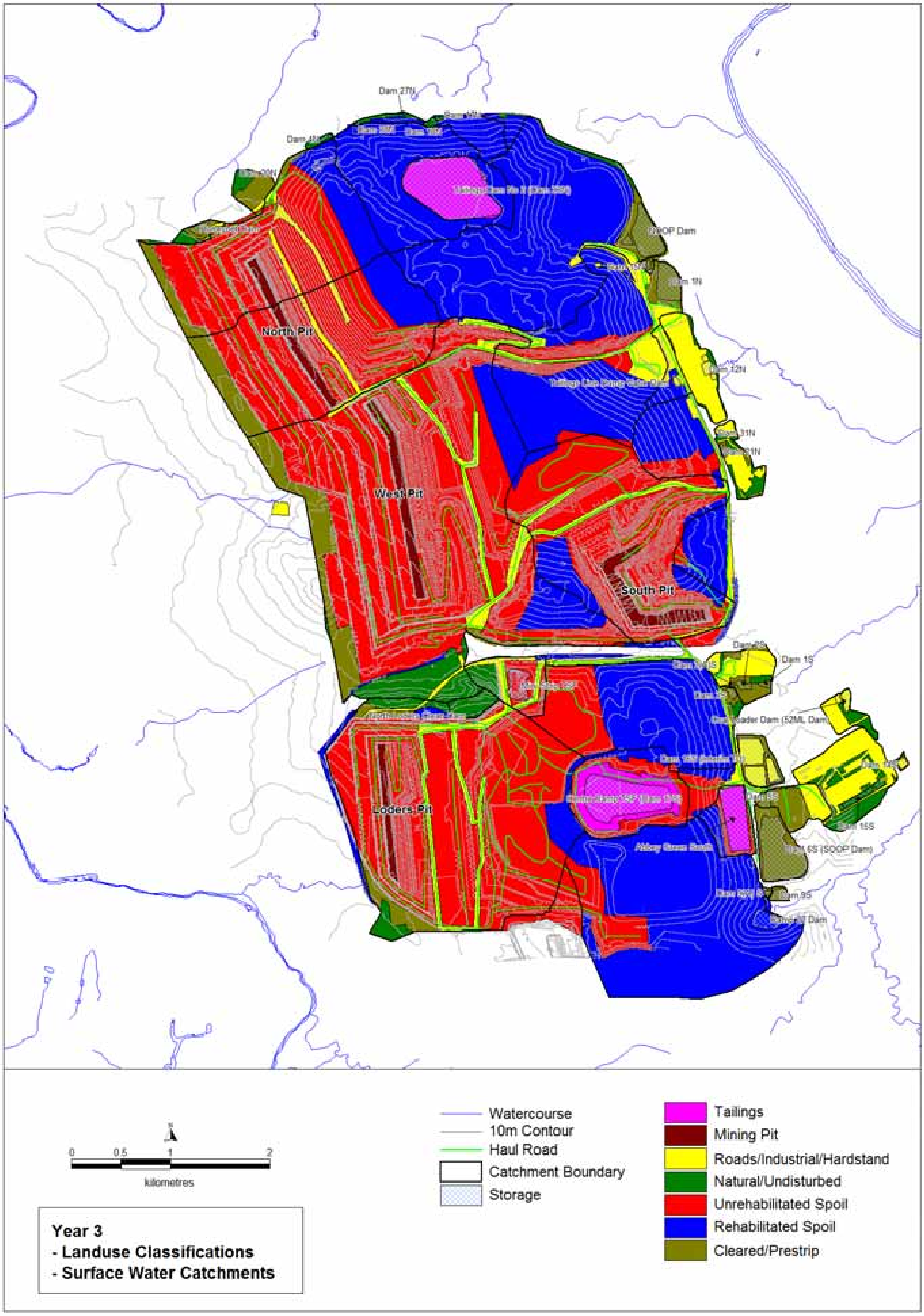

Figure 6.4 MTW Surface Catchments & Land Use Classifications – Year 3

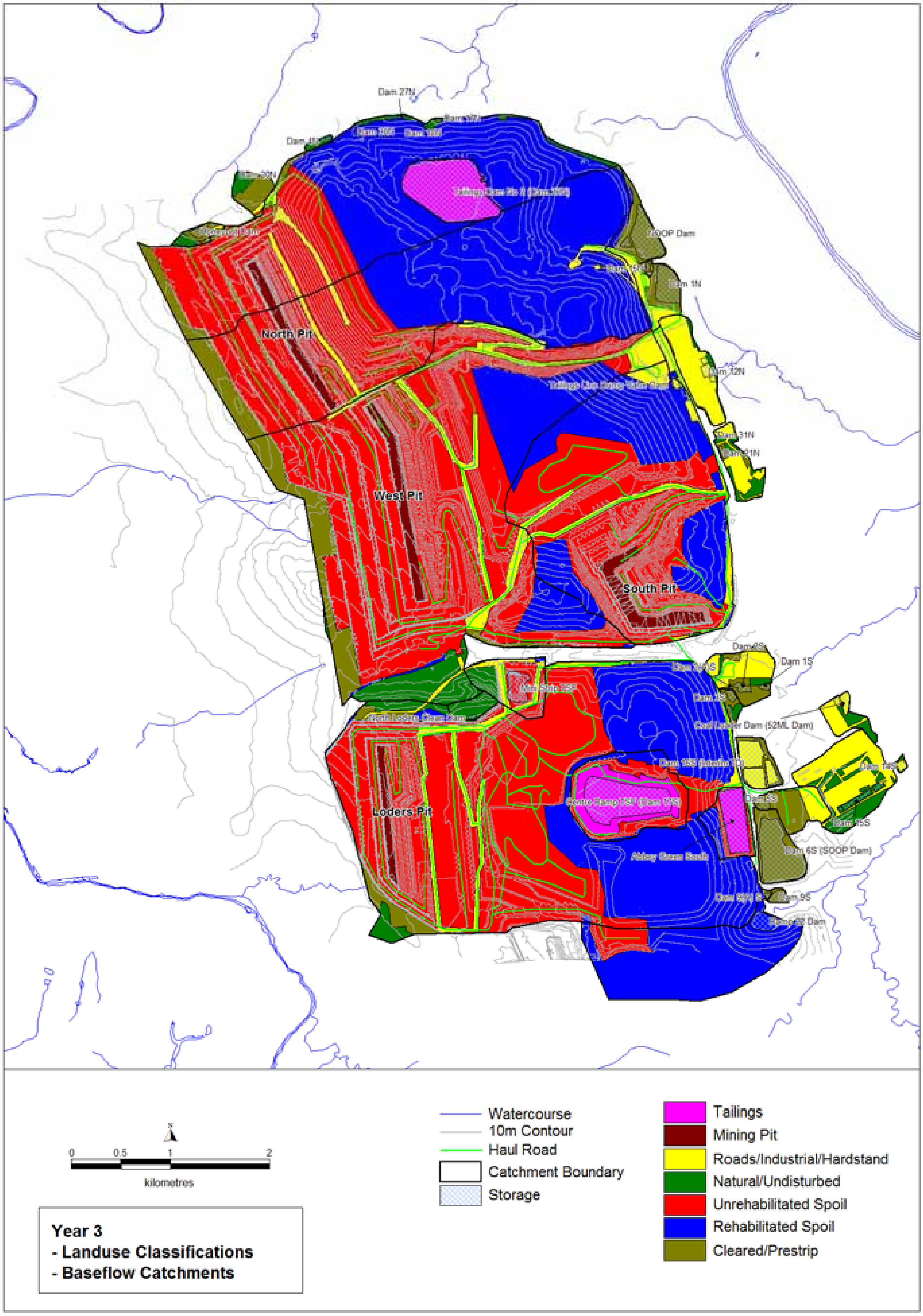

Figure 6.5 MTW Baseflow Catchments & Land Use Classifications – Year 3

wrm water + environment

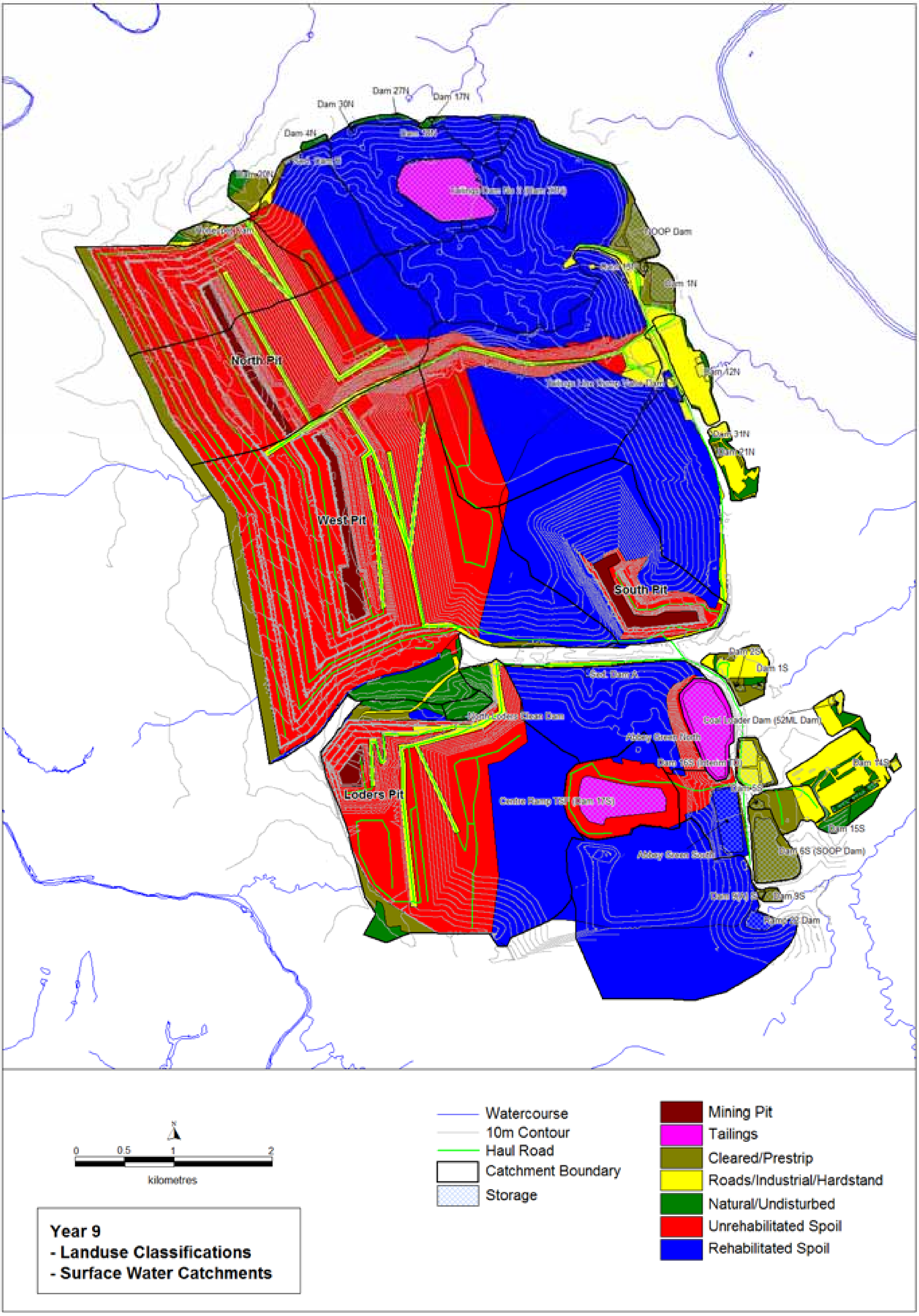

Figure 6.6 MTW Surface Catchments & Land Use Classifications – Year 9

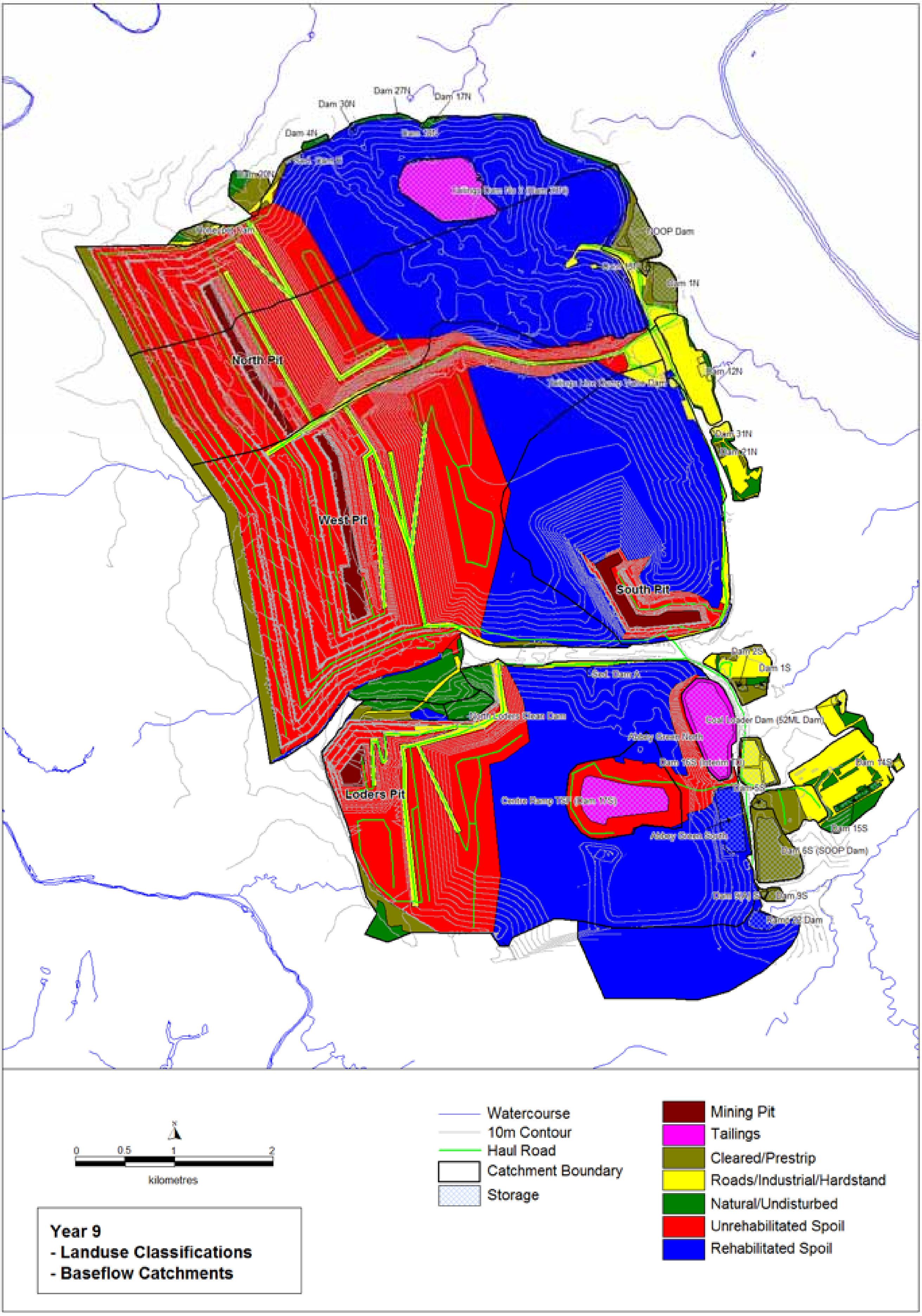

Figure 6.7 MTW Baseflow Catchments & Land Use Classifications – Year 9

wrm water + environment

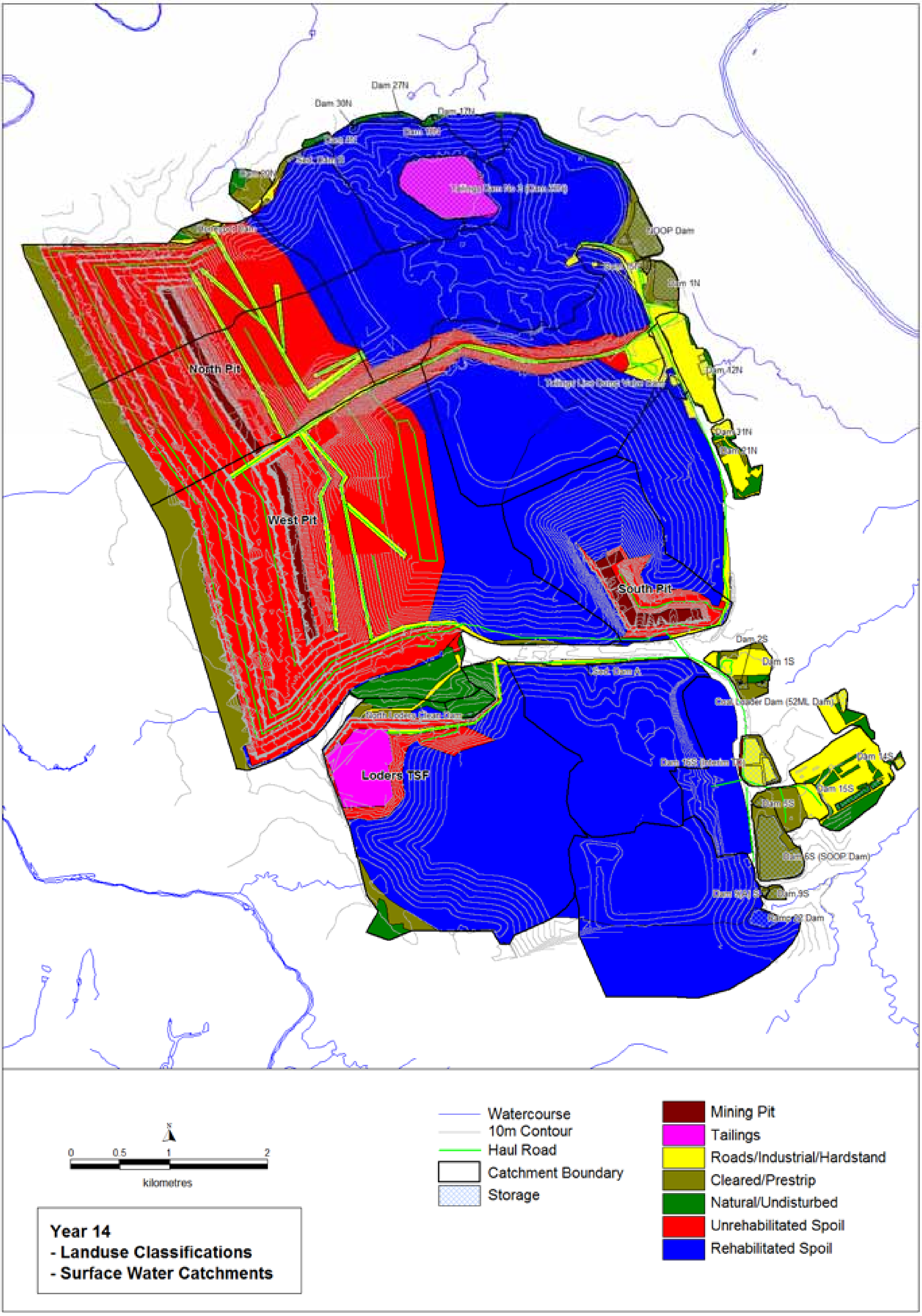

Figure 6.8 MTW Surface Catchments & Land Use Classifications – Year 14

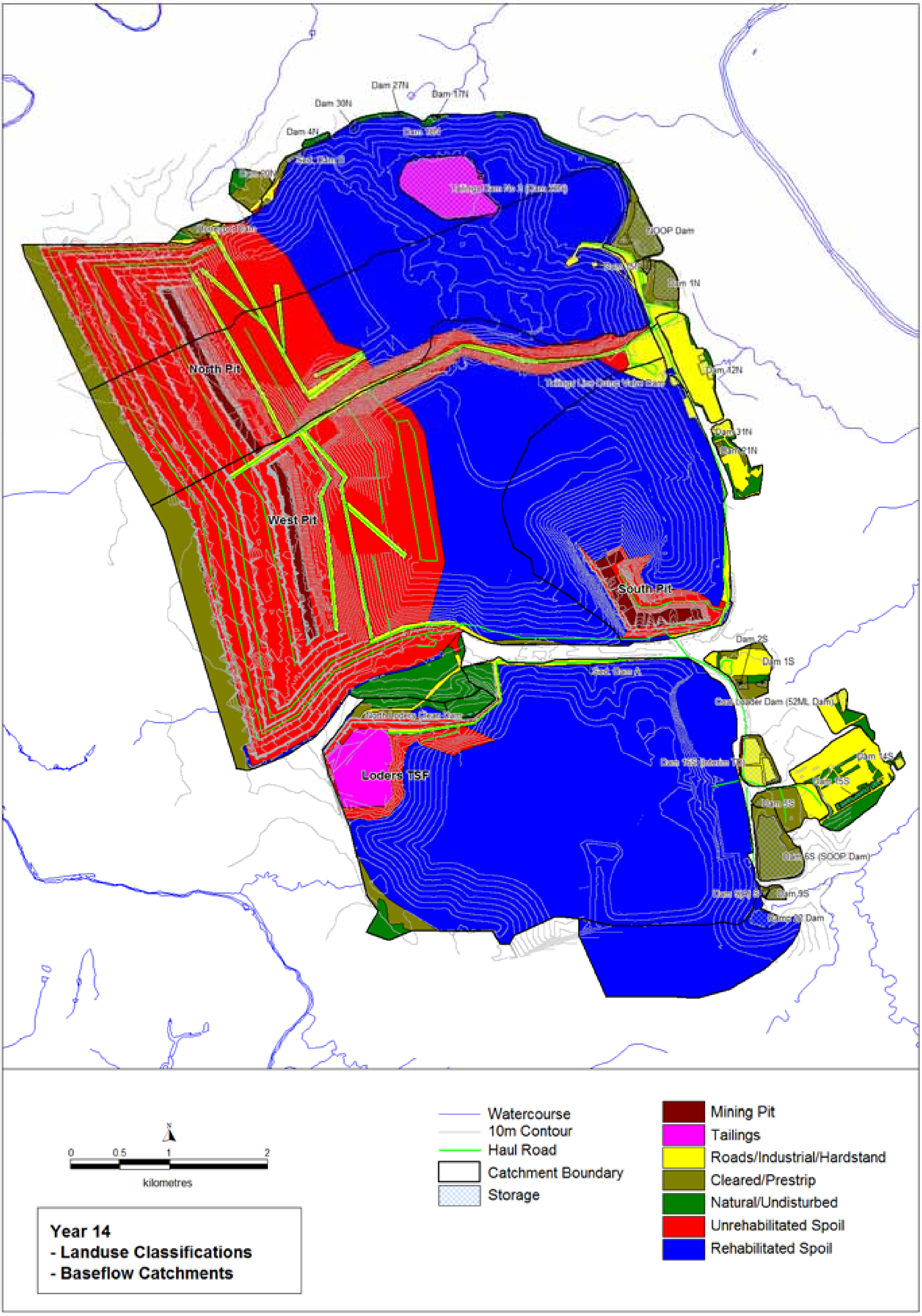

Figure 6.9 MTW Baseflow Catchments & Land Use Classifications – Year 14

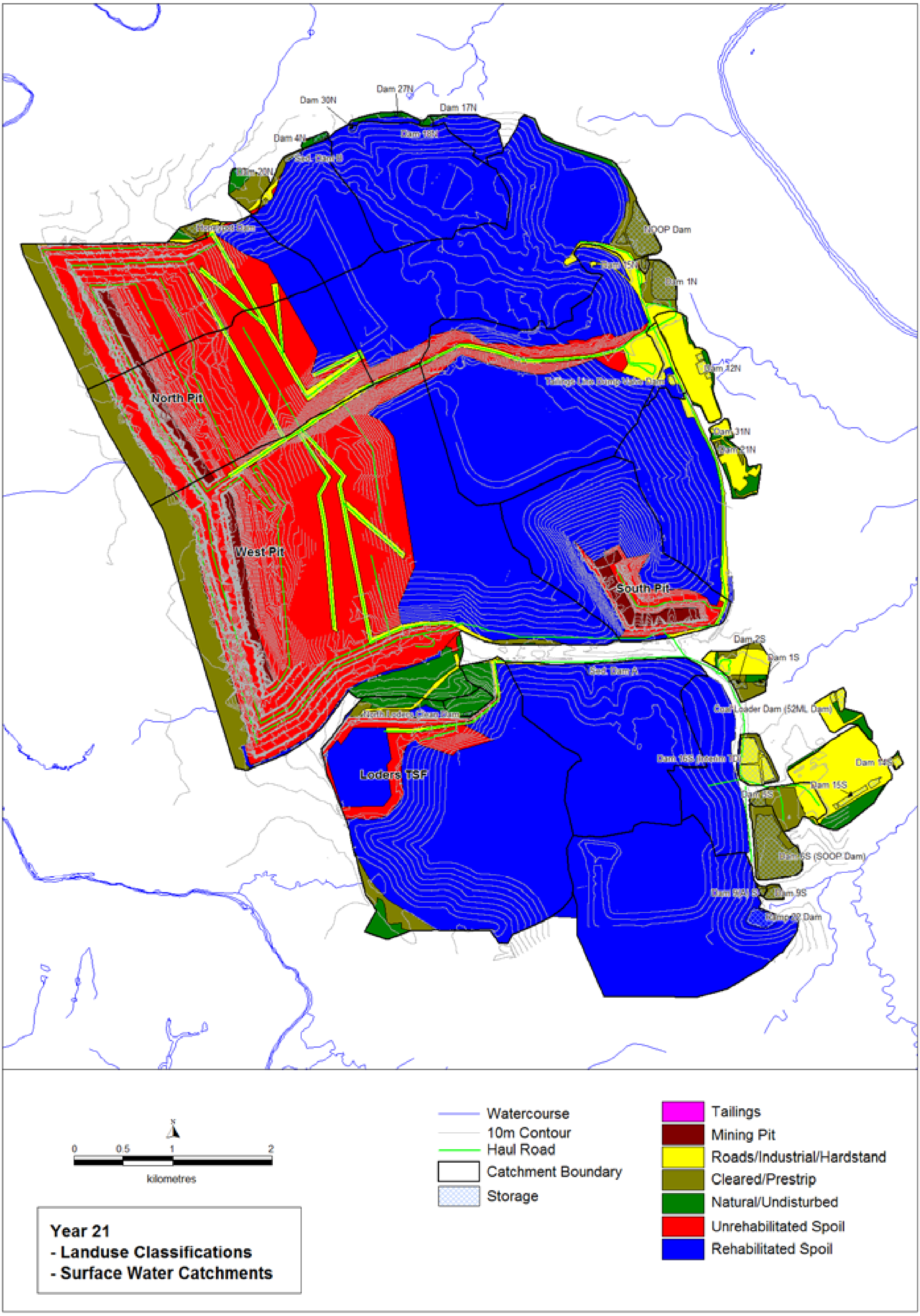

Figure 6.10 MTW Surface Catchments & Land Use Classifications – Year 21

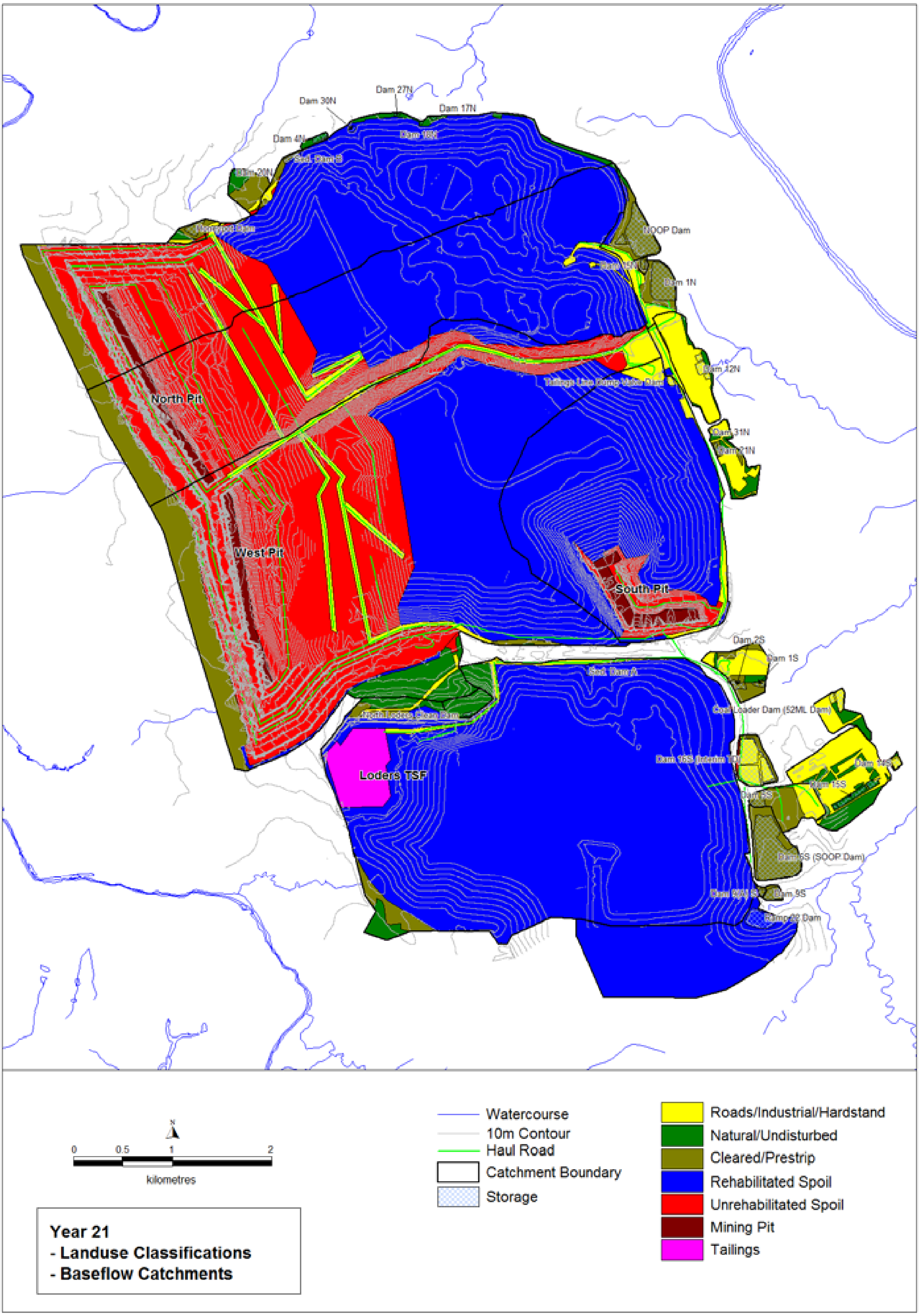

Figure 6.11 MTW Baseflow Catchments & Land Use Classifications – Year 21

6.5.5 Water Quality

An estimate of salinity generation rates for each land use type and water source (raw water, groundwater) has been made based on the MTW water quality monitoring program (refer Section 2.6.2). It is proposed to adopt the salinity generation rates shown in Table 6.5.

Table 6.5 MTW Salinity Generation Rates

Land Use Classification / Salt Source	Salinity Generation Rate (µS/cm)	Basis
Natural/Undisturbed	300	Wollombi Brook, Dam 11N
Cleared/Prestrip	1,500	Dam 12S, Dam 6N
Mining Pit	15,000	Assumed same as groundwater salinity
Unrehabilitated Spoil	4,000	Dam 1N, Dam 6S
Rehabilitated Spoil	600	Dam 30N
Roads/Industrial/Hardstand	3,000	Dam 15S
Tailings	10,000	Dam 1N, Dam 6S
MTJV Raw Water Supply	650	Hunter River
Groundwater	15,000*a	(AGE, 2014a)

Notes: *a Average water quality of alluvial aquifers in Mount Thorley area, samples taken from 1993 to 2013 indicates an EC of between 931 to 27,800µS/cm.

6.5.6 Water Demands

CHPP

The MTW coal preparation facilities consist of two plants:

- Warkworth Mine CPP (North Plant); and
- MTO CPP (South Plant).

MTW has provided forecast total washed and unwashed coal throughputs and production rates. Based on the provided production schedule and the 2013 plant characteristics (WRM, 2014), plant moisture balances for each of the North CHPP and South CHPP have been determined and are shown in Table 6.6 to Table 6.9.

Note that 0.5 Mtpa of coal bypass will be produced for the life of the proposal. It is assumed that the bypass coal has negligible water requirements and therefore does not impact the site water balance.

Table 6.6 Warkworth Mine CPP (North Plant) – Year 0

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.22	25,254	5.5	23,865	1,389
Product Coal	6.59	18,056	8.8	16,467	1,589
Tailings	4.79	13,133	83.1	2,219	10,913
Coarse Rejects	2.22	6,029	14.1	5,179	850
				Process Plant Makeup Requirement	**11,963**
				Plant yield (wet)	71.5 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30 %
				Water use (L/ROM tonne (wet))	474

Table 6.7 Warkworth Mine CPP (North Plant) – Year 3 to Year 21

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.52	26,093	5.5	24,568	1,435
Product Coal	6.81	18,655	8.8	17,014	1,642
Tailings	4.95	13,569	83.1	2,293	11,276
Coarse Rejects	2.27	6,229	14.1	5,351	878
				Process Plant Makeup Requirement	**12,361**
				Plant yield (wet)	71.5 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	474

Table 6.8 MTO CPP (South Plant) – Year 0

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	7.92	21,688	4.8	20,647	1,041
Product Coal	5.63	15,418	7.6	14,246	1,172
Tailings	2.62	7,165	73.2	1,920	5,245
Coarse Rejects	1.90	5,198	13.8	4,480	717
				Process Plant Makeup Requirement	**6,093**
				Plant yield (wet)	71.1 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	281

Table 6.9 MTO CPP (South Plant) – Year 3 to Year 21

Item	Mtpa (wet)	t/day (wet)	Total Moisture (%)	Dry Solids (t/day)	Moisture (kL/d)
Raw Feed	9.45	25,901	4.8	24,658	1,243
Product Coal	6.72	18,413	7.6	17,014	1,399
Tailings	3.12	8,557	73.2	2,293	6,263
Coarse Rejects	2.27	6,207	13.8	5,351	857
				Process Plant Makeup Requirement	**7,276**
				Plant yield (wet)	71.1 %
				Plant yield (dry)	69.0 %
				Fine/coarse split (dry)	30.0 %
				Water use (L/ROM tonne (wet))	281

Haul Road Dust Suppression

A dry day haul road watering rate of 3.5mm/d was determined based on the average recorded rate over the 2013 period (WRM, 2014). This rate has been adopted and applied to the varying watered haul road length as the mine develops, with an assumed watered width of 20m. The resultant average dust suppression water requirements are presented in Table 6.10. Estimates of haul road lengths were based on indicative mine plan information as presented in Figure 6.4 to Figure 6.11.

Table 6.10 Estimated Haul Road Dust Suppression Requirements

Mining Stage	Dust Suppression Area (ha)	Maximum Daily Dust Suppression (kL/d)*	Yearly Average Dust Suppression (ML/a)**
Year 0	199	6,962	1,623
Year 3	185	6,478	1,510
Year 9	174	6,106	1,423
Year 14	140	4,910	1,144
Year 21	136	4,770	1,107

* For a non-rainfall (<0.1 mm) day.
** Based on long term average including rainfall days.

Miscellaneous Industrial Demand and Vehicle Washdown

The miscellaneous industrial use and the vehicle washdown are sourced directly from the MTJV raw water pipeline. Usage is metered; however the breakdown of industrial use and vehicle washdown is not available at Warkworth Mine. The MTW 2013 water balance update (WRM, 2014) estimated the usages and return rates at the north and south workshops and vehicle washdown locations.

The average rates over 2012/13 were estimated as follows:

- South vehicle washdown 53kL/d (8kL/d return, 45kL/d loss)
- South workshop misc. industrial use 151kL/d (100 per cent loss)

- North vehicle washdown 53kL/d (8kL/d return, 45kL/d loss)
- North workshop misc. industrial use 59kL/d (100 per cent loss)

These usages have been assumed to vary based on plant throughput. A return rate of 15 per cent has been adopted for vehicle washdown.

Demand Summary

Table 6.11 shows a summary of demands over the life of the proposal.

Table 6.11 Summary of Demands (ML/a)

Demand	2014	2017	2023	2028	2035
CHPP gross (net)*a	6,591 (2,466)	7,168 (2,731)	7,168 (2,731)	7,168 (2,731)	7,168 (2,731)
Haul Road Dust Suppression*b	1,623	1,510	1,423	1,144	1,107
Misc. Industrial Use & Vehicle Washdown – gross (net)*a	135 (126)	146 (136)	146 (136)	146 (136)	146 (136)
Total – gross (net)*a	**8,349 (4,215)**	**8,824 (4,377)**	**8,737 (4,290)**	**8,458 (4,011)**	**8,421 (3,974)**

*a Net rates include return.
*b Long term average (dependant on rainfall). Based on haul road lengths of 92.6km, 87.2km, 70.1km and 68.1km for 2017, 2023, 2028 and 2035 year indicative mine plans respectively.

6.5.7 Proposed Sediment Dams

Conceptual sediment dam locations have been proposed based on the indicative mine plans and are shown in Figure 6.4 to Figure 6.11. The locations and sizes of the sediment dams are conceptual for inclusion in the water balance modelling and will be refined and confirmed through detailed design and incorporated into the MTW Water Management Plan (WMP).

Sizing of the proposed sediment basins has been undertaken in accordance with the Blue Book (DECC, 2008) requirements for Type D basins. Adopted sediment dam sizes are shown in Table 6.12. Note that the pump rates shown in Table 6.12 are based on a 5 day management period. To reduce these required pumping rates, the guidelines specify adjustment factors to the 5-day volumes for alternate management periods as 85 per cent for 2 days, 125 per cent for 10 days, and 170 per cent for 20 days.

A summary of the assumptions and parameters adopted for the concept sizing of the sediment basins is as follows:

- The catchment areas used to size each sediment dam are the maximum area draining to a dam at any time during the mine life;
- Type D basin (for dispersive soils);
- Design rainfall: duration of disturbance >3 years, 90th percentile, 5 day rainfall depth (for standard receiving waters) = 42.8mm;
- Volumetric runoff coefficient C_v = 0.69;
- Sediment storage zone = 50 per cent of settling zone; and
- Maximum 5m storage depth.

Table 6.12 Proposed Sediment Dam Sizing

Sediment Dam	Catchment Area (ha)*	5-Day Volume (ML)	5-Day Pump Out Rate (L/s)
Sediment Dam A	238	105	244
Sediment Dam B	102	45	105

Notes: * Maximum catchment area reporting to sediment dam over project life.

6.5.8 Hunter River Salinity Trading Scheme

To model future HRSTS discharges from MTW, a Hunter River streamflow and water quality time series was obtained from NOW's IQQM model (full development case with 2004 water sharing plan rules) for the period 16/09/1892 to 30/6/2007. The modelling rules for HRSTS discharges are based on Hunter River stream flow and salinity, and discharge dam volumes and salinity (refer Appendix C).

It is assumed that the number of salt credits held by MTW is not a limitation to releases. Historically there have been sufficient credits available for trade.

The proposal includes an upgrade to the approved discharge point at MTO (Dam 9S) to increase the maximum discharge rate to 300ML/d. The maximum discharge rate at Warkworth Mine (Dam 1N) will remain at 100ML/d.

Controlled releases to the Hunter River under HRSTS are allowed at MTO when the combined inventory of Dam 6S + Dam 9S is greater than 1,500ML, and at Warkworth Mine when the inventory of Dam 1N is greater than 220ML. This ensures that water is not being released at times when the on-site inventory is low and water retention is a key objective.

6.6 WATER MANAGEMENT SYSTEM PERFORMANCE ASSESSMENT

6.6.1 Overview

Key surface water issues for the proposal include:

- Potential for uncontrolled spills from the saline water dams;
- Potential to impact on production due to in-pit water accumulation; and
- Potential for inadequate supplementary water supply from external sources to meet mine-site demands for production and dust suppression.

An assessment of the impacts of the proposal's mine water management system has been undertaken using the water balance model, against the following key performance indicators:

- Mine water inventory: the risk of accumulation (or reduction) of the overall mine water inventory at the proposal, and the associated volumes;
- External water requirements: the risk of requiring imported external water to supplement on-site mine water supplied and the reliability of water supply;
- Uncontrolled spillway discharges: the risk of uncontrolled discharges from the site storages to receiving waters; and
- Overall site water balance.

6.6.2 Interpretation of Results

Water balance results have been analysed in two ways:

- By mine stage – the results for each climatic realisation are averages over the duration of each mine stage (results presented in Section 6.6.3); and
- Annual statistical results – a statistical analysis is performed on an annual basis as a percentile (results presented in Sections 6.6.4 to 6.6.8).

The modelling methodology of a forecast simulation is described in Section 6.2. In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 21 years of mine life, based on 93 realisations with different climatic sequences. The 50th percentile probability represents the median results, the 10th percentile represent 10 per cent exceedance and the 90th percentile results represent 90 per cent exceedance. There is an 80 per cent chance that the result will fall within the 10th and 90th percentiles and a 98 per cent chance the result will fall between the 1st and 99th percentiles. Importantly, note that a percentile trace shows the percentile chance of a particular value on each day, and ***does not*** represent continuous results from a single model realisation e.g. the 50th percentile trace does not represent the model time series for median climatic conditions.

6.6.3 Overall Site Water Balance

A water balance for one of the 93 modelled realisations is presented in Table 6.13, averaged over each stage of modelled mine life. The results are presented in Table 6.13 to allow a direct comparison of inflows, outflows and overall water balance between each of the mine stages for the average of all climate realisations for each mine stage. It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Haul road dust suppression;
- Evaporation;
- External water requirement;
- Controlled releases; and
- Site releases/spills.

The results for the mine stage averages over all climatic realisations show that over the life of the proposal:

- External raw water supply is required in every stage of mine life, with the greatest amount required in Year 21;
- The largest demand from the water management system is due to the CHPP (includes fine tailings moisture retention, product coal and rejects moisture);
- Total mine water demand (including CHPP makeup, dust suppression and miscellaneous industrial use and vehicle washdown) ranges between approximately 4,000ML/a to 4,400ML/a, with the highest demand in Year 3;
- No overflows from the saline water storages occurred in the simulation period; and
- The combined spill volumes from the sediment dams is highest in Year 14 (316ML/a), which corresponds to the stage with the highest rainfall yield, and ranges between 91ML/a and 316ML/a for the remaining stages.

Table 6.13 MTW Average Water Balance for Each Mine Stage over all Climatic Realisations

Process	Volume (ML/a)				
	Year 0 (2 years)	Year 3 (4 years)	Year 9 (7 years)	Year 14 (5 years)	Year 21 (4 years)
INFLOWS					
Rainfall Runoff	3,524	3,846	4,111	4,210	4,278
Groundwater	186	10	0	0	0
External Raw Water Requirements	1,251	1,807	1,720	1,519	1,803
ROM moisture	877	978	978	978	978
Redbank Power Station	25	25	25	25	25
Total Inflows	**5,873**	**6,665**	**6,833**	**7,016**	**7,084**
OUTFLOWS					
Evaporation	495	656	751	607	817
Fine tailings moisture retention	1,774	1,965	1,965	1,965	1,965
Haul road dust suppression	1,644	1,533	1,471	1,195	1,171
Misc. ind. demand & vehicle wash	126	136	136	136	136
Product coal moisture	1,008	1,110	1,110	1,110	1,110
Coarse rejects moisture	572	633	633	633	633
HRSTS Discharges	561	453	548	369	366
Offsite Sediment Dam Releases	91	214	240	316	315
Offsite Saline Dam Releases	0	0	0	0	0
Total Outflows	**6,253**	**6,679**	**6,803**	**6,274**	**6,450**
Change in Site Water Inventory	***-380***	***-14***	***+30***	***+742***	***+634***

6.6.4 Pit Storage Characteristics

An assessment of pit inventory characteristics has been undertaken to determine the likelihood of water inundating the pit, which could impact production. A forecast assessment has been used.

Figure 6.12 shows the predicted probability of the modelled total in-pit storage volume. A build-up of water in the active pits generally occurs when the out-of-pit storages are too full to accept additional pit water, or the catchment runoff draining to the pit is greater than the dewatering pump capacity.

Figure 6.13, Figure 6.14, Figure 6.15 and Figure 6.16 show the predicted probability of the modelled in-pit storage volume as a percentage of days for North Pit, West Pit, South Pit and Loders Pit, respectively. The assessment of in-pit inventory shows that:

- There is a one per cent chance of total in-pit volume up to 1,900ML at any year of project life;
- There is a 10 per cent chance of total in-pit volume up to 400ML at any year of project life;
- All individual pits are considered to have a low probability of pit inundation, and are likely to accumulate volumes of up to 900ML only in extreme climate conditions.

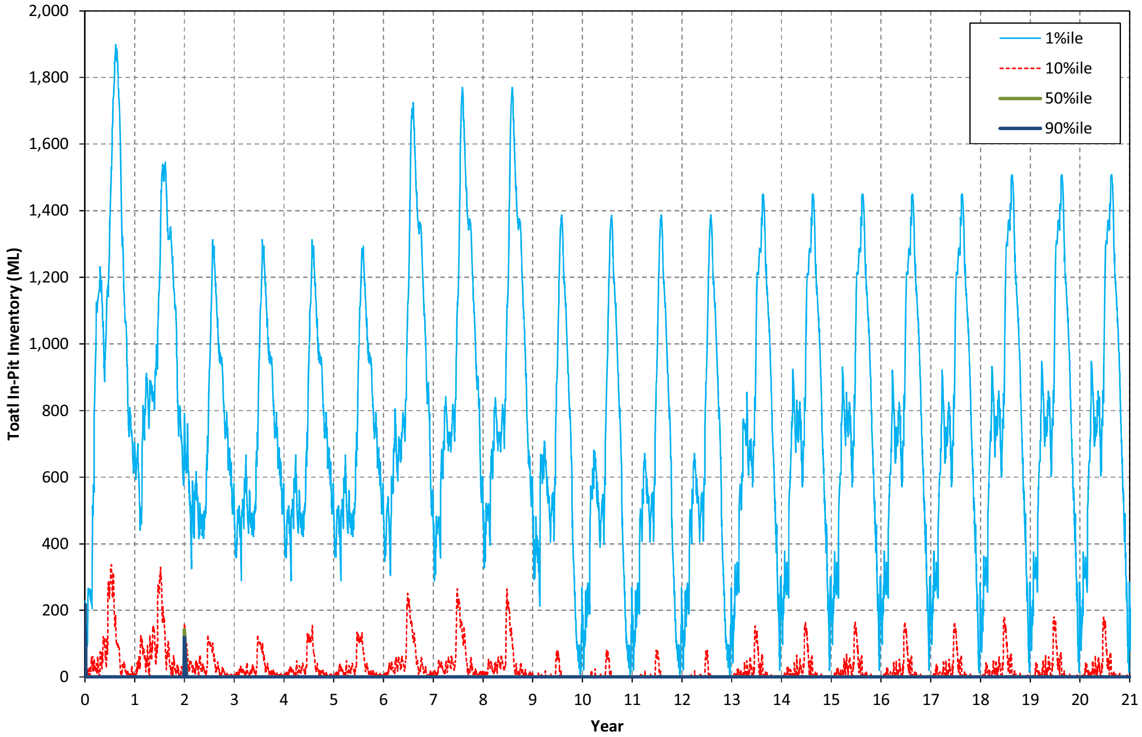

Figure 6.12 Total In-Pit Storage Inventory (ML)

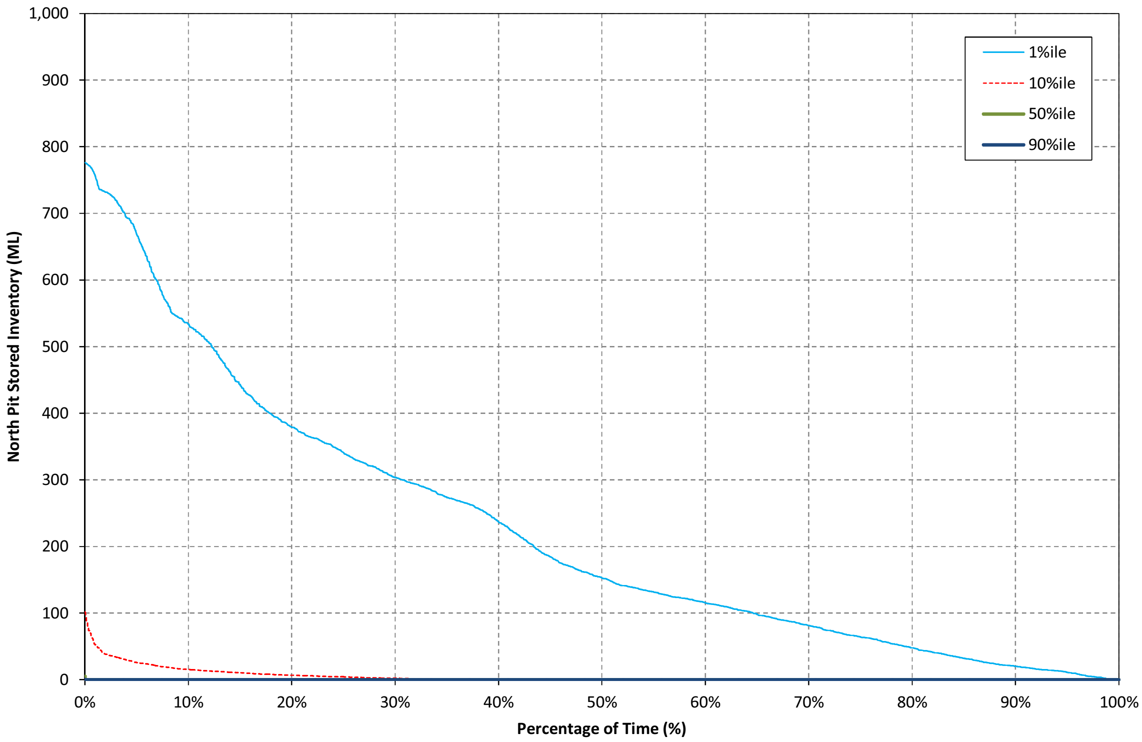

Figure 6.13 North Pit Inundation Characteristics

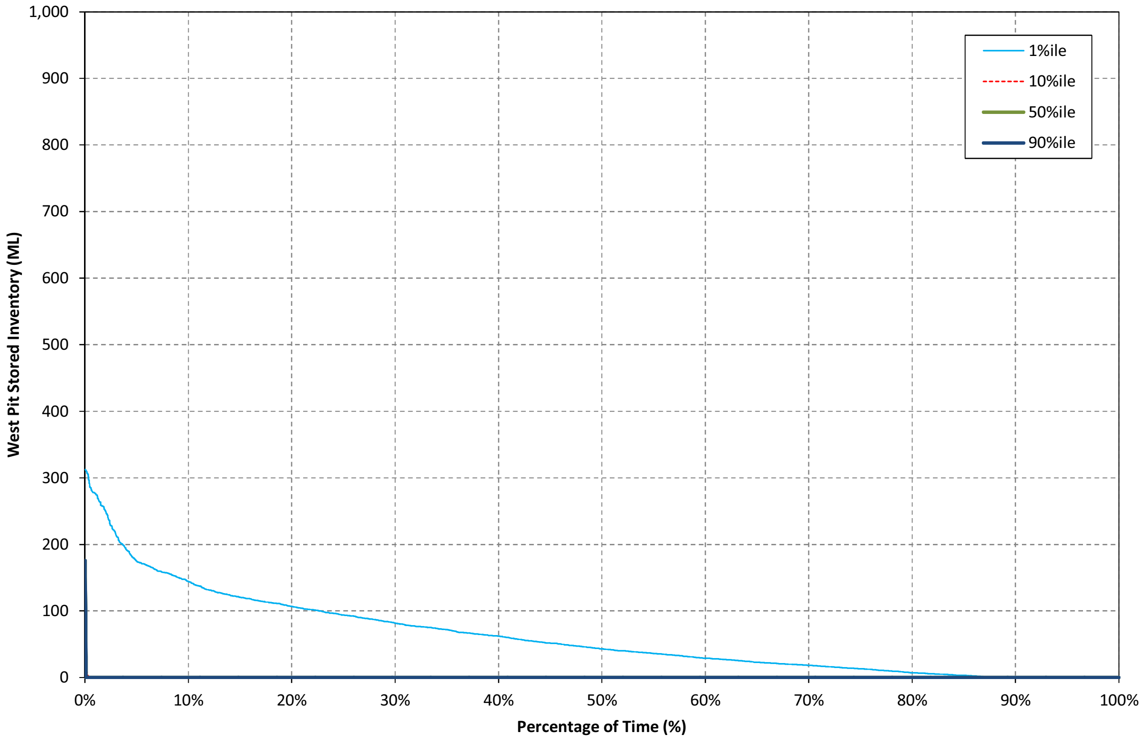

Figure 6.14 West Pit Inundation Characteristics

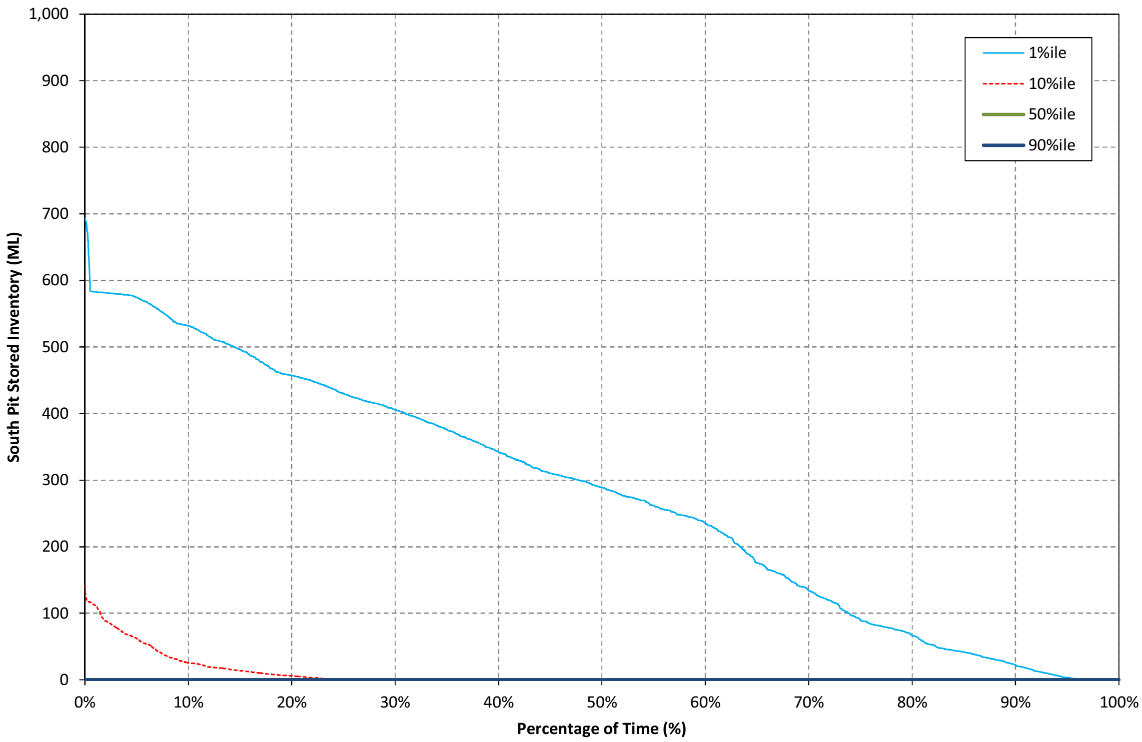

Figure 6.15 South Pit Inundation Characteristics

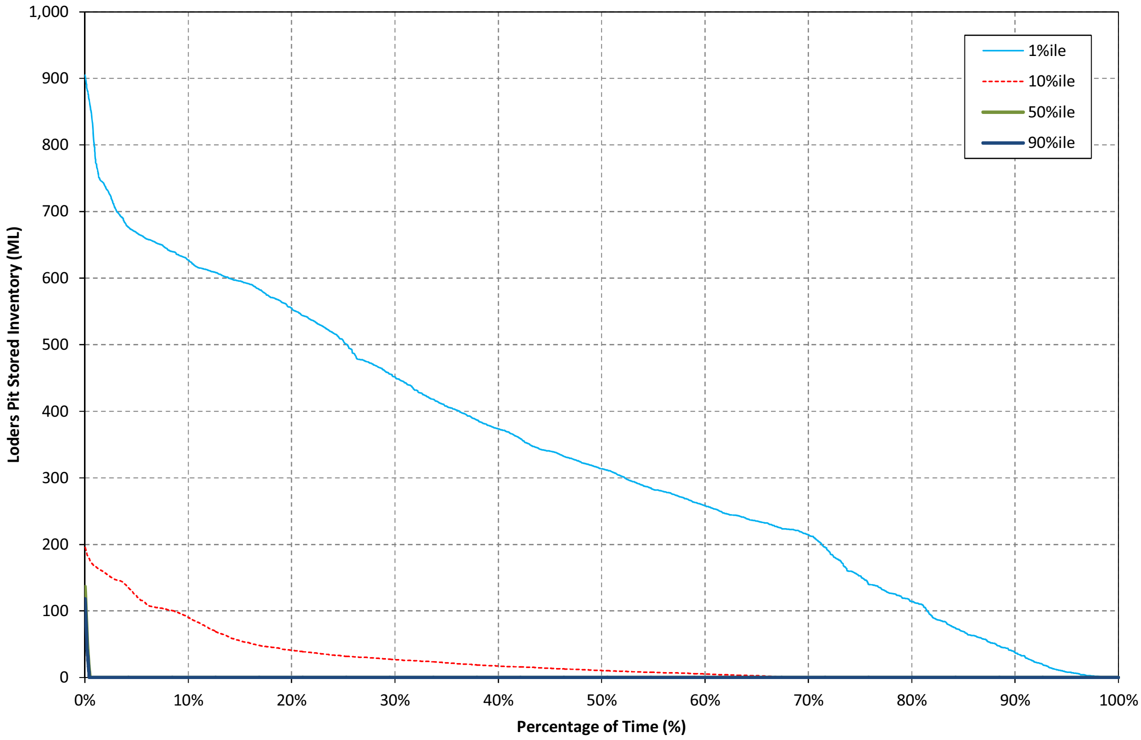

Figure 6.16 Loders Pit Inundation Characteristics

6.6.5 Out-of-Pit Storage Characteristics

A forecast assessment has been undertaken to estimate the future out-of-pit water inventory. The out-of-pit water storages included in the analysis are the four main saline water storage dams on site (existing and proposed):

- Dam 6S (SOOP Dam);
- Dam 9S;
- Dam 1N; and
- NOOP Dam (proposed).

Figure 6.17 shows the predicted probability of the modelled total out-of-pit storage inventory. The combined capacity (to spillway) of the four primary saline water storages is 2,621ML (prior to construction of NOOP Dam), and 3,363ML including the NOOP Dam capacity. The results show that:

- Consistent with the in-pit inventory results, the water management system is not at risk of accumulating water over the life of the project and is able to recover prior to each subsequent wet season;
- The total out-of-pit inventory:
  - Has a one per cent chance of reaching at least 2,000ML in Years 0 to 2, and at least 2,500ML in any year after that;
  - Has a 10 per cent chance of reaching between 1,500ML to 2,500ML in any year;

– Has a 50 per cent chance of reaching an inventory of at least 300ML in any year;

– Has a 90 per cent chance of reaching an inventory of at least 0ML to 100ML in any year (equivalent to a 10 per cent chance of not exceeding approximately 0ML to 100ML in any year).

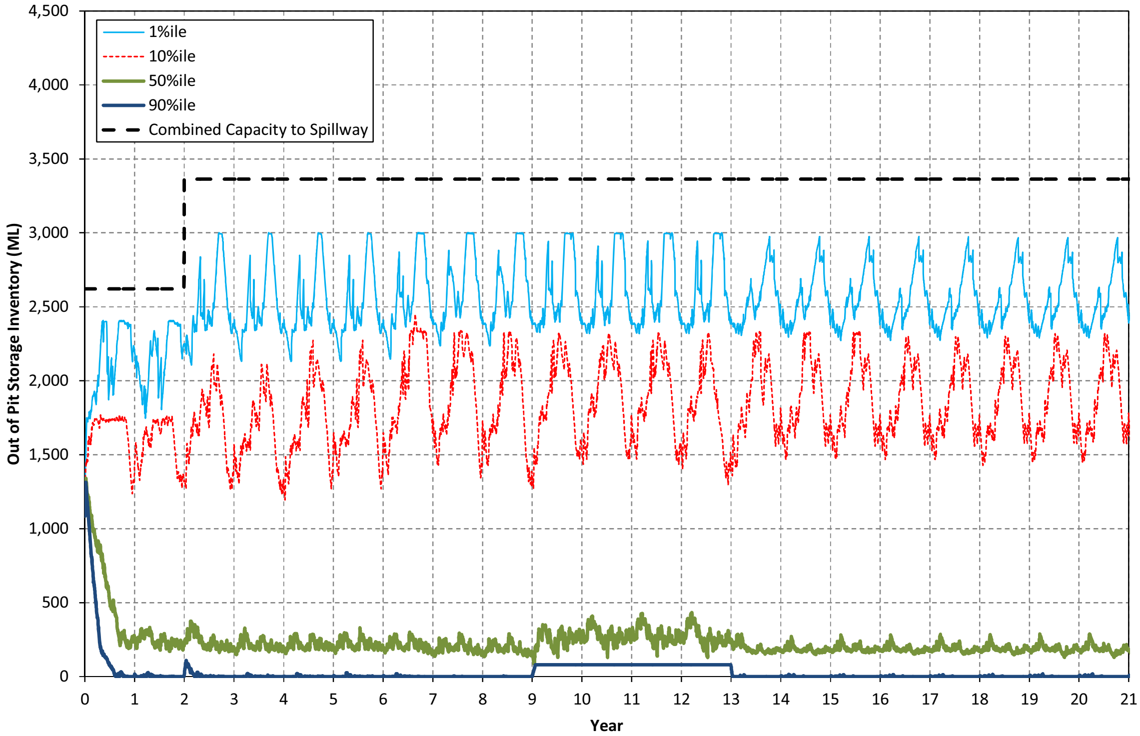

Figure 6.17 Out-of-Pit Water Inventory

6.6.6 Controlled HRSTS Discharges to Hunter River

The potential for controlled releases under the proposal has been assessed using a forecast assessment simulation. The predicted probability of the annual controlled discharges from MTO and Warkworth Mine are provided in Figure 6.18 and Figure 6.19 respectively. The results show that:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharge structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance of controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes of controlled discharges (100ML) will be required from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance of controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

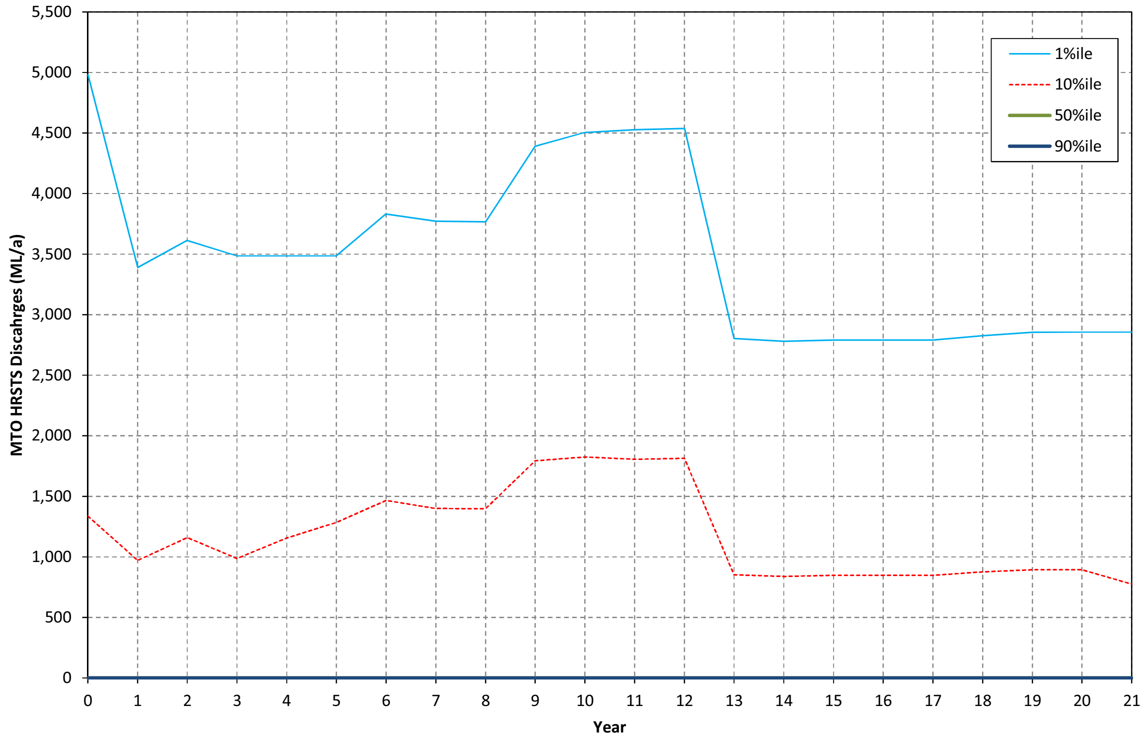

Figure 6.18 MTO Discharges to Hunter River

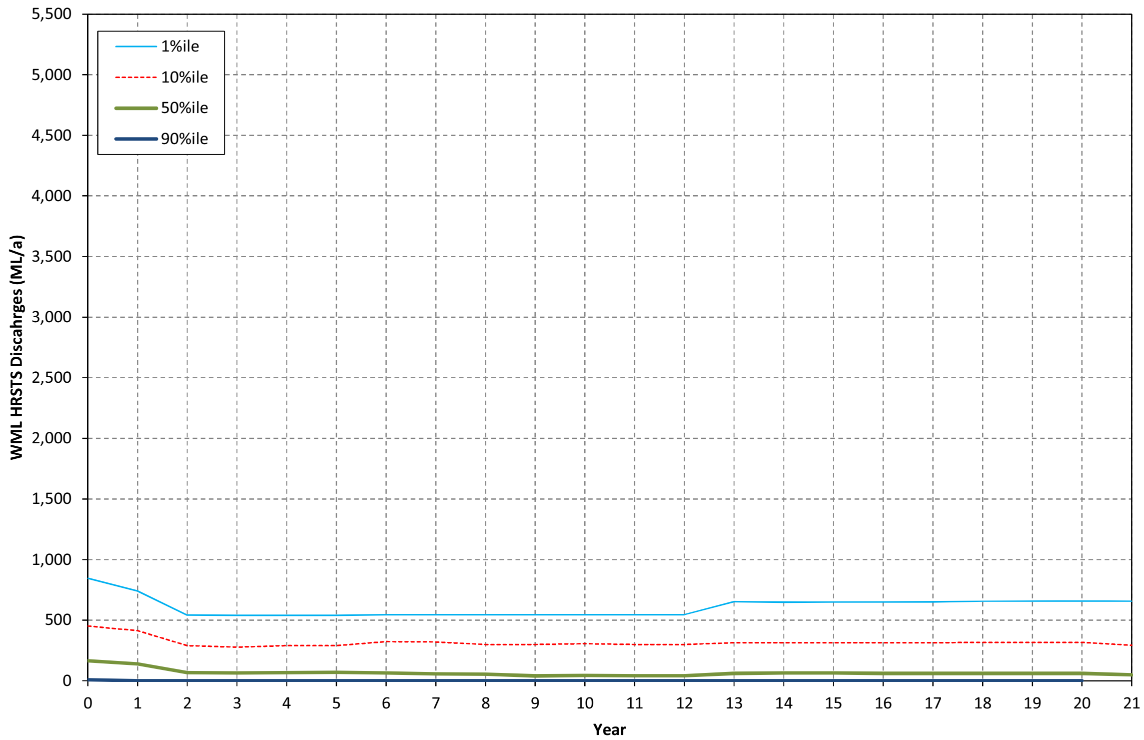

Figure 6.19 Warkworth Mine Discharges to Hunter River

6.6.7 External Water Requirements

For the purposes of current investigations, the term 'external water requirements' represents the amount of imported water from external third party sources, such as the Hunter River (or other sources such as water sharing agreements with nearby mine sites) that is required to sustain the nominated design production rate and associated operational demands for the proposal. The simulation of the water management system assumes that any shortfall in water captured onsite is made up from imported water – that is, during dry periods imported water is used to ensure that all operational demands are met. Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

This potential requirement for external water supply has been assessed using a forecast assessment simulation. The predicted probability of annual external water requirement is provided in Figure 6.20. The results show that:

- A minimum of 140ML/a of external raw water (from the Hunter River) will be required for the life of the proposal. This is consistent with site demands of industrial use and vehicle wash of around 140ML/a which are supplied from raw water sources only;
- There is a 90 per cent chance that at least 450ML of external water will be required in any year of project life.
- A step change in external water requirement occurs in around Year 2 which is consistent with the modelled decrease in groundwater inflows at MTO, and an increase in production. From Year 3 onwards the external water requirements are generally consistent with:
  - A 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
  - A 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

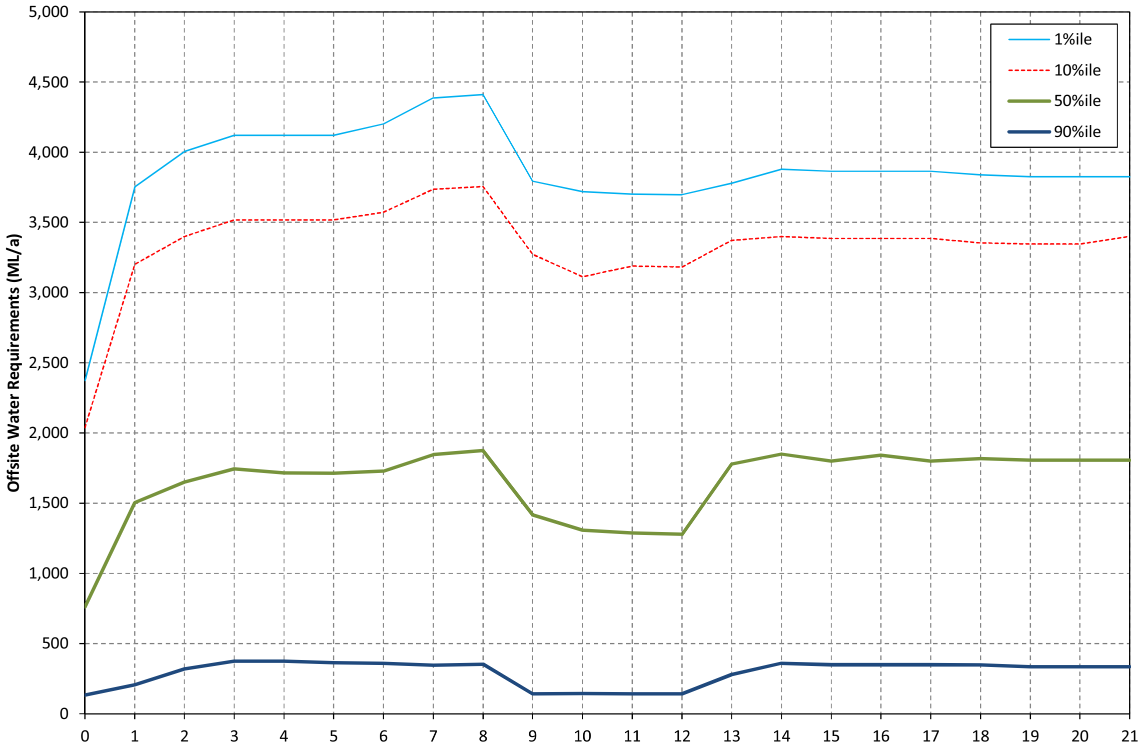

Figure 6.20 MTW External Water Requirements

6.6.8 <u>Uncontrolled Offsite Discharges</u>

Expected discharges from the proposal have been assessed on the basis of simulated spillway overflows from site storages to receiving waters. The assessment includes storages which have the ability to discharge via a spillway into the receiving waters, including saline dams and sediment dams. No saline water discharges were simulated for the life of the project. Figure 6.21 shows the sediment dam offsite overflows, assessed using a forecast simulation. Results show that sediment dam overflows increase over the life of the proposal, consistent with the increase in rehabilitation of spoil areas and diversion of these areas offsite.

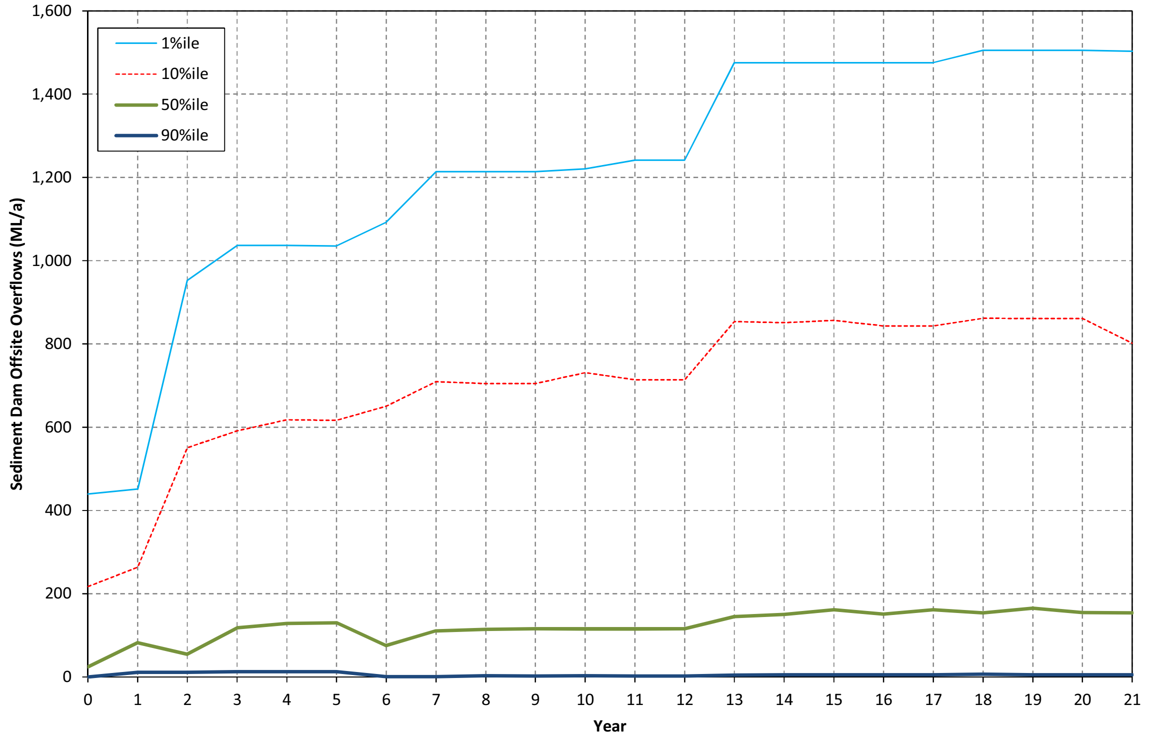

Figure 6.21 Sediment Dam Offsite Overflows (ML/a)

6.7 FINAL LANDFORM STORAGE AND WATER QUALITY BEHAVIOUR

6.7.1 Overview

The behaviour of the MTW final voids has been simulated to assess the long term accumulation of water and salts. Two final voids will remain: North Pit and West Pit final voids at Warkworth mine, as well as a depression at MTO at the location of the partially backfilled Loders Pit, which is proposed to be used for tailings storage.

6.7.2 Groundwater Behaviour

Figure 6.22 shows the estimated groundwater inflows to the Warkworth final void and Loders depression (AGE, 2014), and outflows. An iterative methodology was used to achieve agreement between the surface water model and groundwater model. The groundwater inflows from the spoil to the void are initially quite high, and decrease sharply. This is a result of the capping of tailings dams which used to seep to the void. The groundwater inflows from spoil then reach an equilibrium which is essentially rainfall runoff baseflow through the spoil piles. Note that water seeps out of the Loders depression, some of which flows to the Warkworth Void and some flows to the Wollombi alluvium. The potential impact on the Wollombi alluvium is discussed further in the AGE (2014) Groundwater Impact Assessment.

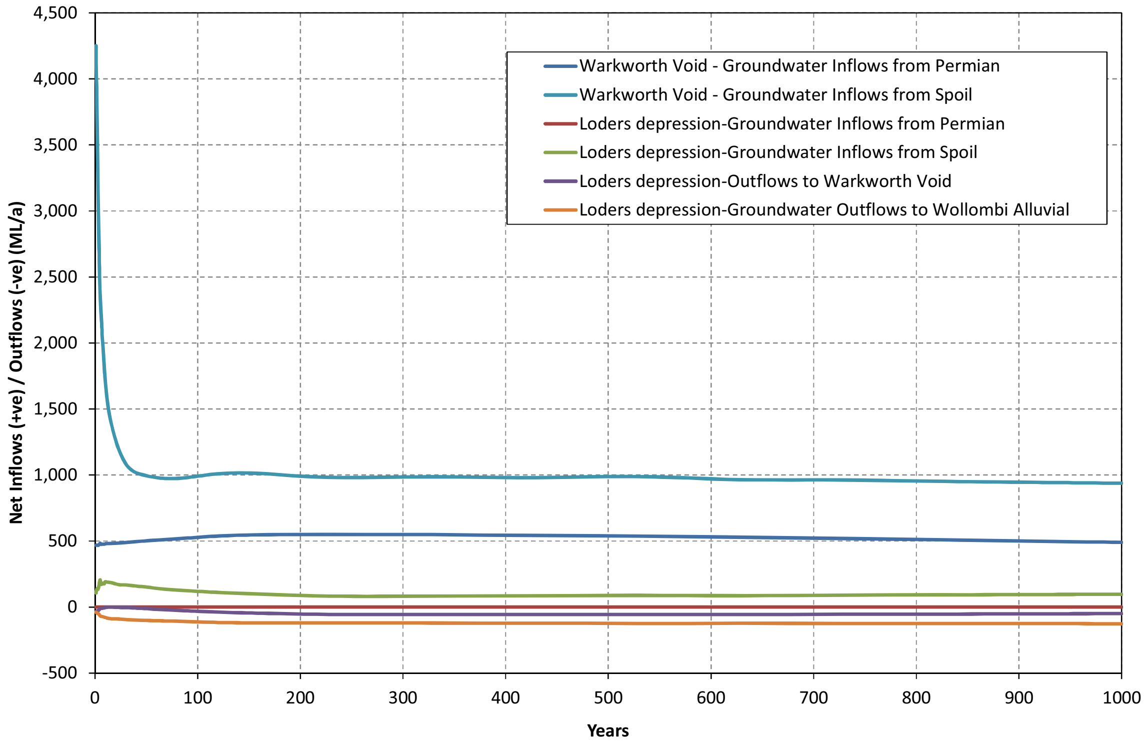

Figure 6.22 Final Void Groundwater Inflow/Outflow (AGE, 2014)

6.7.3 OPSIM Model Configuration

The final landform configuration and contributing catchment area are shown in Figure 6.23. Following mine closure, there are no further operational demands and all infrastructure and mine water storages are rehabilitated. The water balance and final equilibrium water level of the final void is dependent on the rainfall and runoff entering the void, evaporation loss from the void, and the inflow or outflow of groundwater. Permanent drainage of spoil dumps will be constructed on the eastern (low-wall) side to minimise capture of surface runoff in the final void. The model was run for a period of 1,000 years, using looped Data Drill rainfall and evaporation. The following assumptions were made with regards to salinity:

- Permian groundwater inflow salinity at both Warkworth mine and MTO: 10,000µS/cm, based on the average of bore water quality monitoring for Permian groundwater at the mines.
- Spoil groundwater inflow salinity (including water seeping from tailings dams and rainfall runoff baseflows through the spoil pile): 9,000µS/cm, based on measurement at the pit face of the spoil seepage water quality.
- Rainfall runoff surface flow salinity for rehabilitated spoil: 600µS/cm, based on median water quality measured in Dam 30N which has a rehabilitated spoil surface runoff catchment.

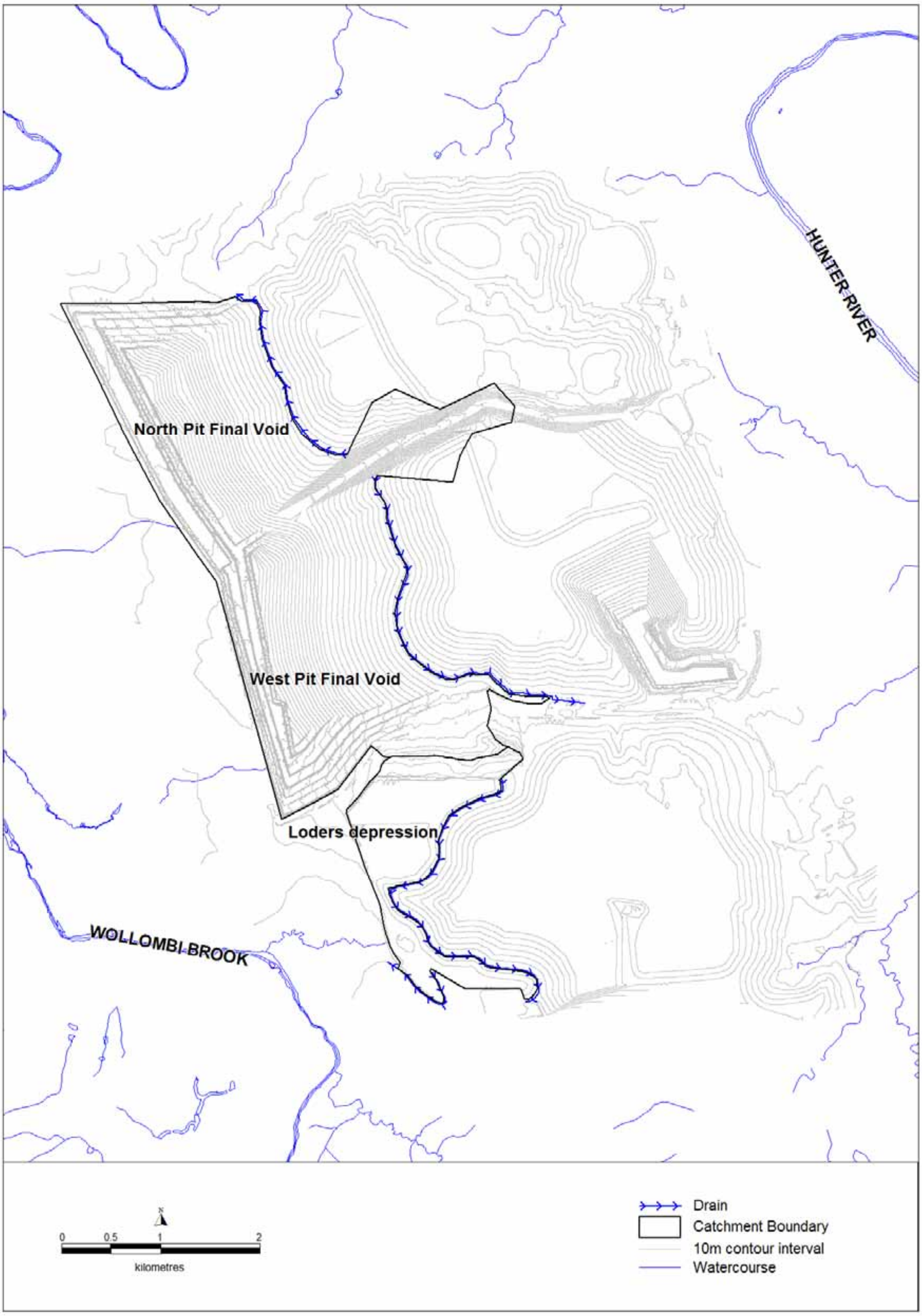

Figure 6.23 MTW Final Landform Catchment Plan

6.7.4 OPSIM Model Results

Figure 6.24 shows the simulated Warkworth final void water level and salinity as EC. The final void water level increases until it reaches equilibrium of inflows and outflows at approximately 20m AHD. This is approximately 54m below the crest level of the void. The salinity increases at a rate of approximately 30µS/cm per year, reaching 30,000µS/cm over the modelled 1,000 year period. This is due to the concentration of salts from evaporation.

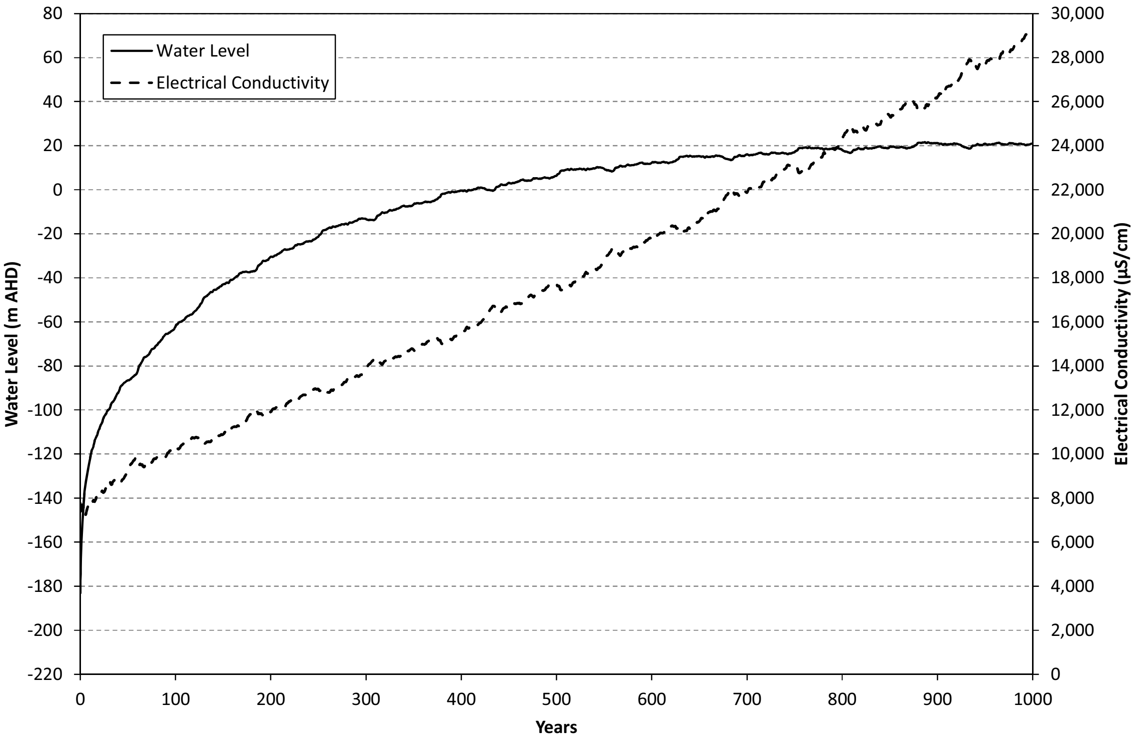

Figure 6.24 Warkworth Final Void Water Level and Salinity

Figure 6.25 and Figure 6.26 shows the Loders depression water level and stored volume, respectively. The depression stores water for approximately the first 100 years, and thereafter is mostly empty, with a lake forming at times for periods of up to 10 years in response to large rainfall events. The maximum water level reached is approximately 67m AHD (1,300ML) in the first 100 years, and thereafter approximately 64m AHD (500ML). This is approximately 3m and 6m lower than the crest level respectively. Note that a level of 67m AHD and 64m AHD equates to approximately 45% and 20% of the capacity of the depression, respectively.

Figure 6.27 shows the Loders depression salinity as a monthly average. A monthly average has been presented as the model shows artificial large spikes in EC when there are very small water volumes stored in the void. Figure 6.27 also shows the 90th percentile, median and 10th percentile ECs over the period when the depression is regularly emptying (100 to 1000 years). The results show a median EC of 3,000µS/cm, and 90th percentile EC of 8,000µS/cm.

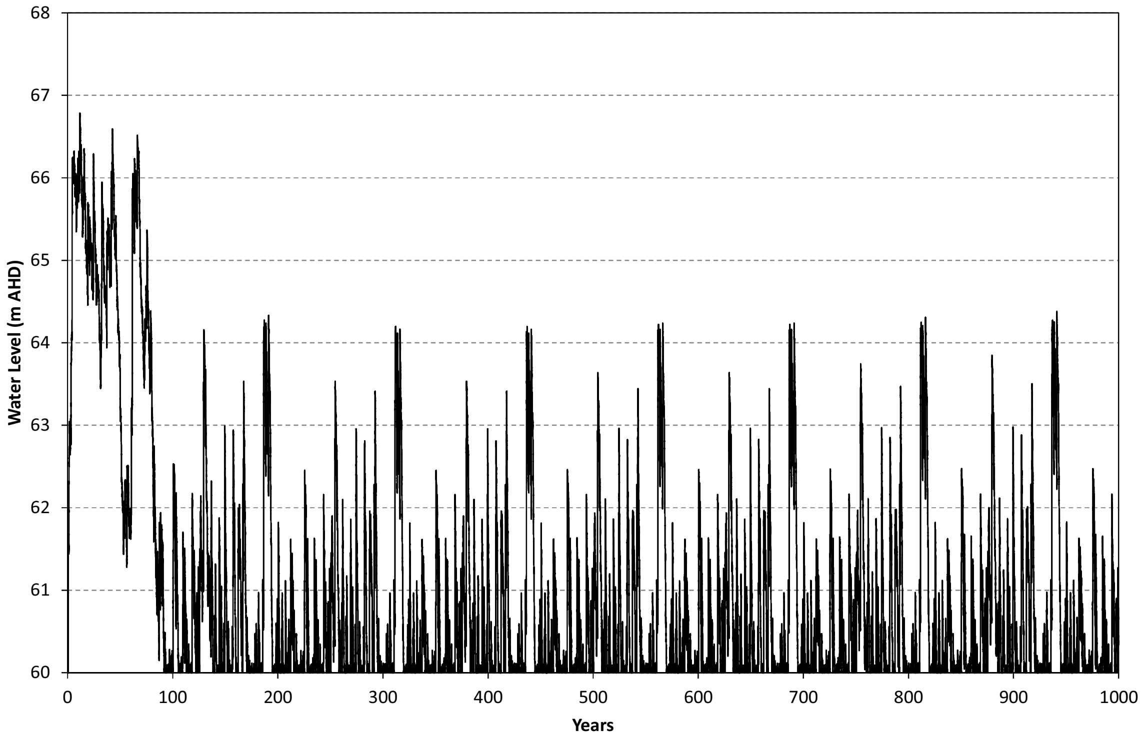

Figure 6.25 Loders Depression Water Level

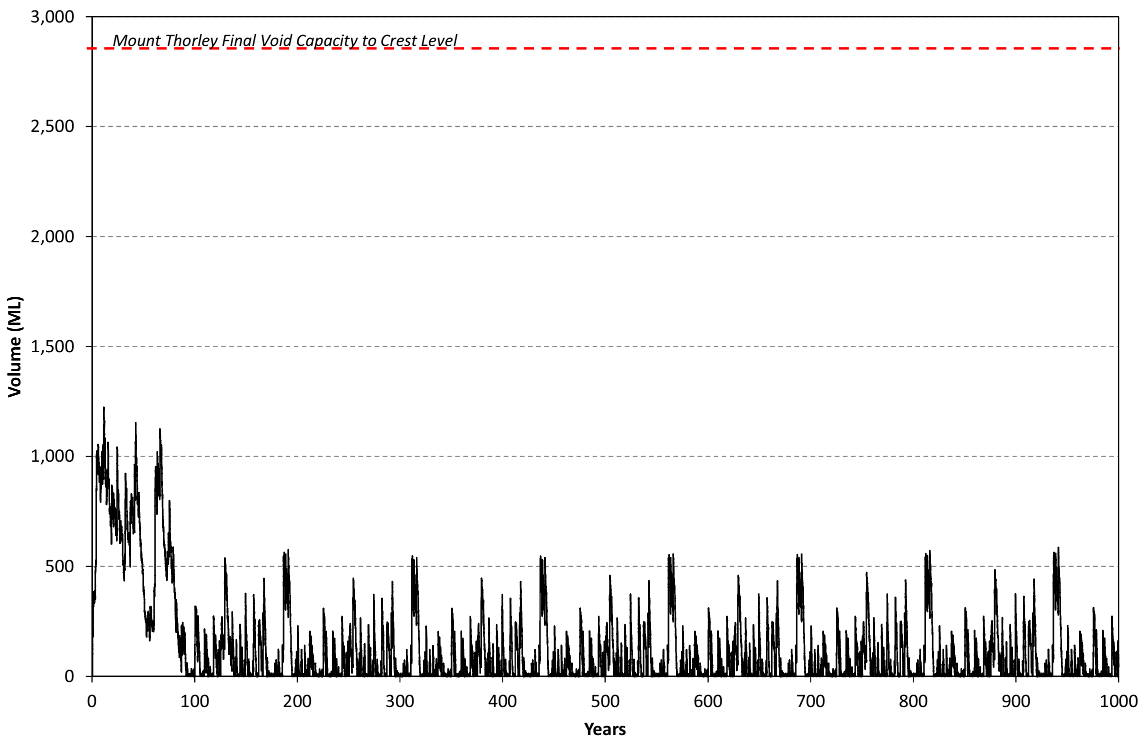

Figure 6.26 Loders Depression Stored Volume

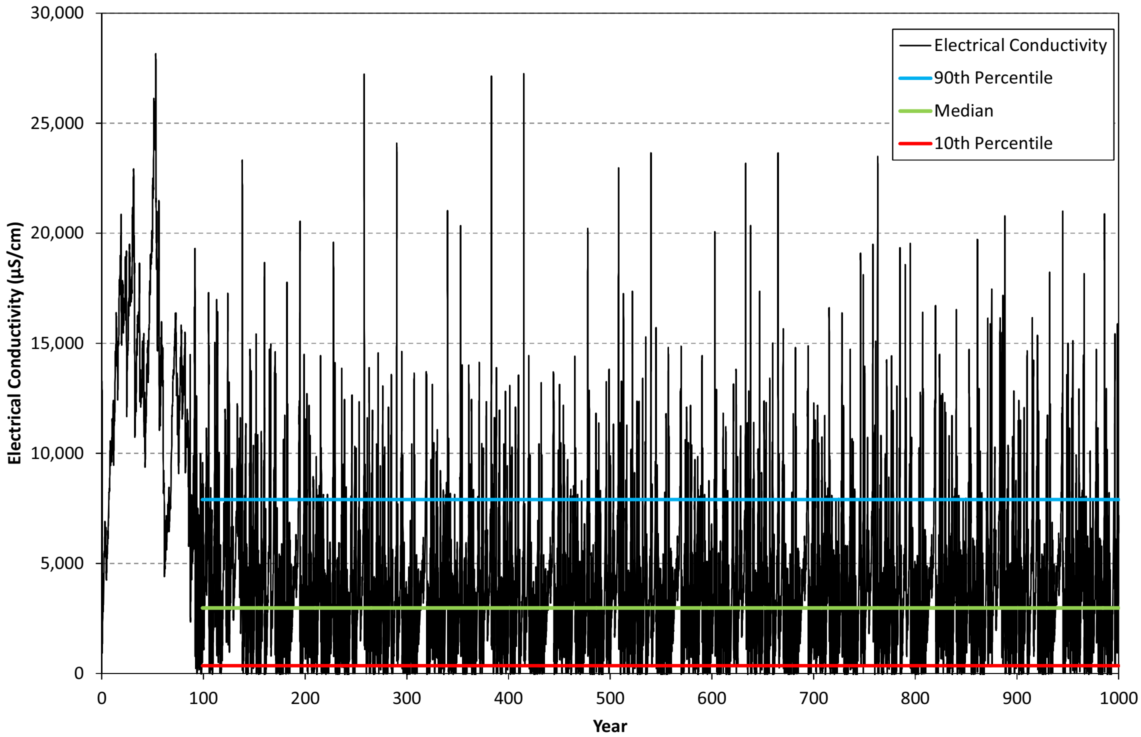

Figure 6.27 Loders Depression Salinity (Monthly Average)

6.8 MINE WATER BALANCE SUMMARY

The forecast results of the mine water balance model show that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in CHPP throughput and decrease in groundwater inflows to Mount Thorley. From Year 3 onwards the external water requirements are generally consistent:

- There is a 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required; and
- There is a 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

Note that Tailings Dam 2 (Dam 33N) will remain uncapped until the contract with Redbank Power Station to accept ash expires in 2031. The Year 21 mine layout (Figure 6.10) shows the TD2 as rehabilitated, however the water balance model assumes it is uncapped for the life of the mine. Rainfall runoff on the TD2 contributes less than 100ML/a to the water balance in an average rainfall year (45ha catchment area x 658mm/a long term average annual rainfall x 40% long term volumetric runoff coefficient), which is 1.4% of the Year 21 total inflows of around 7,100ML/a (refer Table 6.13). The effect of capping the TD2 on the water balance model results will reduce the external water requirements by approximately 100ML/a for the Year 21 mine stage only, which are estimated at 1,800ML/a on average (note that the year 21 mine stage is modelled as the final 4 years of the project life). Therefore this assumption is not considered to have a significant impact on the water balance model results.

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance that controlled releases from MTO will not be required in any year of the life of the proposal, and small volumes (100ML) will be discharged from Warkworth Mine in any year of the life of the proposal; and
- There is a 10 per cent chance that controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of the life of the proposal, and around 400ML from Warkworth Mine in any year of the life of the proposal.

6.9 ADAPTIVE MANAGEMENT OF MINE WATER BALANCE

The model results presented above represent the application of the adopted mine water management system rules over the mine life, regardless of climatic conditions. In reality, there are numerous options for adaptive management of the mine water management system to accommodate climatic conditions. For example, temporary adjustments to pumping arrangements could be made to accommodate very wet or dry periods. These alternative management approaches would be used to reduce the risks to the project associated with climatic variability.

7 MITIGATION MEASURES

7.1 OVERVIEW

Surface water at the Site is managed in accordance with MTW's WMP which was prepared in consultation with NOW and the NSW Environment Protection Authority. The impacts of the proposal on surface water resources will be mitigated through the implementation of the following measures to be documented in the revised site Water Management Plan:

- A mine site water management system to control the flow and storage of water of different qualities across the site;
- A sediment control plan to reduce sediment loads from disturbed area runoff; and
- A surface water monitoring program to continually assess environmental impacts and ensure that the site water management system is meeting its objectives of managing impacts on receiving waters.

An overview of each of these management measures are provided in the following sections.

7.2 MINE WATER MANAGEMENT SYSTEM

A key objective of the MTW mine water management system is to minimise the risk of uncontrolled releases from mine site storages. To achieve this objective, operation of the mine water management system will be based on the following principles:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Operation of the mine water management system to ensure no uncontrolled releases of mine water from the site;
- Collection of potentially sediment-affected runoff in sediment dams for treatment prior to release from site;
- Transfer of groundwater and seepage inflows to the open cut pits to the mine water system for reuse;
- Collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system; and
- Minimisation of fresh water usage by recycling water from the mine water system before taking additional water from external sources.

Details of the operation of the mine water management system are provided in Section 6.5.

An important component of the mine water management system will be to ensure that contingency measures are in place to accommodate either a surplus or deficit of water on site. Appropriate water licences or external sources will be obtained to meet the potential shortfall in water during dry conditions. Mine operations will also be planned to ensure that mining can continue during extended wet periods when water may accumulate in the open cut mining areas.

The site water management plan will detail reporting and action procedures to identify any lack of compliance with objectives and a process for implementing corrective actions.

7.3 EROSION AND SEDIMENT CONTROL PLAN

The design of sediment control measures for the proposal will be based on the principle of ensuring that runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment. Design of proposed erosion and sediment control measures will be based on the recommended design standards in the following guidelines:

- Managing Urban Stormwater, Soils and Construction (Landcom, 2004); and
- Managing Urban Stormwater, Soils and Construction, Volume 2E Mines and Quarries (DECC, 2008).

Proposed sediment dam sizes and locations are detailed in Section 6.5.7.

7.4 DRAINAGE OF FINAL LANDFORM

The rehabilitated overburden east of mining operations will be drained using the approach currently adopted at MTW which is based on:

- Topsoiling and revegetation of the finished landform;
- Construction of contour drains across the batter slope to minimise the potential for rilling and gullying of the finished landform;
- Collection of inflows from contour drains in rock chutes which flow downslope; and
- Flows from rock chutes are directed to sediment basins prior to release from site.

7.5 SURFACE WATER MONITORING PROGRAM

The existing MTW surface water monitoring program is described in Section 2.6.2.

The surface water monitoring locations and frequencies of the receiving waterways are considered appropriate to identify any changes in water quality associated with the proposal.

The site dam watering monitoring program will be updated to include additional locations as new dams are constructed:

- Saline storages: EC, pH and TSS will be monitored on a monthly basis. A comprehensive analysis will be undertaken annually.
  - NOOP Dam.
- Sediment dams: EC, pH and TSS will be monitored on a monthly basis. A comprehensive analysis will be undertaken annually.
  - Ramp 22 Dam;
  - Sediment Dam A; and
  - Sediment Dam B.

8 CONCLUSION

The proposed surface water management system has been developed in conjunction with the mine planning and operational teams to develop a surface water management system that has minimal impacts on surface water resources. The proposed surface water management system is a continuation of the current surface water management system, and the results of the surface water impact assessment indicate that the impacts of the proposal on surface water resources are unlikely to be significantly different to the existing approved operations.

The forecast results of the mine water balance model show that there is a step change in external water requirements which occurs in around Year 2, consistent with the increase in CHPP throughput and decrease in groundwater inflows to Mount Thorley. From Year 3 onwards the external water requirements are generally consistent:

- There is a 50 per cent chance that between 1,500ML/a to 2,000ML/a of external water will be required;
- There is a 10 per cent chance that between 3,000ML/a to 3,700ML/a of external water will be required; and
- There is a one per cent chance that between 3,700ML/a to 4,500ML/a of external water will be required.

Note that the current MTJV allocation is 1,012ML/a (at 100 per cent Available Water Determination (AWD)).

The results of the water balance modelling indicate a low probability of pit inundation, and no offsite uncontrolled release (overflows) from saline storages.

HRSTS discharges will be required for site water management, with the following discharge characteristics:

- Overall, much greater volumes are discharged from MTO than Warkworth Mine, which is consistent with the capacity of the discharges structures (200ML/d at MTO and 100ML/d at Warkworth Mine) and dam volumes;
- There is a 50 per cent chance that controlled releases from MTO will not be required in any year of project life, and small volumes (100ML) will be discharged from Warkworth Mine in any year of project life;
- There is a 10 per cent chance that controlled releases from MTO of between 1,000ML to 2,000ML will be required in any year of project life, and around 400ML from Warkworth Mine in any year of project life; and
- There is a one per cent chance that between 3,000ML to 4,500ML from MTO will be discharged in any year of mine life; and 500ML to 800ML of discharges from Warkworth Mine in any year of project life.

There is a maximum reduction of 0.56 per cent of the Wollombi Brook catchment to the Hunter River, and a maximum reduction of 0.19 per cent of the Hunter River (not including Wollombi Brook) during mining. Post-mining, the reduction in catchment area is 0.44 per cent and 0.04 per cent for Wollombi Brook and the Hunter River respectively. There is a median net runoff reduction to the Hunter River of up to 75ML/a during mining, and up to 104ML/a post-mining.

MTW currently undertakes an extensive surface water monitoring program, which will continue to be implemented for the proposal. Monitoring includes on site dams (both saline and sediment), receiving waters (upstream and downstream Hunter River, Wollombi Brook and their tributaries), and additional monitoring which is undertaken during periods of controlled release under the HRSTS. Additional saline storages and sediment dams constructed as part of the proposal will be monitored in accordance with the current monitoring program.

If required, additional water licences would be obtained from licensed sources, and therefore there will be no adverse impact on other licensed users who will still have access to their entitlement (subject to climatic availability and the operation of the water supply scheme).

Overall, the impacts of the Project on surface water resources are unlikely to be significantly greater than those of the existing mining operation.

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APPENDIX A

SUMMARY OF MTW WATER QUALITY MONITORING PROGRAM RESULTS

Water Quality Parameter		Hunter River		Loders Creek			Doctors Creek		Longford Creek	Sandy Hollow Creek	Wollombi Brook		Saltpan Creek
		W1	W3	W2	W5	W15	W4	W14	W27	WW5	Wollombi_ Brook	Wollombi_ Brook Upstream	SP1
Al - Total (mg/l)	10%ile	0.33	0.11	0.56	0.06	0.08	0.13	0.56	3.33	6.60	0.04	-	-
	Median	0.52	1.11	1.20	0.33	0.25	0.28	3.66	14.70	6.60	0.05	-	-
	90%ile	5.73	15.65	1.52	8.76	2.86	0.47	8.59	30.54	6.60	0.05	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
As - Total (mg/l)	10%ile	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.001	-	-
	Median	0.001	0.001	0.001	0.002	0.002	0.004	0.002	0.004	0.002	0.001	-	-
	90%ile	0.001	0.003	0.002	0.006	0.003	0.006	0.008	0.006	0.004	0.001	-	-
	N	10	9	4	12	6	3	6	4	3	9	0	0
B (mg/l)	10%ile	0.00	0.03	0.03	0.05	0.02	0.06	0.02	0.04	0.03	0.02	-	-
	Median	0.04	0.04	0.04	0.08	0.07	0.08	0.05	0.05	0.04	0.05	-	-
	90%ile	0.05	0.06	0.04	0.09	0.14	0.14	0.08	0.05	0.04	0.06	-	-
	N	9	9	4	10	5	3	6	3	3	8	0	0
Ba (mg/l)	10%ile	0.022	0.021	0.027	0.064	0.012	0.153	0.018	0.061	0.069	0.055	-	-
	Median	0.031	0.032	0.034	0.086	0.071	0.220	0.048	0.089	0.082	0.098	-	-
	90%ile	0.085	0.126	0.039	0.130	0.110	0.244	0.108	0.107	0.112	0.251	-	-
	N	9	9	4	11	5	3	6	3	3	8	0	0
Ca - Total (mg/l)	10%ile	27	24	37	18	25	11	13	5	13	12	-	-
	Median	39	39	50	78	49	20	35	6	15	14	-	-
	90%ile	44	49	105	119	113	22	65	10	17	15	-	-
	N	7	8	6	7	7	3	5	5	2	3	0	0
$CaCO_3$ - Total Hard (mg/l)	10%ile	77	86	336	392	140	584	38	41	-	109	-	-
	Median	163	230	560	1,111	210	584	88	41	-	109	-	-
	90%ile	249	266	944	1,830	1,506	584	138	41	-	109	-	-
	N	2	3	3	2	3	1	2	1	0	1	0	0
Cl- (mg/l)	10%ile	132	140	-	3,231	2,407	1,830	515	25	-	180	-	-
	Median	136	144	-	3,275	2,675	1,830	515	34	-	191	-	-
	90%ile	140	147	-	3,319	2,943	1,830	515	42	-	201	-	-
	N	2	2	0	2	2	1	1	2	0	2	0	0
EC Field (uS/cm (25TRef))	10%ile	440	450	600	1,726	2,180	1,200	620	200	162	368	437	6,786
	Median	645	630	800	7,270	4,840	5,760	3,305	288	270	764	600	16,810
	90%ile	890	890	1,082	12,570	8,108	16,024	11,620	390	442	1,060	923	24,880
	N	90	81	85	135	88	37	26	31	32	138	18	15
EC Lab (uS/cm (25TRef))	10%ile	810	533	470	4,200	646	25,320	535	-	-	746	-	-
	Median	810	845	1,135	4,200	6,770	25,320	4,695	-	-	830	-	-
	90%ile	810	7,240	5,925	4,200	10,978	25,320	9,475	-	-	886	-	-
	N	1	84	84	1	85	1	56	0	0	3	0	0
Fe - Filtered (mg/L)	10%ile	0.03	0.05	0.01	0.04	0.01	0.02	0.05	0.32	0.59	0.05	-	-
	Median	0.12	0.22	0.02	0.13	0.03	0.02	0.23	0.35	1.71	0.06	-	-
	90%ile	0.21	0.22	0.02	1.85	0.12	0.02	2.21	2.73	2.82	1.12	-	-
	N	3	3	2	6	3	2	3	3	2	5	0	0
K - Total (mg/l)	10%ile	3	3	4	15	8	26	7	6	7	4	-	-
	Median	4	4	4	27	14	45	19	7	7	5	-	-
	90%ile	4	4	5	34	25	71	32	10	8	6	-	-
	N	7	7	2	7	6	3	5	5	2	3	0	0
Li (mg/l)	10%ile	0.002	0.004	0.005	0.019	0.017	0.048	0.012	0.005	0.005	0.002	-	-
	Median	0.005	0.006	0.005	0.088	0.037	0.093	0.037	0.007	0.005	0.004	-	-
	90%ile	0.030	0.039	0.007	0.140	0.053	0.107	0.207	0.013	0.005	0.005	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
Mg - Total (mg/l)	10%ile	23	14	23	26	41	143	15	3	11	16	-	-
	Median	28	28	29	317	136	205	29	7	13	18	-	-
	90%ile	35	36	34	418	388	243	94	7	15	19	-	-
	N	7	7	3	7	6	3	5	5	2	3	0	0
Mn - Total (mg/l)	10%ile	0.056	0.003	0.050	0.038	0.016	0.011	0.011	0.030	0.025	0.227	-	-
	Median	0.110	0.108	0.114	0.073	0.081	0.012	0.092	0.047	0.052	0.428	-	-
	90%ile	0.352	0.766	0.130	0.313	0.416	0.037	0.298	0.050	0.098	2.030	-	-
	N	9	9	4	10	5	3	6	3	3	8	0	0
Na - Total (mg/l)	10%ile	42	40	67	480	362	2,226	107	19	21	102	-	-
	Median	73	66	88	2,380	896	3,970	563	26	28	104	-	-
	90%ile	80	80	106	2,794	2,590	5,274	1,111	38	35	110	-	-
	N	7	7	3	7	6	3	5	5	2	3	0	0
P - Total (mg/l)	10%ile	0.06	0.07	0.06	0.05	0.04	0.14	0.13	0.04	0.15	0.02	-	-
	Median	0.09	0.19	0.11	0.06	0.07	0.20	0.88	0.13	0.16	0.02	-	-
	90%ile	2.35	2.62	0.15	0.17	0.10	0.36	3.89	0.27	0.16	0.02	-	-
	N	6	6	3	4	4	3	5	4	2	2	0	0
pH Field	10%ile	7.5	7.6	7.4	7.9	7.4	7.8	7.3	6.9	7.1	7.0	7.2	7.5
	Median	8.0	8.1	8.0	8.2	8.0	8.7	8.1	7.4	7.7	7.4	7.6	8.1
	90%ile	8.4	8.4	8.3	8.6	8.4	9.0	8.6	7.8	8.1	8.0	8.0	8.6
	N	89	80	85	133	88	37	26	31	32	137	18	15
pH Lab	10%ile	7.6	7.7	7.5	7.9	7.3	8.3	7.3	6.8	-	8.0	-	-
	Median	7.6	8.2	8.1	8.0	8.1	8.8	8.2	6.8	-	8.0	-	-
	90%ile	7.6	9.0	8.9	8.1	8.9	9.3	8.7	6.8	-	8.0	-	-
	N	1	86	87	2	85	2	56	1	0	1	0	0
Rb - Total (mg/l)	10%ile	0.001	0.001	0.002	0.010	0.002	0.007	0.003	0.007	0.018	0.003	-	-
	Median	0.002	0.002	0.003	0.014	0.006	0.008	0.007	0.024	0.018	0.003	-	-
	90%ile	0.004	0.009	0.004	0.025	0.011	0.008	0.019	0.038	0.018	0.004	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
Se (mg/l)	10%ile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
	Median	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-	-
	90%ile	0.05	0.07	0.00	0.01	0.55	0.01	0.11	0.01	0.00	0.01	-	-
	N	9	8	4	10	5	3	6	3	3	8	0	0
Si (mg/l)	10%ile	3.01	4.01	10.60	0.16	0.20	0.43	0.07	2.89	5.50	5.95	-	-
	Median	12.20	14.50	13.00	2.65	1.11	1.26	0.16	10.63	5.50	7.04	-	-
	90%ile	14.82	15.60	16.20	4.97	4.75	2.09	10.43	18.37	5.50	8.13	-	-
	N	4	5	3	4	4	2	3	2	1	2	0	0
SO_4 - Total (mg/l)	10%ile	26	21	32	274	232	713	28	4	20	2	-	-
	Median	34	32	35	550	1,300	1,001	33	9	29	5	-	-
	90%ile	145	186	37	2,099	2,516	1,288	850	24	34	13	-	-
	N	8	6	2	10	4	2	5	4	3	9	0	0
Sr - Total (mg/l)	10%ile	0.125	0.163	0.384	0.379	0.177	1.564	0.139	0.102	0.190	0.207	-	-
	Median	0.380	0.351	0.400	1.600	0.550	1.820	0.510	0.129	0.190	0.231	-	-
	90%ile	0.490	0.487	0.520	3.244	2.862	2.604	0.959	0.171	0.190	0.254	-	-
	N	5	6	3	5	5	3	4	3	1	2	0	0
TSS (mg/L)	10%ile	5	8	10	4	3	8	15	3	19	2	5	5
	Median	21	22	21	14	14	35	54	43	45	6	5	10
	90%ile	65	61	59	97	80	78	110	129	94	18	9	20
	N	88	80	84	129	83	36	25	30	32	135	14	13
Turbidity (NTU)	10%ile	17.0	22.0	42.2	3.9	240.0	-	100.0	-	-	-	-	-
	Median	17.0	22.0	55.0	3.9	240.0	-	100.0	-	-	-	-	-
	90%ile	17.0	22.0	67.8	3.9	240.0	-	100.0	-	-	-	-	-
	N	1	1	2	1	1	0	1	0	0	0	0	0
Zn - Total (mg/l)	10%ile	0.005	0.005	0.003	0.005	0.005	0.007	0.006	0.005	0.017	0.004	-	-
	Median	0.005	0.022	0.005	0.007	0.008	0.012	0.026	0.018	0.025	0.005	-	-
	90%ile	0.019	0.064	0.006	0.030	0.042	0.013	0.134	0.043	0.173	0.005	-	-
	N	10	9	4	12	6	3	6	4	3	9	0	0

N = Number of samples
Note: The value of analytes analysed in a concentration below the detection limit were replaced for the value of the detection limit.

Water Quality Parameter		Saline Storage								Sediment Dam / Clean Water Storage				
		Dam 1N	Dam 11N	Dam 25N	Dam 6S	Dam 9S	Dam 12S	Dam 15S	Dam 2S	Dam 6N	Dam 27N	Dam 30N	Dam 1S	Dam 3S
Al - Total (mg/l)	10%ile	0.09	0.91	19.60	0.09	0.26	0.51	0.21	-	0.28	-	0.09	0.18	2.71
	Median	0.16	14.90	26.00	0.47	0.38	18.00	0.37	-	0.28	-	0.09	0.48	3.89
	90%ile	10.06	25.86	36.72	1.33	0.71	62.04	1.15	-	0.28	-	0.09	5.85	4.83
	N	5	8	3	9	9	5	7	0	1	0	1	7	4
As - Total (mg/l)	10%ile	0.001	0.001	0.002	0.021	0.002	0.003	0.002	-	0.002	-	0.001	0.005	0.002
	Median	0.013	0.004	0.004	0.026	0.007	0.005	0.011	-	0.002	-	0.002	0.008	0.005
	90%ile	0.017	0.007	0.009	0.030	0.025	0.015	0.026	-	0.002	-	0.002	0.010	0.009
	N	10	8	3	10	13	8	15	0	1	0	2	12	4
B (mg/l)	10%ile	0.06	0.04	0.05	0.07	0.08	0.02	0.01	-	0.10	-	0.05	0.03	0.05
	Median	0.08	0.05	0.06	0.08	0.10	0.05	0.07	-	0.10	-	0.05	0.05	0.05
	90%ile	0.11	0.07	0.08	0.09	0.12	0.05	0.09	-	0.10	-	0.05	0.05	0.06
	N	10	8	3	9	13	7	13	0	1	0	1	11	4
Ba (mg/l)	10%ile	0.015	0.077	0.127	0.098	0.027	0.118	0.025	-	0.247	-	0.070	0.013	0.043
	Median	0.033	0.129	0.197	0.104	0.051	0.225	0.057	-	0.247	-	0.070	0.049	0.068
	90%ile	0.114	0.270	0.200	0.117	0.085	0.358	0.099	-	0.247	-	0.070	0.133	0.091
	N	9	7	3	7	12	8	14	0	1	0	1	11	4
Ca - Total (mg/l)	10%ile	15	3	4	11	7	2	10	-	4	-	9	8	4
	Median	40	5	5	13	13	3	12	-	4	-	11	20	4
	90%ile	50	11	8	16	17	16	16	-	4	-	13	39	5
	N	18	6	3	9	8	5	9	0	1	0	2	8	4
$CaCO_3$ - Total Hard (mg/l)	10%ile	502	17	88	199	200	5	53	-	-	-	142	169	47
	Median	590	56	88	199	200	5	115	-	-	-	142	506	47
	90%ile	848	95	88	199	200	5	177	-	-	-	142	842	47
	N	13	2	1	1	1	1	2	0	0	0	1	2	1
Cl- (mg/l)	10%ile	-	107	81	856	856	585	863	-	1,280	-	65	316	262
	Median	-	377	159	928	946	585	913	-	1,280	-	91	942	401
	90%ile	-	587	342	1,060	964	585	963	-	1,280	-	117	1,708	651
	N	0	3	3	9	3	1	2	0	1	0	2	3	4
EC Field (uS/cm (25TRef))	10%ile	3,790	156	297	5,122	4,956	190	2,465	1,372	8,269	278	484	595	2,066
	Median	7,260	220	478	6,140	7,460	460	4,895	2,190	8,385	351	581	1,230	3,560
	90%ile	8,725	2,591	1,417	7,392	8,729	2,212	7,860	5,670	8,501	594	899	7,010	5,285
	N	110	18	6	24	112	99	106	17	2	10	8	106	18
EC Lab (uS/cm (25TRef))	10%ile	737	193	-	-	7,857	177	7,950	-	-	-	-	2,445	-
	Median	6,440	255	-	-	7,950	383	7,950	-	-	-	-	2,785	-
	90%ile	8,875	1,787	-	-	8,008	589	7,950	-	-	-	-	3,125	-
	N	120	4	0	0	4	2	1	0	0	0	0	2	0
Fe - Filtered (mg/L)	10%ile	0.02	0.61	-	-	0.01	0.73	0.02	-	-	-	-	0.03	0.09
	Median	0.05	0.79	-	-	0.01	0.79	0.05	-	-	-	-	0.09	0.10
	90%ile	0.09	3.25	-	-	0.01	2.96	0.25	-	-	-	-	0.13	0.11
	N	4	3	0	0	1	3	3	0	0	0	0	4	2
K - Total (mg/l)	10%ile	23	3	2	23	27	9	18	-	36	-	9	10	8
	Median	36	8	4	25	30	20	29	-	36	-	10	14	11
	90%ile	44	30	7	28	34	34	35	-	36	-	11	40	17
	N	5	7	3	9	8	5	9	0	1	0	2	8	4
Li (mg/l)	10%ile	0.131	0.008	0.009	0.169	0.197	0.008	0.074	-	0.418	-	0.012	0.004	0.016
	Median	0.275	0.016	0.015	0.177	0.212	0.017	0.169	-	0.418	-	0.012	0.007	0.022
	90%ile	0.358	0.076	0.023	0.204	0.294	0.134	0.273	-	0.418	-	0.012	0.021	0.038
	N	5	8	3	9	9	5	6	0	1	0	1	6	4
Mg - Total (mg/l)	10%ile	25	3	6	26	13	2	9	-	15	-	14	0	5
	Median	36	5	7	32	19	10	21	-	15	-	20	17	8
	90%ile	67	56	14	39	25	58	44	-	15	-	25	131	9
	N	6	7	3	9	9	5	9	0	1	0	2	8	4
Mn - Total (mg/l)	10%ile	0.004	0.005	0.050	0.003	0.005	0.038	0.005	-	0.002	-	0.018	0.015	0.014
	Median	0.008	0.059	0.088	0.006	0.011	0.120	0.009	-	0.002	-	0.018	0.047	0.027
	90%ile	0.046	0.106	0.158	0.214	0.030	0.199	0.018	-	0.002	-	0.018	10.137	0.036
	N	9	6	3	9	12	7	13	0	1	0	1	10	4
Na - Total (mg/l)	10%ile	1,306	26	115	1,340	1,720	29	992	-	2,220	-	82	70	361
	Median	1,800	37	203	1,450	1,860	51	1,580	-	2,220	-	114	346	530
	90%ile	1,900	770	386	1,594	2,197	526	2,032	-	2,220	-	145	1,413	923
	N	5	7	3	9	8	5	9	0	1	0	2	8	4
P - Total (mg/l)	10%ile	0.01	0.03	0.26	0.01	0.01	0.05	0.03	-	0.05	-	0.06	0.30	0.05
	Median	0.02	0.17	0.26	0.02	0.02	0.20	0.07	-	0.05	-	0.06	0.66	0.09
	90%ile	0.48	0.72	0.59	0.05	0.03	0.51	0.09	-	0.05	-	0.06	0.94	0.12
	N	6	8	3	7	9	4	5	0	1	0	1	5	4
pH Field	10%ile	8.4	7.8	7.8	8.7	8.4	7.4	8.6	8.4	9.8	7.6	7.9	8.0	8.9
	Median	8.7	8.1	8.4	9.0	8.8	8.1	8.9	8.9	9.8	7.9	8.3	8.8	9.2
	90%ile	8.9	9.0	8.7	9.1	9.0	8.7	9.1	9.2	9.8	9.1	8.9	10.0	9.5
	N	109	17	6	24	111	98	105	17	2	10	8	88	18
pH Lab	10%ile	7.7	7.0	-	-	8.7	7.1	9.0	-	-	-	-	8.0	-
	Median	8.7	7.1	-	-	8.7	7.7	9.0	-	-	-	-	9.1	-
	90%ile	9.0	8.1	-	-	8.7	7.9	9.0	-	-	-	-	9.3	-
	N	123	3	0	0	1	3	1	0	0	0	0	20	0
Rb - Total (mg/l)	10%ile	0.043	0.020	0.027	0.035	0.048	0.008	0.015	-	0.002	-	0.005	0.005	0.014
	Median	0.061	0.036	0.042	0.041	0.055	0.053	0.036	-	0.002	-	0.005	0.007	0.018
	90%ile	0.063	0.063	0.065	0.042	0.060	0.127	0.050	-	0.002	-	0.005	0.027	0.019
	N	5	7	3	9	9	5	6	0	1	0	1	6	4
Se (mg/l)	10%ile	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-	0.01	-	0.01	0.00	0.01
	Median	0.01	0.01	0.01	0.01	0.01	0.00	0.01	-	0.01	-	0.01	0.00	0.01
	90%ile	0.01	0.01	0.01	0.02	0.01	0.01	0.03	-	0.01	-	0.01	0.01	0.02
	N	10	7	3	9	13	7	13	0	1	0	1	11	4
Si (mg/l)	10%ile	5.62	0.28	-	3.38	5.30	4.62	1.97	-	-	-	-	1.46	17.80
	Median	6.25	20.90	-	6.85	6.40	4.70	5.10	-	-	-	-	2.05	17.80
	90%ile	7.65	37.30	-	13.81	9.24	46.22	6.70	-	-	-	-	3.97	17.80
	N	4	5	0	4	5	3	6	0	0	0	0	4	1
SO_4 - Total (mg/l)	10%ile	444	12	53	784	730	43	279	-	1	-	33	32	242
	Median	1,011	34	131	869	939	67	789	-	1	-	53	164	346
	90%ile	1,304	224	202	924	1,290	435	923	-	1	-	73	864	586
	N	10	6	3	10	11	5	12	0	1	0	2	8	4
Sr - Total (mg/l)	10%ile	0.316	0.096	0.212	0.934	0.382	0.110	0.170	-	0.644	-	0.528	0.223	0.177
	Median	0.640	0.145	0.258	1.180	0.648	0.160	0.370	-	0.644	-	0.528	0.280	0.248
	90%ile	0.833	0.529	0.336	1.460	0.882	0.721	1.348	-	0.644	-	0.528	1.928	0.349
	N	5	8	3	9	9	4	7	0	1	0	1	7	4
TSS (mg/L)	10%ile	5	22	124	9	8	21	15	14	5	22	5	7	12
	Median	17	54	513	41	18	91	36	56	7	46	9	36	36
	90%ile	114	150	1350	136	88	1042	163	605	8	50	25	251	80
	N	118	19	6	24	110	99	105	17	2	5	7	104	18
Turbidity (NTU)	10%ile	4.9	13.1	-	-	7.9	780.8	140.0	-	-	-	-	-	-
	Median	17.4	62.0	-	-	22.0	2080.0	140.0	-	-	-	-	-	-
	90%ile	135.0	1292.4	-	-	47.4	3064.0	140.0	-	-	-	-	-	-
	N	46	3	0	0	47	3	1	0	0	0	0	0	0
Zn - Total (mg/l)	10%ile	0.005	0.005	0.026	0.005	0.005	0.008	0.005	-	0.005	-	0.005	0.005	0.009
	Median	0.005	0.044	0.054	0.005	0.005	0.028	0.013	-	0.005	-	0.005	0.005	0.020
	90%ile	0.036	0.089	0.096	0.006	0.021	7.458	0.027	-	0.005	-	0.005	0.029	0.021
	N	10	8	3	10	13	8	15	0	1	0	2	12	4

N = Number of samples
Note: The value of analytes analysed in a

APPENDIX B

MTW CATCHMENT AND LAND USE CLASSIFICATION TABLES

Table B. 1 Year 0 Catchment Areas and Land Use Classifications (ha) - Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	**Mining Pit**	**Natural/ Undisturbed**	**Rehab. Spoil**	**Roads/ Industrial/ Hardstand**	**Tailings**	**Unrehab. Spoil**	
AGS	1.3			4.8	0.4	14.3	5.8	**26.7**
52ML Dam			4.1		8.7			**12.8**
Dam 10S	2.8			48.9			0.9	**52.6**
Dam 11N			53.7					**53.7**
Dam 11S	0.7			0.1				**0.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 12S	64.3		7.9		5.9			**78.1**
Dam 14S			0.4		1.0			**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16N	2.1		7.6	63.9			1.0	**74.7**
Dam 16S	4.9					12.5		**17.4**
Dam 17S (CRTSF)				11.9	14.2	29.2	24.9	**80.2**
Dam 18N				1.0				**1.0**
Dam 1N	14.1			58.0	21.3		103.6	**197.0**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.5		3.8		0.8			**13.0**
Dam 27N			0.5	5.1				**5.6**
Dam 30N	11.3			91.7				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 32N (TD1)	1.2			40.7				**41.9**
Dam 33N (TD2)	2.4			13.1		45.9		**61.4**
Dam 3S	7.4		1.5	141.9	6.2		25.8	**182.8**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6N	1.9		7.0		0.1			**9.1**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.9			0.0				**0.9**
Dam 9S	2.4							**2.4**
Dams 13,14,15N	12.3			146.3	4.0		2.1	**164.8**
Honeypot Dam	6.8		35.8		4.0			**46.7**
Loders Pit	8.2	12.7	8.1	3.3	25.1		347.7	**405.2**
Mini Strip TSF			7.4	0.3	11.2		15.7	**34.6**
North Loders Clean Dam			8.9					**8.9**
North Pit	49.3	6.2	5.0	10.9	9.0		148.1	**228.6**
North Pit North	20.9	5.4		8.5	9.7		124.9	**169.4**
South Pit	0.2	7.4	1.2	37.7	15.6		272.5	**334.6**
West Pit	25.5	19.2	74.7	18.0	35.0		462.8	**635.1**
Grand Total	**302.3**	**50.9**	**262.2**	**706.1**	**273.8**	**101.9**	**1,535.8**	**3,233.6**

Table B. 2 Year 0 Catchment Areas and Land Use Classifications (ha) - Baseflow component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			4.8	0.4	14.3	5.8	**26.7**
52ML Dam			4.1		8.7			**12.8**
Dam 10S	1.2			0.9				**2.1**
Dam 11N			53.7					**53.7**
Dam 11S	0.7			0.1				**0.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 12S	64.3		7.9		5.9			**78.1**
Dam 14S			0.4		1.0			**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16N	2.1		0.8				1.0	**4.0**
Dam 16S	4.9					12.5		**17.4**
Dam 17S (CRTSF)				3.4	9.0	29.2	14.7	**56.4**
North Loders Clean Dam			8.9					**8.9**
Dam 1N	14.1			0.7	5.7		0.6	**21.0**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.5		3.8		0.8			**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 32N (TD1)	1.2			40.7				**41.9**
Dam 33N (TD2)						45.9		**45.9**
Dam 3S	3.1		1.5		0.3			**4.9**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6N	1.9		7.0		0.1			**9.1**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.9			0.0				**0.9**
Dam 9S	2.4							**2.4**
Dams 13,14,15N	7.8			0.5	1.4		0.9	**10.7**
Honeypot Dam	6.8		35.8		4.0			**46.7**
Loders Pit	14.2	12.7	8.1	297.2	47.6		423.4	**803.1**
Mini Strip TSF			7.4	0.3	11.2		15.7	**34.6**
North Pit	55.5	6.2	5.8	233.8	14.5		152.9	**468.7**
North Pit North	32.6	5.4	7.3	179.2	9.7		124.9	**359.1**
South Pit		7.4	0.1	114.8	27.1		307.9	**457.3**
West Pit	25.0	19.2	76.4	24.5	45.8		535.2	**726.1**
Grand Total	**301.4**	**50.9**	**263.6**	**900.9**	**294.8**	**101.9**	**1,583.0**	**3496.9**

Table B. 3 Year 3 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			6.4	0.2	14.7	5.0	**27.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	5.5				11.9			**17.4**
Dam 17S (CRTSF)				9.1		51.8	26.0	**87.0**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			149.8	34.0		35.3	**232.4**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 3S	3.3		1.5	118.2	3.2		49.3	**175.5**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		2.1		0.4		0.5	**6.8**
Loders Pit	17.4	11.2	15.6	19.0	32.8		381.2	**477.1**
Mini Strip TSF			7.4	0.5	10.2		16.3	**34.3**
NOOP Dam	17.7		4.2	264.0	4.5		0.1	**290.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	22.8	12.2		30.7	10.6		183.2	**259.4**
North Pit North	15.7	6.0	0.4	38.7	10.7		159.1	**230.5**
Ramp 22 Dam	0.3			267.9			33.8	**302.0**
South Pit		18.5		37.4	17.7		227.3	**300.9**
West Pit	53.4	20.4	35.8	55.4	42.9		522.6	**730.5**
Grand Total	**220.2**	**68.2**	**122.1**	**1120.1**	**291.1**	**111.5**	**1640.1**	**3572.9**

Table B. 4 Year 3 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGS	1.3			6.4	0.2	14.7	5.0	**27.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	5.5				11.9			**17.4**
Dam 17S (CRTSF)				9.1		51.8	26.0	**87.0**
Dam 1N	13.3			0.7	7.7		0.0	**21.8**
Dam 1S/2S	10.1		2.2		15.6			**27.9**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 3S	3.1		1.5		0.3			**4.9**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		2.1		0.4		0.5	**6.8**
Loders Pit	17.9	11.2	15.5	287.5	41.9		476.5	**850.5**
Mini Strip TSF			7.4	0.5	10.1		16.3	**34.3**
NOOP Dam	18.5			2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	22.8	12.2	0.4	306.8	16.3		183.7	**542.2**
North Pit North	15.7	6.0	8.3	220.5	10.7		159.1	**420.3**
Ramp 22 Dam				123.2			14.3	**137.5**
South Pit		18.5	0.3	156.8	32.3		246.8	**454.8**
West Pit	53.5	20.4	35.8	108.6	60.2		554.5	**832.9**
Grand Total	**221.0**	**68.3**	**123.1**	**1224.7**	**306.5**	**110.8**	**1683.1**	**3737.5**

Table B. 5 Year 9 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGN						36.7	0.9	**37.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17S (CRTSF)				9.1		29.2	46.8	**85.1**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			229.4	34.2		116.7	**393.6**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 4N			1.9					**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.2	7.0	22.6	143.9	37.4		287.2	**515.3**
NOOP Dam	17.7		4.2	264.9	4.4			**291.2**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	15.3	13.2		50.9	17.6		244.6	**341.6**
North Pit North	14.9	6.1			12.0		158.4	**191.4**
Ramp 22 Dam	0.3			300.7			0.3	**301.3**
Sed. Dam A				133.8	1.0		16.4	**151.2**
Sed. Dam B	2.8			72.9	1.5		25.1	**102.3**
South Pit		18.0		171.9	2.7		44.4	**237.0**
West Pit	40.0	22.3	35.1	81.1	42.2		587.7	**808.4**
Grand Total	**174.7**	**66.6**	**117.8**	**1581.5**	**275.8**	**110.9**	**1530.1**	**3875.1**

Table B. 6 Year 9 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
AGN						36.7	0.9	**37.6**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17S (CRTSF)				9.1		29.2	46.8	**85.1**
Dam 1N	13.3			0.8	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8		0.7		0.3	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	18.9	7.0	22.6	471.8	42.5		321.0	**883.8**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	15.4	13.2	0.4	327.9	22.5		245.1	**624.4**
North Pit North	17.7	6.1	7.9	254.7	13.5		183.6	**483.4**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.0		381.4	18.1		45.6	**463.0**
West Pit	40.1	22.3	35.2	175.5	60.4		702.8	**1036.3**
Grand Total	**194.0**	**66.6**	**119.5**	**1763.2**	**290.0**	**110.1**	**1547.2**	**4090.5**

Table B. 7 Year 14 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17N			0.8	18.4				**19.2**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			296.8	34.2		49.3	**393.6**
Dam 1S,2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N			0.0	103.0				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				16.4		45.0		**61.4**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A) S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.1		22.6	376.4	9.3	42.2	47.8	**515.3**
NOOP Dam	17.7		4.2	340.9	5.7		10.0	**378.6**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	28.9	12.8		11.5	23.8		249.9	**326.9**
North Pit North	29.0	6.8		10.9	13.4		217.1	**277.2**
Ramp 22 Dam	0.3			301.0			0.0	**301.3**
Sed. Dam A				235.3	0.8			**236.1**
Sed. Dam B	2.8			97.6	1.4		0.4	**102.3**
South Pit		18.5		172.2	2.7		43.6	**237.0**
West Pit	68.8	20.5	35.1	181.2	44.7		601.8	**952.2**
Grand Total	**248.8**	**58.6**	**118.6**	**2165.3**	**258.8**	**87.2**	**1221.3**	**4158.8**

Table B. 8 Year 14 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Land Use							
	Cleared/ Prestrip	**Mining Pit**	**Natural/ Undisturbed**	**Rehab. Spoil**	**Roads/ Industrial/ Hardstand**	**Tailings**	**Unrehab. Spoil**	**Grand Total**
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 1N	13.3			0.8	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 33N (TD2)				1.7		44.3		**46.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.8		22.6	861.9	14.3	42.2	47.8	**1006.5**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.0	12.8	0.4	364.1	30.1	0.3	260.4	**697.1**
North Pit North	31.8	6.8	7.9	290.0	14.8	0.4	217.5	**569.2**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.5		382.8	18.1		43.6	**463.0**
West Pit	68.9	20.5	35.2	342.0	62.9		650.6	**1180.1**
Grand Total	**247.0**	**58.6**	**119.5**	**2383.8**	**273.2**	**87.2**	**1221.3**	**4390.4**

Table B. 9 Year 21 MTW Catchment Areas and Land Use Classifications (ha) – Surface component

Storage	Runoff Set							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 17N			0.8	18.4				**19.2**
Dam 18N			0.8	0.2				**1.0**
Dam 1N	13.3			296.8	34.3		49.3	**393.7**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 27N			2.5	3.0				**5.6**
Dam 30N				164.4				**103.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honeypot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.1		22.6	375.1	9.2	42.2	47.9	**514.1**
NOOP Dam	17.7		4.2	340.8	5.7		9.9	**378.6**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.1	14.3		30.1	23.8		229.8	**327.1**
North Pit North	28.9	10.4		33.1	13.5		191.3	**277.1**
Ramp 22 Dam	0.3			300.8			0.0	**301.2**
Sed. Dam A				237.0	0.8			**237.8**
Sed. Dam B	2.8			97.6	1.4		0.4	**102.3**
South Pit		18.5		172.2	2.7		43.5	**237.0**
West Pit	68.8	19.5	35.1	249.5	44.7		534.5	**952.1**
Grand Total	**248.9**	**62.7**	**118.6**	**2336.1**	**258.9**	**42.2**	**1108.0**	**4159.3**

Table B. 10 Year 21 MTW Catchment Areas and Land Use Classifications (ha) – Baseflow component

Storage	Land Use							Grand Total
	Cleared/ Prestrip	Mining Pit	Natural/ Undisturbed	Rehab. Spoil	Roads/ Industrial/ Hardstand	Tailings	Unrehab. Spoil	
52ML Dam			4.1		8.7			**12.8**
Dam 12N	0.4		3.0		28.4			**31.7**
Dam 14S			0.4		1.0			**1.4**
Dam 15N	1.4							**1.4**
Dam 15S			20.3		38.6			**58.9**
Dam 16S	3.0				12.1		0.7	**15.8**
Dam 1N	13.3			0.7	7.7		0.0	**21.8**
Dam 1S/2S	8.6		1.9		12.9			**23.4**
Dam 20N	8.2		3.8	0.1	0.7		0.2	**13.0**
Dam 31N + 21N	1.5		7.2		11.2			**20.0**
Dam 4N			1.9	0.1				**1.9**
Dam 5S	14.1				7.8			**21.9**
Dam 6S	26.9							**26.9**
Dam 9(A)S	0.6			0.3				**0.9**
Dam 9S	2.4							**2.4**
Honey Pot Dam	3.8		1.1		1.4		0.5	**6.8**
Loders Pit	17.8		22.6	909.8	14.1	42.2		**1006.5**
NOOP Dam	17.7		0.8	2.5	2.5			**23.5**
North Loders Clean Dam			8.9					**8.9**
North Pit Mid	29.1	14.3	0.4	382.8	30.1	0.3	240.3	**697.2**
North Pit North	31.7	10.4	7.9	358.2	14.9	0.5	191.7	**569.3**
Ramp 22 Dam				137.5				**137.5**
South Pit		18.5		382.8	18.1		43.6	**463.0**
West Pit	68.9	19.5	35.2	410.3	63.0		583.2	**1180.0**
Grand Total	**231.7**	**62.7**	**119.5**	**2586.8**	**273.2**	**42.5**	**1060.2**	**4392.9**

APPENDIX C

MODELLING OF RELEASES UNDER THE HRSTS

The following approach to the HRSTS modelling was adopted:

1. Hunter River Streamflow time series – simulated streamflow data was obtained from NOW's IQQM model (full development case with 2004 water sharing plan rules) for the period 16/09/1892 to 30/6/2007.
2. Salinity –Recorded salinity data was obtained for the Hunter River at Singleton (#210129) from the PINEENA database, covering the period February 1993 to October 2009. Based on the recorded historical data, a relationship between streamflow and water quality was developed. EC's for 'High' flows only (2,000 – 10,000ML/d) were plotted against flow rates and a logarithmic trend line fitted to the data, giving salinity as a function of flow rate.
3. The salinity function was then applied to get a Hunter River flow and EC time series at Singleton which was used in OPSIM as the reference node.
4. In OPSIM, controlled discharges were simulated using an Environmental Transfer (ETN) node with two 'rules' for discharge. Rule 1 limits the volume of discharges based on the flow rates in the Hunter River, as shown in Table C. 1. Rule 2 limits the salt load discharged based on the salinity in the Hunter River and the discharge dams (Dam 9S and Dam 1N), as shown in Table C. 2.

Table C. 1 HRSTS Rule 1 (Volume Limit Rating)

Hunter River Qref (ML/d)	Site Discharge Qmax (ML/d)	Apply Rule 2	Comment
0	0	x	No site discharges allowed when Hunter River flows are <2,000 ML/d.
2,000	0	x	
2,000	100	✓	When Hunter River flows are 2,000 – 10,000 ML/d, up to 100 ML/d can be discharged from each discharge location, with salinity restrictions as per 'Rule 2'.
10,000	100	✓	
High	100	✓	When Hunter River flows are >10,000 ML/d, up to 100 ML/d can be discharged from each discharge location, with salinity restrictions as per 'Rule 2'.

Where:

- Qref is the reference volume [ML/d] (in this case, the Hunter River).
- Qmax is the discharge limit [ML/d] for Qref. At Warkworth Mine, this rate is 100ML/d. At MTO, this rate is 200ML/d.

Table C. 2 HRSTS Rule 2 (EC Rating)

Method	Cr (µS/cm)	K Value	Comment
K + Cr	0	900	If the EC in the Hunter River is zero, the concentration in the Hunter River can inrease by up to 900µS/cm due to discharges under the HRSTS.
K + Cr	900	0	If the EC in the Hunter River is 900µS/cm, the concentration in the Hunter River cannot increase due to discharges under the HRSTS.

Where:

- Cr is the concentration at the Reference Node (in this case, the Hunter River).
- K is the concentration increase (linearly interpolated between the specified values and the limiting transfer concentration is calculated as K+Cr).

In addition, discharges do not occur when the inventory in the source dams is below a nominal threshold, as follows:

- Dam 1N - if the volume in Dam 1N is less than 220ML (70 per cent of maximum operating volume)
- Dam 9S – if the combined volumes in Dam 9S and Dam 6S is less than 1,500ML (70 per cent of maximum operating volume).

Note that it is assumed that the number of salt credits held by MTW is not a limitation to releases. Historically there have been sufficient credits available for trade.

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