Section 4

Environmental Features, Management Measures and Impacts

Preamble

This section describes the specific environmental features of the Site and its surrounds that would or may be affected during the life of the amended Rocky Hill Coal Project. Where appropriate, impact assessment criteria are outlined together with the methodology used to predict the potential impacts of the amended Project. The proposed design and/or operational safeguards and management measures are presented, followed by an assessment of the predicted level of impact the proposed activities may have after the implementation of those measures. Where appropriate, proposed monitoring programs are also outlined.

Reference is made at the commencement of Sections 4.2 to 4.18 to the requirements in the DGRs relating to each issue and, where relevant, in the correspondence provided by a range of government agencies or organisations that accompanied the DGRs, or was provided in 2015/2016 following consultation regarding the amended Project. A summary of the requirements included in the additional correspondence provided with the DGRs and where each requirement is addressed in the EIS is presented in **Appendix 4**.

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4.1 REGIONAL AND LOCAL CONTEXT

4.1.1 Introduction

The descriptions of various environmental aspects of the amended Project throughout this section are reliant upon a range of background information common to many of the key environmental issues. In this subsection, background information is provided on the topography, climate, land ownership and residences, land uses and the community in the vicinity of the Site.

4.1.2 Topography

4.1.2.1 Regional Topography

The Site is located within the Stroud-Gloucester Valley, a local valley comprising a series of ridges and undulating lowlands. The regional topography at the northern end of the valley around the Site is shown on **Figure 4.1**. The ridges generally trend north-south, rising 100m to 200m above the valley floor with side slopes ranging from approximately 14° to 45°. The undulating lowlands, with typical slopes of <5° and elevations of 100m AHD to 130m AHD, occur across the valley floor. Terracing occurs adjacent to the main watercourses with the terraces and adjacent floodplains subject to periodic flooding.

Two main river systems are present within the Stroud-Gloucester Valley, namely the Avon River and Gloucester River system which drains to the north, and the Karuah River Coastal System which drains to the south (see Section 4.7.2.1).

4.1.2.2 Local Topography

The Mine Area is located on the eastern side of the Stroud-Gloucester Valley and straddles the two major topographic units, namely the ridges and intermediate undulating lowlands. The local topography is shown on **Figure 4.2**. The most prominent local topographic feature is the Gloucester Bucketts or the Bucketts Range approximately 2km to 3km west and southwest of Gloucester township and 5km to 7km northeast of the Mine Area. Elevations along the top of the Gloucester Bucketts vary from approximately 400m AHD in the south to 546m AHD in the north. The ridge immediately to the east of the Mine Area is referred to locally as the Mograni Range. One named hill within the Mograni Range immediately east of the Mine Area is "Rocky Hill", with an elevation of approximately 440m AHD.

The undulating lowlands centred on the Avon River and Waukivory Creek display gentle slopes with the overall northerly slope consistent with the flow direction of both watercourses.

4.1.2.3 Site Topography

The overall topography of the Site and its immediate surrounds, as well as the individual components areas within the Site, are displayed in **Figure 4.3**.

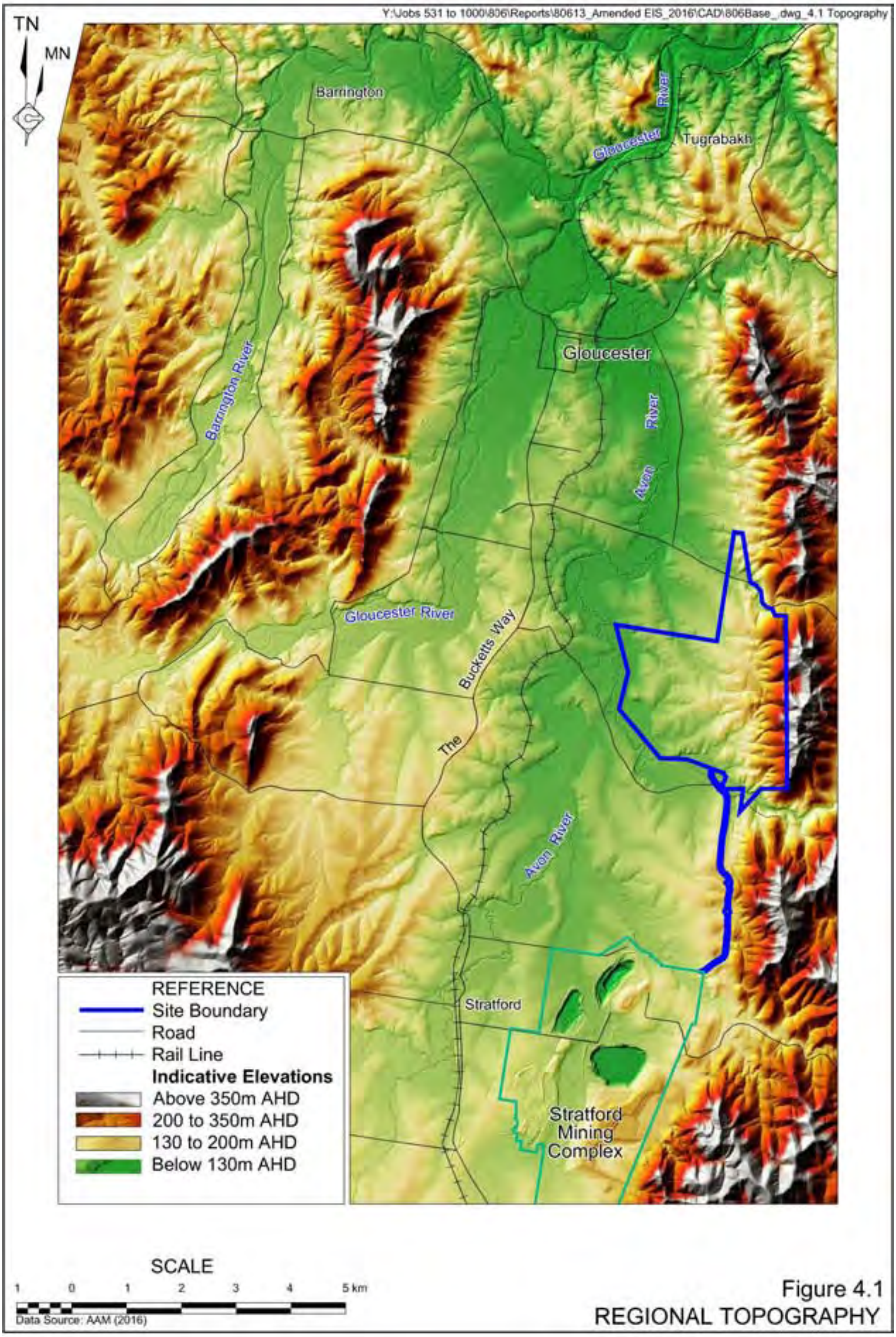


Figure 4.1
REGIONAL TOPOGRAPHY

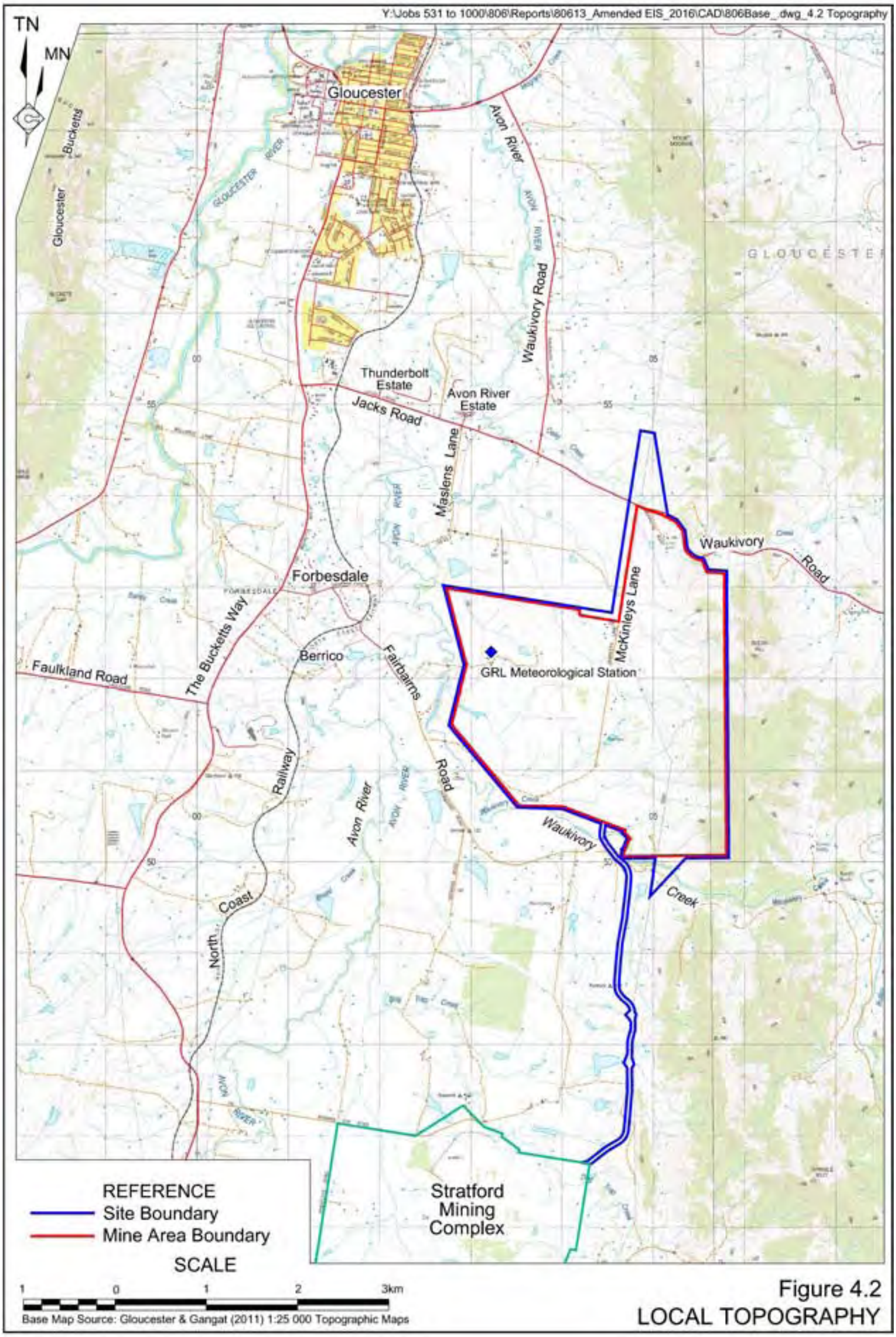


Figure 4.2
LOCAL TOPOGRAPHY

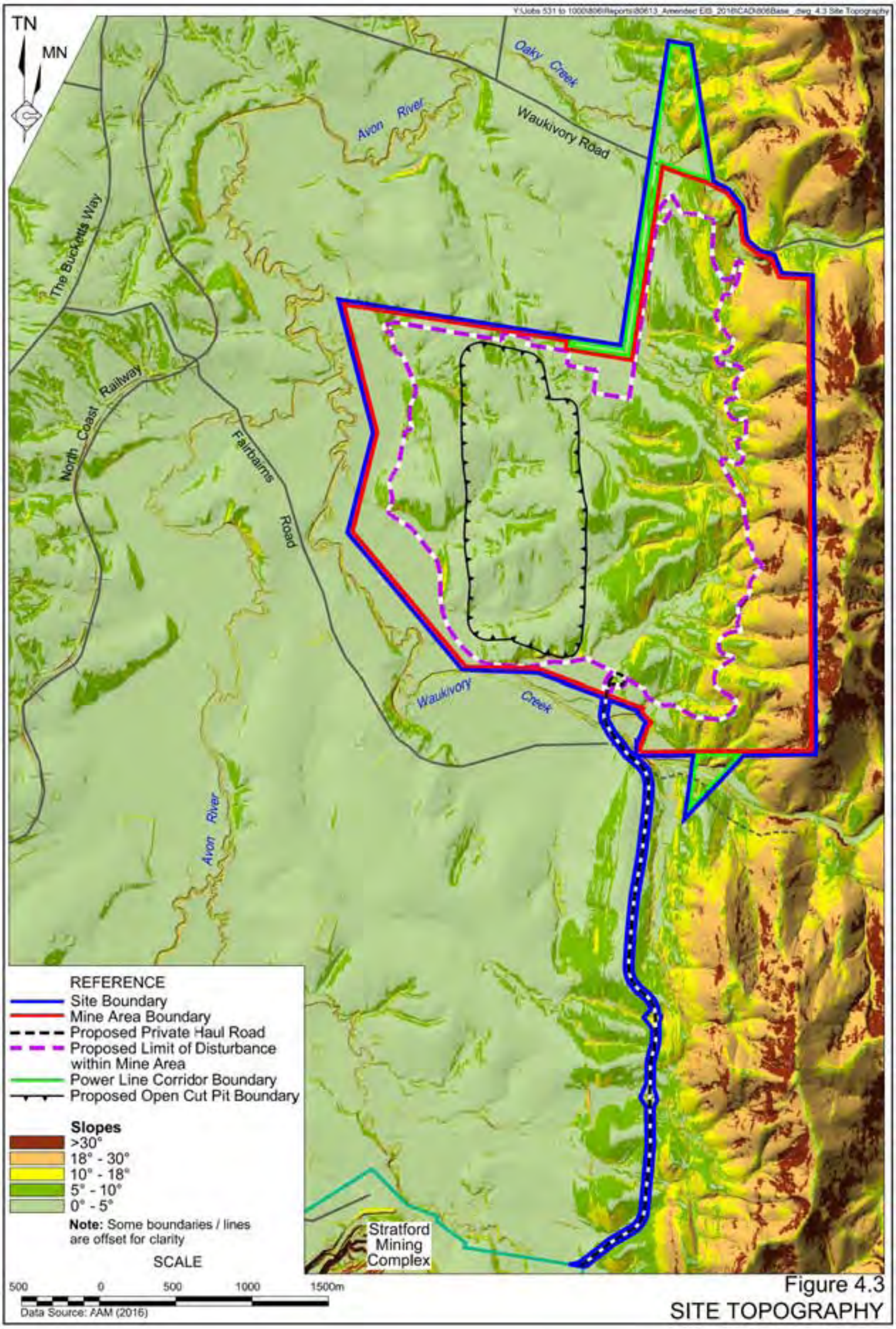


Figure 4.3
SITE TOPOGRAPHY

The Mine Area is located on the lower western slopes of the Mograni Range with elevations varying from approximately 100m AHD near the Avon River and Waukivory Creek to approximately 200m AHD in the area of the proposed eastern limit of mine-related disturbance. Slopes within the area of the proposed open cut pits are typically <5º with some small areas with slopes between 5º and 10º. In the areas to the east of the proposed open cut pits where the permanent and interim overburden emplacements are to be located, the slopes gradually steepen and approach 18º. Further to the east beyond the area of disturbance, the bulk of the slopes are steeper than 18º and periodically exceed 30º.

The corridor for the private haul road is located to the south of the Mine Area and is generally aligned parallel to the Mograni Range, with elevations varying from approximately 100m AHD near the proposed crossing of Waukivory Creek to approximately 170m AHD towards the southern limit of the corridor. The bulk of the corridor is located on the eastern side of a low north-south trending ridge. Side slopes along the ridge typically vary from 5° to 18°.

4.1.3 Meteorology

4.1.3.1 Introduction

Climatic conditions have the potential to influence a range of project-related impacts at surrounding residences or receivers, and the local environment. The climate in the vicinity of Gloucester is referred to as “warm temperate”, i.e. warm to hot summers and mild to cool winters, with the rainfall pattern having a summer maximum.

This subsection provides a brief overview of the climatic conditions in the vicinity of the Site, focusing particularly on those aspects of the climate that are likely to influence the potential project-related environmental impacts.

4.1.3.2 Data Sources

Long-term climate data for rainfall and evaporation were sourced from the Science Delivery Division of the Department of Science, Information Technology and Innovation (DSITI). A Patched Point Dataset (PPD) for the Gloucester Post Office (GPO) (Station # 060015), which is located approximately 5.5km northwest of the Mine Area (see **Figure 4.4**) was used. In this dataset, gaps in the original Bureau of Meteorology measurements are filled with information derived by interpolation of recorded data between stations as described by Jeffrey *et al* (2001).

Additional climate data not recorded at the Gloucester Post Office Station was sourced from the following BOM stations.

- Chichester Dam (Station # 061151) – Temperature: The station is located approximately 38km southwest of Gloucester.
- Lostock Dam (Station # 061288) – Relative humidity: The station is located approximately 57km southwest of Gloucester.

A summary of the principal monthly meteorological statistics for these stations is provided in **Table 4.1**.

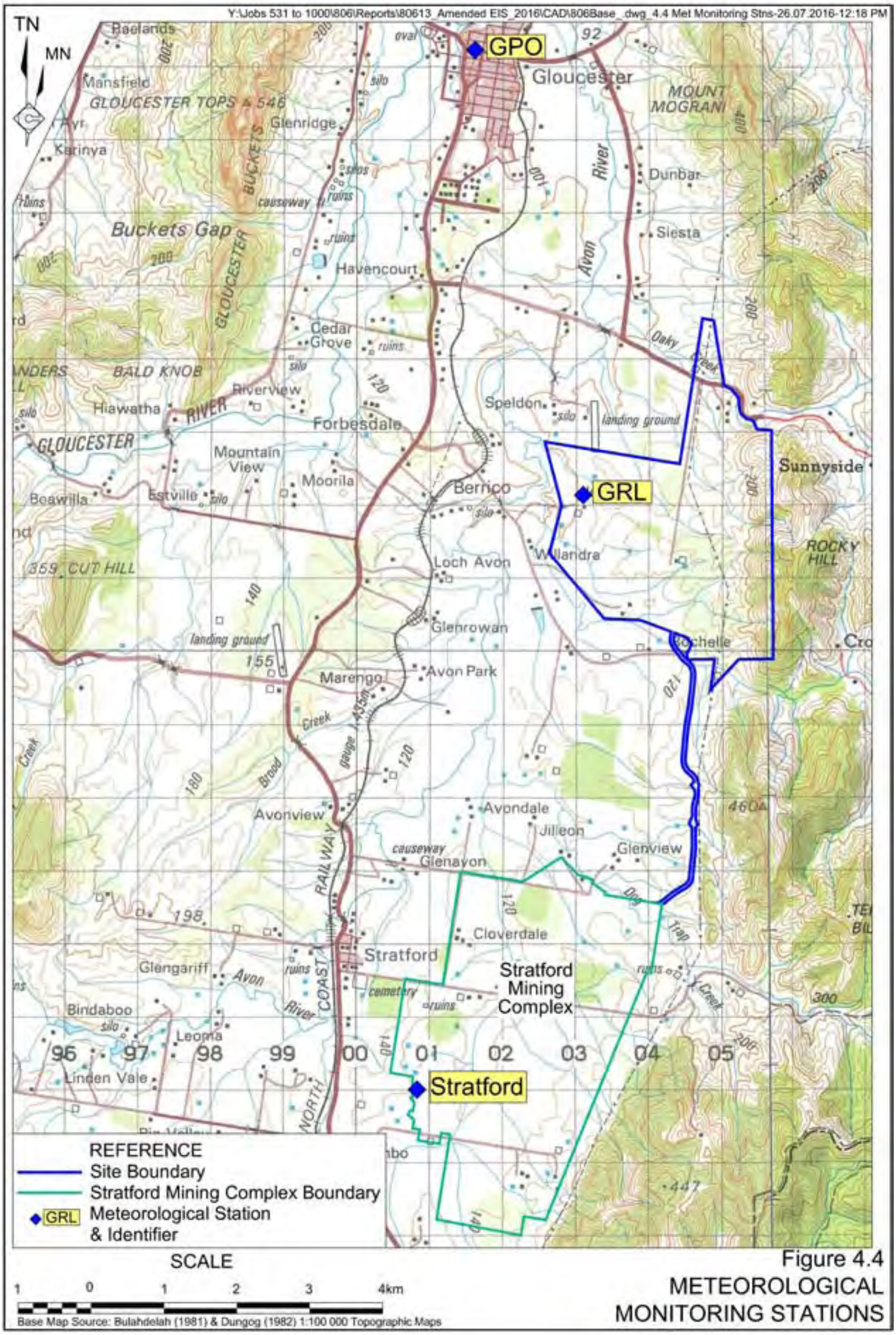


Figure 4.4
METEOROLOGICAL MONITORING STATIONS

The Applicant established a comprehensive meteorological station within the Mine Area in 2010 and Yancoal has been collecting meteorological data since 1995 at a meteorological station within the Stratford Mining Complex (see "Stratford" on **Figure 4.4**). Climatic data collected from both stations have been used and referenced in the relevant specialist consultant's assessments. A summary of temperature, relative humidity, rainfall and evaporation data is presented in **Table 4.1**. The data for both GRL and Stratford are presented for the same period to enable a direct correlation between the data sets.

Table 4.1
Monthly Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C) Chichester Dam Station (Station # 061151) Period of Record 18 Years (1938 – 1956)													
Mean maximum temperature	26.2	24.8	23.3	20.2	17.4	14.2	13.7	16.5	19.1	21.4	24.2	26.6	-
Mean minimum temperature	16.7	16.7	16.2	12.7	9.7	7.0	6.2	6.9	9.8	12.1	14.9	17.2	-
Relative Humidity (%) Lostock Dam (Station # 061288) Period of Record 37 /10 Years (1972 – 2010 / 1927 - 1982)													
Mean 9:00am relative humidity	79	84	84	81	83	81	79	74	69	68	74	73	78
Mean 3:00pm relative humidity	53	59	61	55	56	61	54	46	43	50	45	53	53
Rainfall (mm) PPD[1] Gloucester Post Office (Station # 060015) - Period of Record 126 Years (1889 – 2015)													
Mean monthly rainfall	114	123	128	78	68	68	51	47	51	68	86	103	984
Highest monthly rainfall	474	752	540	324	343	402	274	354	176	277	237	353	1864
Lowest monthly rainfall	0	3	10	0	0	0	0	0	0	0	0	3	498.4
Highest daily rainfall	155	158	184	115	152	118	114	109	90	121	107	112	-
Average Rain Days (>1mm)	9	9	9	7	7	6	5	5	5	7	8	8	-
Rainfall (mm) GRL Meteorological Station - Period of Record 6 Years (2010 – 2016)													
Mean monthly rainfall	121.1	125.7	114.0	72.0	57.4	88.5	39.1	47.4	46.7	41.6	124.2	97.0	963.0
Highest monthly rainfall	228.8	212.4	191.6	112.8	157.2	236.2	79.2	135.2	89.6	85.2	214.6	195.4	1357.4
Lowest monthly rainfall	14.4	55.0	74.8	44.8	4.8	17.2	10.4	2.0	12.4	4.6	37.8	19.0	744.6
Rainfall (mm) Stratford Mining Complex Meteorological Station - Period of Record 6 Years (2010 – 2016)													
Mean monthly rainfall	119.7	130.8	99.8	77.1	65.8	92.4	40.4	48.7	29.4	42.4	119.4	107.5	962.5
Highest monthly rainfall	266.2	284.2	141.8	130.2	137.2	232.2	86.6	113.8	58.8	91.4	168.0	188.0	1311.2
Lowest monthly rainfall	23.0	13.4	47.4	45.0	11.8	21.8	12.6	4.6	2.0	5.8	40.6	16.6	716.2
Evaporation (mm) PPD[1] for Gloucester Post Office (Station # 060015) - Period of Record 126 Years (1889 – 2015)													
Mean Monthly Evaporation	173	136	123	90	64	55	62	88	117	147	155	187	1396
1. Bureau of Meteorology and Science Delivery Division of the Department of Science, Information Technology and Innovation Patched Point Dataset (PPD).													

4.1.3.3 Temperature

December is the hottest month, with a mean maximum temperature of 26.6°C and a mean minimum of 17.2°C. July is the coldest month with a mean maximum temperature of 13.7°C and mean minimum of 6.2°C.

4.1.3.4 Humidity

The mean 9:00am relative humidity results are generally 20% higher than the mean 3:00pm relative humidity conditions, with February and March displaying the equal highest humidity values throughout the year. The lowest relative humidity values occur during September.

4.1.3.5 Rainfall

Mean annual rainfall recorded at the Gloucester Post Office station has varied between 497mm and 1 862mm over a period of 126 years, with an average of 984mm. Rainfall is distributed unevenly throughout the year with August being the driest month (47mm) and December to March being the wettest, with an average of more than 100mm in each of these months. Rainfall can, however, be extremely variable, with infrequent, high intensity rainfall events occurring. This is confirmed by the highest daily rainfall values shown in **Table 4.1**, and the fact that the maximum daily rainfall values are typically between 1.5 and 2 times average monthly rainfall values.

WRM (2016) includes a map (Figure 2.5) displaying the variation in annual rainfall across the entire Avon River catchment.

Mean annual rainfalls recorded at the GRL and Stratford meteorological stations for the 6 year period since July 2010 are 963mm and 962.5mm respectively, which are similar to the long-term average rainfall recorded at the Gloucester Post Office station. The annual rainfall pattern is also similar to the Gloucester Post Office station, however, the range in the minimum and maximum rainfall is less, which is to be expected given the comparatively short period of records.

The period between December and March with the highest monthly rainfalls poses the greatest risk for soil erosion, with the period from July to October with lowest monthly rainfalls posing the least risk.

4.1.3.6 Evaporation

Mean monthly evaporation at the Gloucester Post Office station varies throughout the year, from 187mm in December to 55mm in June. Mean monthly rainfall exceeds evaporation in March, May and June. During all other months, evaporation exceeds rainfall and annual evaporation exceeds rainfall by a factor of approximately 1.4.

Evaporation is not recorded at either of the GRL or Stratford meteorological stations.

4.1.3.7 Wind

A comparative set of wind roses from both the Applicant's and the Stratford Mining Complex meteorological stations for the 12 month period January to December 2015 is presented on **Figure 4.5**. Comparisons for additional years are presented within the Air Quality Assessment (Part 2A of the *Specialist Consultant Studies Compendium*).

The wind data and wind roses show similar patterns with winds dominant from the southern quadrant, particularly during the day and evening periods, and from the northeastern quadrant, particularly during the night time period. The annual percentage of calms (winds less than 0.5 m/s) ranges from 1.7% during the day to 6.7% during the night-time period.

The wind patterns recorded at both the GRL and Stratford meteorological stations reflect the influence of the north-south orientated topography on the wind directions throughout the Stroud-Gloucester Valley, with **Figure 4.6** displaying a 3-dimensional representation of the Site within the valley.

Table 4.2 presents the dominant average annual and seasonal wind directions and percentage occurrence of wind speeds up to 3m/s (those most important when considering noise propagation) during the day, evening and night periods.

Table 4.2
Comparative Statistics for Wind Data Recorded at the GRL Meteorological Station
January 2011 to November 2015

Period	% Calms (<0.5m/s)	Wind Direction (± 45^o)	Wind Speed		
			0.5 to 2m/s	2m/s to 3m/s	0.5m/s to 3m/s
Daytime (7:00am to 6:00pm)					
Annual	1.7%	S	12.9%	6.7%	19.6%
Summer	1.2%	S	10.4%	5.8%	16.1%
Autumn	1.9%	S	14.6%	7.7%	22.4%
Winter	2.9%	S	15.8%	7.1%	22.8%
Spring	1.1%	S	10.9%	6.3%	17.2%
Evening (6:00pm to 10:00pm)					
Annual	3.9%	SSE	16.3%	5.5%	21.8%
Summer	1.0%	ENE	7.5%	7.6%	15.1%
Autumn	4.9%	SSE	19.1%	5.7%	24.8%
Winter	7.2%	SSE, S, SSW	23.4%, 23.1%, 20.5%	5.7%, 5.8%, 4.7%	29.1%, 28.9%, 25.2%
Spring	2.3%	NE	13.9%	8.1%	22.0%
Night Time (10:00pm to 7:00pm)					
Annual	6.7%	NNE	25.8%	4.6%	30.4%
Summer	6.0%	NE	21.9%	6.3%	28.2%
Autumn	6.8%	N, NNE, NE	26.9%, 29.5%,29.3%	3.5%, 3.3%, 2.6%	30.4%, 32.8%, 31.9%
Winter	6.9%	NNE	26.4%	3.1%	29.5%
Spring	6.9%	NNE, NE	26.2%, 25.6%	5.1%, 4.1%	31.3%, 29.7%
Source: SLR Consulting (2016) – Modified after Appendix G1					

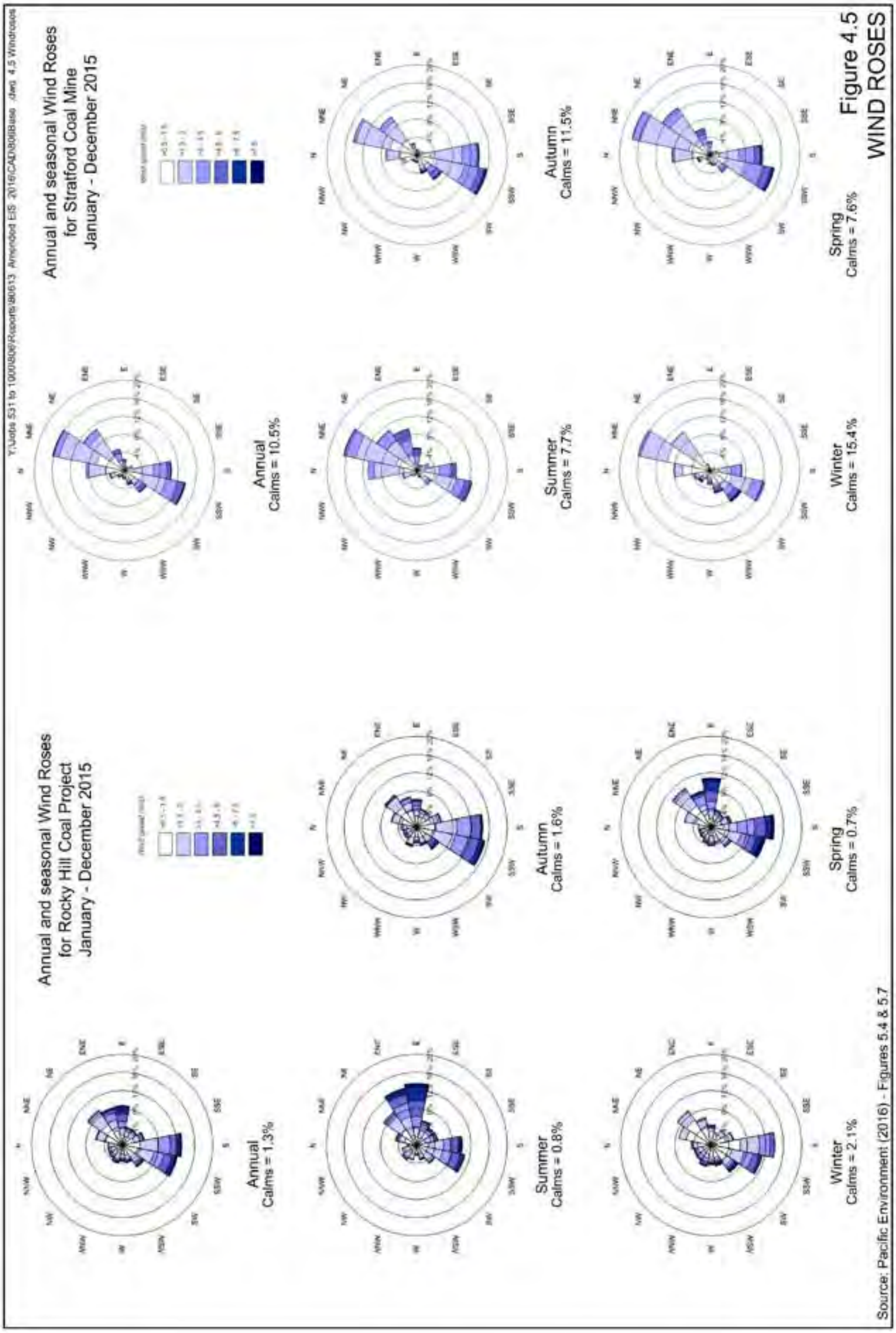
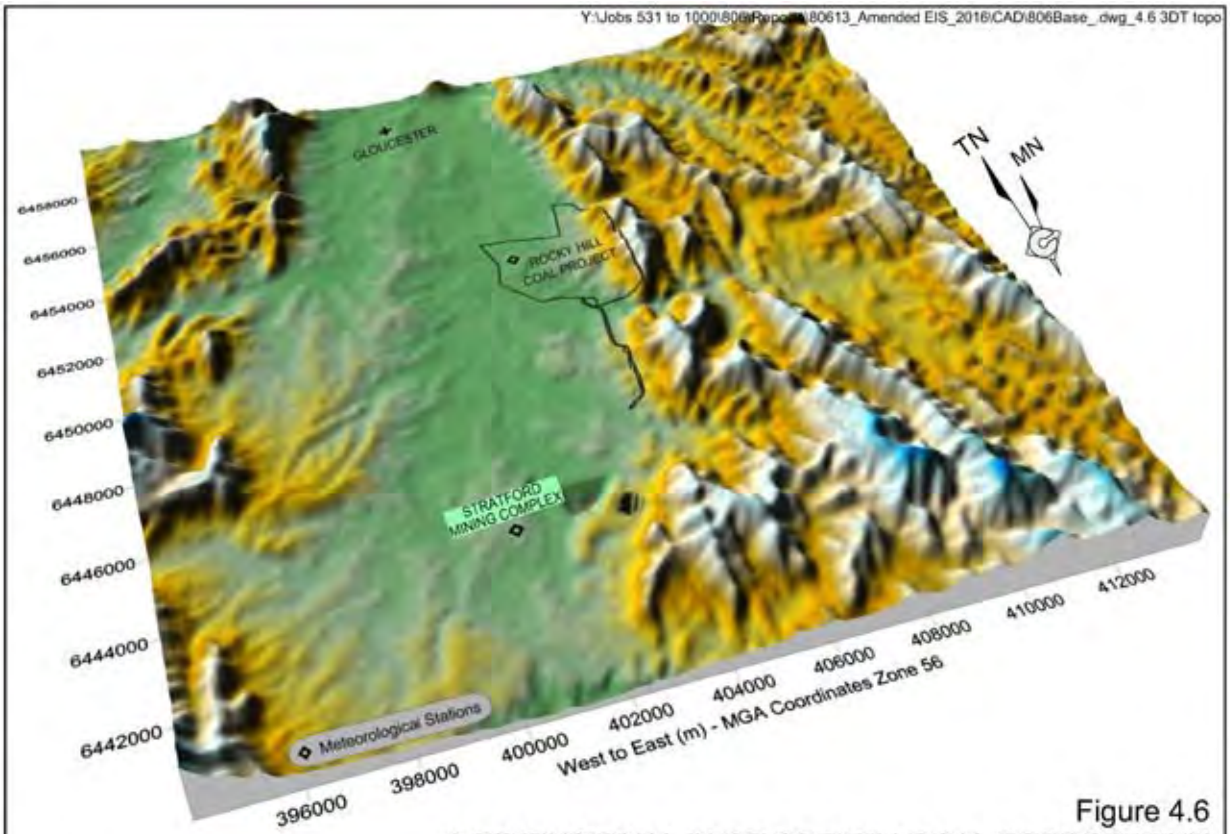


Figure 4.5
WIND ROSES

Source: Pacific Environment (2016) - Figures 5.4 & 5.7



Source: Pacific Environment (2016) - Figure 3.2

Figure 4.6
3-DIMENSIONAL PLOT OF THE LOCAL TOPOGRAPHY

4.1.3.8 Temperature Inversions

Given that the proposed hours of operation for the amended Project are confined to daytime and evening only (i.e. 7:00am to 10:00pm), assessment of atmospheric stability classes and associated estimated temperature gradients is not required. However, SLR (2016) notes that on some evenings atmospheric conditions are such that atmospherically stable conditions occur coinciding with the gradual development of temperature inversions. The Applicant acknowledges that on those evenings, some restrictions may be required in the location of equipment to ensure noise levels are maintained within the relevant noise criteria. These conditions would be more prevalent in winter. Wilkinson Murray (2013) identified temperature inversions greater than 3°C/100m are predicted to occur during 9% of winter evenings, i.e. by 10:00pm.

4.1.4 Land Ownership and Residences

4.1.4.1 Land Ownership

All privately-owned land within the Site is owned by or under option to purchase by the Applicant (or related companies) or owned by Yancoal Australia Limited (Yancoal) (or related companies).

Figure 4.7 presents the land ownership within and in the vicinity of the Site. Land ownership data was sourced from an extensive search of the register of land titles administered by the Land and Property Information (LPI) with ongoing searches undertaken to provide the most complete, up-to-date land ownership information available.

The land ownership search established that the rural properties to the north, west and south of the Site vary in area from 150ha to 250ha with a range of rural lifestyle blocks typically between approximately 4ha and 120ha in area. The rural properties to the east of the Mine Area generally exceed 250ha in area.

Appendix 7 includes a full register of the ownership of land around the Site together with co-ordinates of the residences located on each parcel of land.

4.1.4.2 Residences and Sensitive Receivers

Figure 4.7 also displays the locations of privately-owned residences in the vicinity of the Site, together with those residences that are owned or under option to purchase by the Applicant or owned by Yancoal or AGL or their related companies. Throughout this document, a distinction is made between privately-owned residences and residences on resource company-owned land, specifically with respect to potential noise, vibration and air quality impacts.

The locations of residences on **Figure 4.7** were prepared based on site inspections from public roads by the Applicant and interpretation of aerial photographs. As a result, while all reasonable steps were taken during preparation of these figures and the associated table to ensure their accuracy, it may be that some land ownership details have changed since the date of the latest database search, that changes to land ownership details, though preceding the date of search, have not yet been recorded on the LPI database or that some structures identified as residences are not actual residences and vice versa.

The privately-owned residences in the vicinity of the Site are either scattered on the surrounding rural or lifestyle properties or within one of three rural-residential or large allotment estates, i.e. areas zoned R5 in Gloucester LEP 2010 (see **Figure 3.4**).

Table A7.3 (**Appendix 7**) lists the distances to a representative set of privately-owned residences on the surrounding rural or lifestyle properties from the closest area of disturbance and open cut pit within the Mine Area. **Table A7.4** (**Appendix 7**) lists the nearest privately-owned residences adjacent to the proposed access route to the Mine Area from The Bucketts Way via either Waukivory Road (north of Jacks Road) or Jacks Road.

The closest rural-residential estate is the Forbesdale Estate where properties vary in size from 1.1ha to 13.7ha. The residences in this estate are located between 1.3km and 2.0km west of the western edge of the western and northern amenity barrier and 1.8km and 2.5km west of the closest open cut pit.

The Avon River Estate is located approximately 1.8km to 2.4km northwest of the Mine Area and immediately north of Jacks Road, the main access route to the Mine Area once the Jacks Road Bridge over the Avon River is replaced. The Avon River Estate contains 44 lots varying in size from approximately 4 000m^2 to 27 000m^2. At May 2016, approximately 22 residences were fully constructed and occupied. At that time, a total of approximately 22 lots remained vacant or for sale.

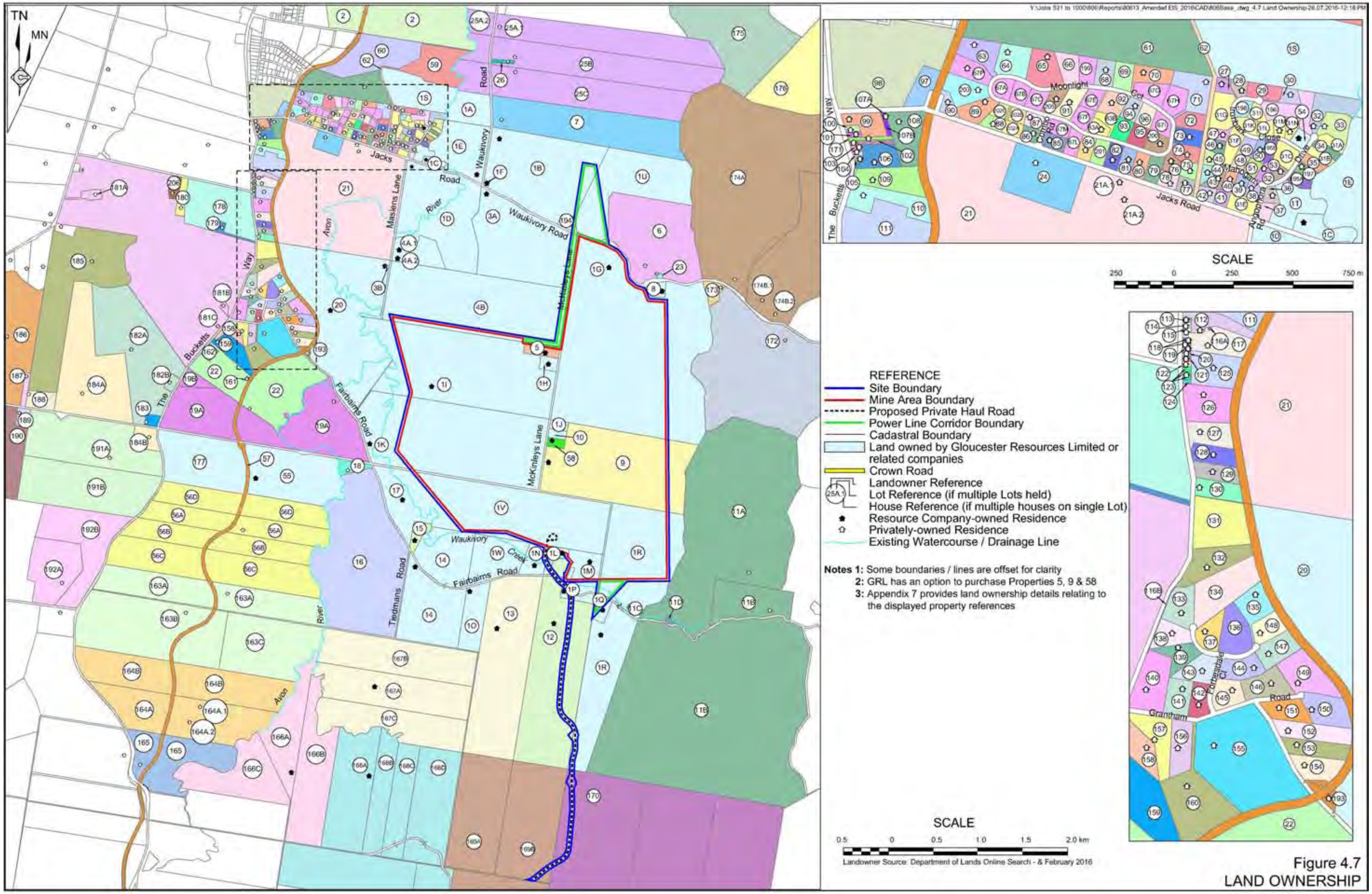


Figure 4.7
LAND OWNERSHIP

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The Thunderbolt Estate, also north of Jacks Road, is located approximately 1.9km to 2.8km northwest of the Mine Area. The estate contains 51 lots varying in size from approximately 4 600m^2 to 20 000m^2. At May 2016, approximately 29 residences were fully constructed and occupied and a total of approximately 22 lots remained for sale and were vacant.

The closest privately-owned residences to the private haul road are located approximately 1.5km to the southeast of its southern-most extent and 3.6km to the west. The residence to the southeast would be closer to the section of the haul road within the Stratford Mining Complex.

Figure 4.8 displays the locations of a range of community facilities within Gloucester township recognised to be sensitive receivers with respect to noise and/or air quality. **Table 4.3** lists the distances from a selection of these facilities to the Site components.

Table 4.3
Distance from Selected Community Facilities in Gloucester to Site Components

Facility (see Figure 4.8) (Reference)	Distance (km)		
	Closest Area of Disturbance	Closest Open Cut Pit	ROM Pad
Gloucester Post Office	5.5	5.9	8.0
Gloucester Urban Area (Reeves Estate)	3.5	4.0	6.3
Gloucester Hospital (H1)	4.7	5.1	7.2
Gloucester High School (S4)	4.5	5.0	6.8
Hillcrest Aged Care Facility (H3)	4.7	5.1	7.2
Gloucester Park Complex (P1)	5.6	6.2	8.1
Babblers Walk (P12)	3.6	3.9	6.0
Anglican Church (C5)	5.2	5.5	7.6
Jehovah's Witness Kingdom Hall (in Industrial Estate) (C6)	3.5	4.0	6.1
Captain Cook Park (P5)	4.1	4.3	6.4

In summary, the closest health facilities (Gloucester Hospital and the Hillcrest Aged Care Facility) are approximately 4.7km from the closest area of disturbance and 5.1km from the closest open cut pit. The closest school is Gloucester High School which is approximately 4.5km from the closest area of disturbance and 5.0km from the closest open cut pit. The closest playing fields are located within Captain Cook Park, approximately 4.1km from the closest area of disturbance and 4.3km from the closest open cut pit.

4.1.5 Land Uses

4.1.5.1 Site Land Uses

Land within the Site has historically been used for agricultural purposes, principally grazing for beef cattle and some dairy operations. The Site also includes areas primarily used for nature conservation on the upper slopes of the Mograni Range. A total of five residences were originally within the Site, one of which has been partially demolished since 2013.

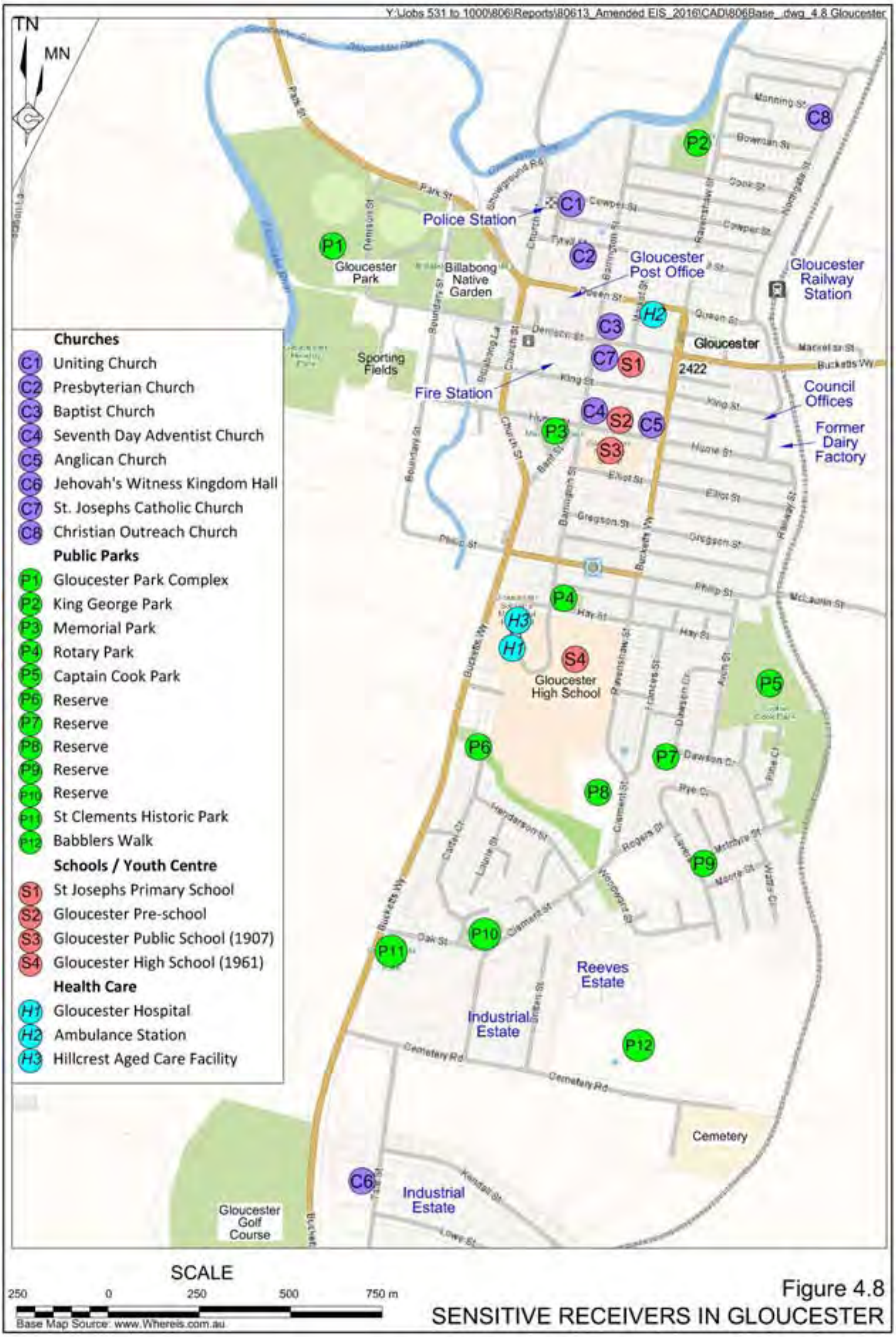


Figure 4.8
SENSITIVE RECEIVERS IN GLOUCESTER

4.1.5.2 Surrounding Land Uses

Figure 4.9 displays the range of land uses in the vicinity of the Site. The land used for agricultural purposes has been categorised based upon the level of agricultural management intervention which has established three types of agricultural land are present, namely areas of:

1. high land productivity intervention;
2. occasional land productivity intervention; and
3. minimal land productivity intervention.

One of the largest dairy operations within the former Gloucester LGA, the Speldon Partnership (the Partnership) Dairy, operates on the Applicant's land adjacent to the Mine Area under a lease agreement. In addition to the lease back of the land formerly owned by the Partnership, the Applicant has reached an agreement with the Partnership to allow grazing and fodder production to be undertaken on land within the Mine Area as well as adjoining land owned by the Applicant that will not be used for mining or mining-related purposes. This represents an increase of up to approximately 1 130ha of land available for dairying and beef production purposes. All other agricultural land owned by the Applicant is also leased for agriculture. Further information on the agricultural uses of the Applicant's land is provided within the Agricultural Impact Statement (Volume 5 Part 13 of the *Specialist Consultant Studies Compendium*).

Land uses that occur in the wider regional area are also dominated by the beef and dairy industries, with smaller, niche livestock operations also existing including goats for milk and meat, pigs and sheep for meat, as well as specialised hormone free beef operations. Fruit, herbs and vegetables are also grown, as well as grapes and olives and silver perch aquaculture operations.

Farmstays and Bed and Breakfasts (B&Bs), which account for more actual available beds than the hotel, motel/resort components within the immediate Gloucester area, occur throughout the former Gloucester LGA, the majority based to the west of The Bucketts Way. In the vicinity of the Site, these businesses include a B&B in Thunderbolt Estate ("Gloucester on Avon") and a B&B in the Forbesdale Estate subdivision ("Avon View") (see **Figure 4.9**). "Ashmar" Farmstays, a farm-based accommodation experience is located approximately 5km southeast of the Mine Area (to the east of the Mograni Range), with self-contained accommodation ("Waterhen's Ramble") located near the village of Waukivory, approximately 6km southeast of the Mine Area and also east of the Mograni Range.

Other notable land uses in the vicinity of the Site include the Gloucester Airstrip directly north of the Mine Area on land owned by the Applicant. The Gloucester Airstrip has a grassed surface without markings or lighting. There are no scheduled services utilising the airstrip but it is utilised by the local Gloucester Aero Club.

The site of the former Boral timber mill on the eastern side of The Bucketts Way is now used as a log processing works. This site is also proposed as a scrap metal collection and processing depot. The remainder of this property is used for cattle grazing or related agricultural purposes such as hay production.

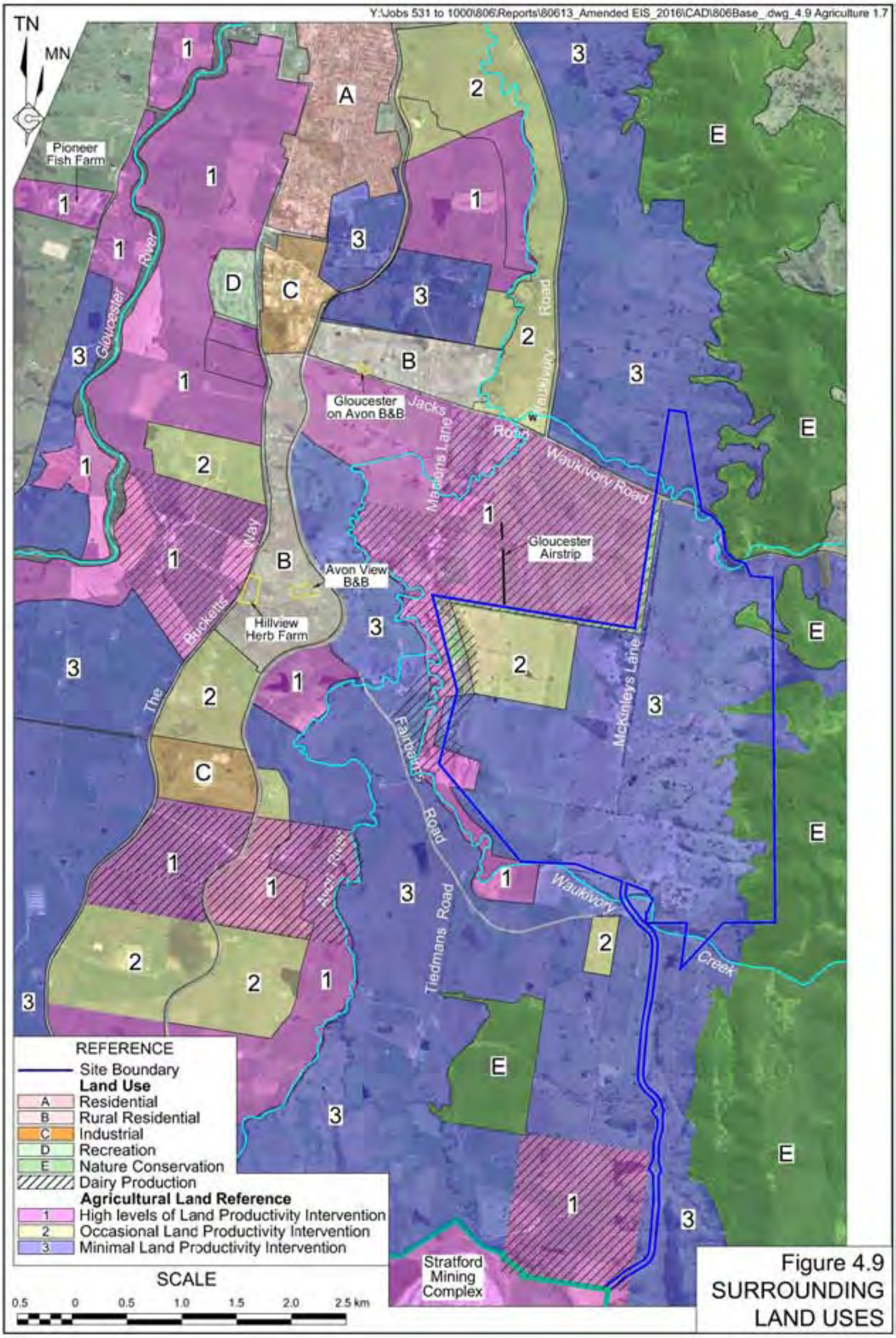


Figure 4.9
SURROUNDING LAND USES

4.2 NOISE

The noise assessment of the amended Project was undertaken by SLR Consulting Australia Pty Ltd (SLR) as part of the overall Noise, Vibration and Blasting Assessment. The full assessment is presented in Volume 1 Part 1 of the Specialist Consultant Studies Compendium and is referenced throughout this section as SLR (2016), with a summary of the assessment presented in the following subsections.

It is noted that reliance has been placed on the previously collected background noise monitoring data, some of which was collected by SLR, with the remainder collected by Wilkinson Murray Pty Ltd, acoustical consultants, who undertook the acoustic assessment of the 2013 Project (Wilkinson Murray, 2013).

It is noted that SLR has also undertaken the acoustical and vibration assessment of the Stratford Extension Project and is therefore well positioned to undertake the required cumulative noise impact assessment of both mining operations.

4.2.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to noise and their risk rankings after the adoption of standard mitigation measures are as follows.

- Noise emissions from activities undertaken during the site establishment and construction stage both on site and off site (high).
- Noise emissions from mining and breaker station operations impacting amenity (medium).
- Noise emissions from activities undertaken during the site establishment and construction stage impacting health (low).
- Noise emissions from mining operations impacting health (low).
- Noise generated during transportation of sized coal from the Mine Area to the Stratford Mining Complex (low).

In addition, the Director-General's Requirements issued by the then Department of Planning and Infrastructure (DP&I) (now DPE) identified "Noise" as one of the key issues requiring assessment. The principal assessment requirements from DP&I relating to noise include the following.

- Construction, operational and off-site transport noise impacts.
- Reasonable and feasible mitigation measures (including assessments of restricted night-time operations, not operating at night and not operating during evening and night-time[1] hours), including evidence that there are no such measures available other than those proposed.
- Monitoring and management measures, in particular real-time, attended noise monitoring and predictive meteorological forecasting.

[1] The amended Project would not involve any night-time activities.

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA, the former Gloucester Shire Council, NSW Health – Hunter New England Local Health District, and BGSPA. The additional matters identified in that correspondence are generally consistent with those listed within the DGRs, although the EPA requested that the EIS detail the number and location of residents who will be able to hear mine noise for the first time. The BGSPA also requested that problem noise "be recorded inside the dwelling as well as outside".

Some of the matters raised by the EPA have been discussed further with officers of the Authority to clarify the approach to be taken in the Noise Impact Assessment and the EIS.

4.2.2 Existing Noise Environment

4.2.2.1 Introduction

Noise which is currently audible at residences in the vicinity of the Site is variously attributable to a range of sources including:

- traffic on local roads and The Bucketts Way;
- trains on the North Coast Railway Line;
- domestic noises such as lawn mowers and leaf-blowers;
- rural noises such as tractors, stock and birds;
- wind in trees;
- livestock/vehicles on properties and at the Gloucester Livestock Exchange Centre; and
- occasional light aircraft using the Gloucester airstrip.

The existing noise environment has been established through a comprehensive program involving both unattended and attended noise monitoring undertaken by both SLR Australia Consulting Pty Ltd and Wilkinson Murray Pty Ltd.

4.2.2.2 Unattended Noise Monitoring

Unattended noise monitors were placed at 16 separate, representative locations in the vicinity of the Site during four periods of 9 to 19 days per period between July 2010 and July 2012, with the locations of these noise monitors displayed on **Figure 4.10**. Monitoring during July 2012 included four locations within Gloucester township. Noise levels were continuously monitored at 15-minute intervals and the data analysed to determine the Rating Background Level (RBL)[2] and the long-term average, or $L_{Aeq(period)}$ noise level at each location. These values are used in the EPA's Industrial Noise Policy (INP) to determine noise criteria, as described below. Meteorological data recorded at the Applicant's on-site meteorological station were reviewed for each monitoring period to identify the unfavourable conditions for measured noise levels, i.e. periods of rain or periods when the wind speed exceeded 5m/s, and noise levels recorded under these conditions were excluded, as required under the INP.

[2] Rating Background Level – the overall single-figure background noise level representing each assessment period (day / evening / night) over the whole monitoring period.

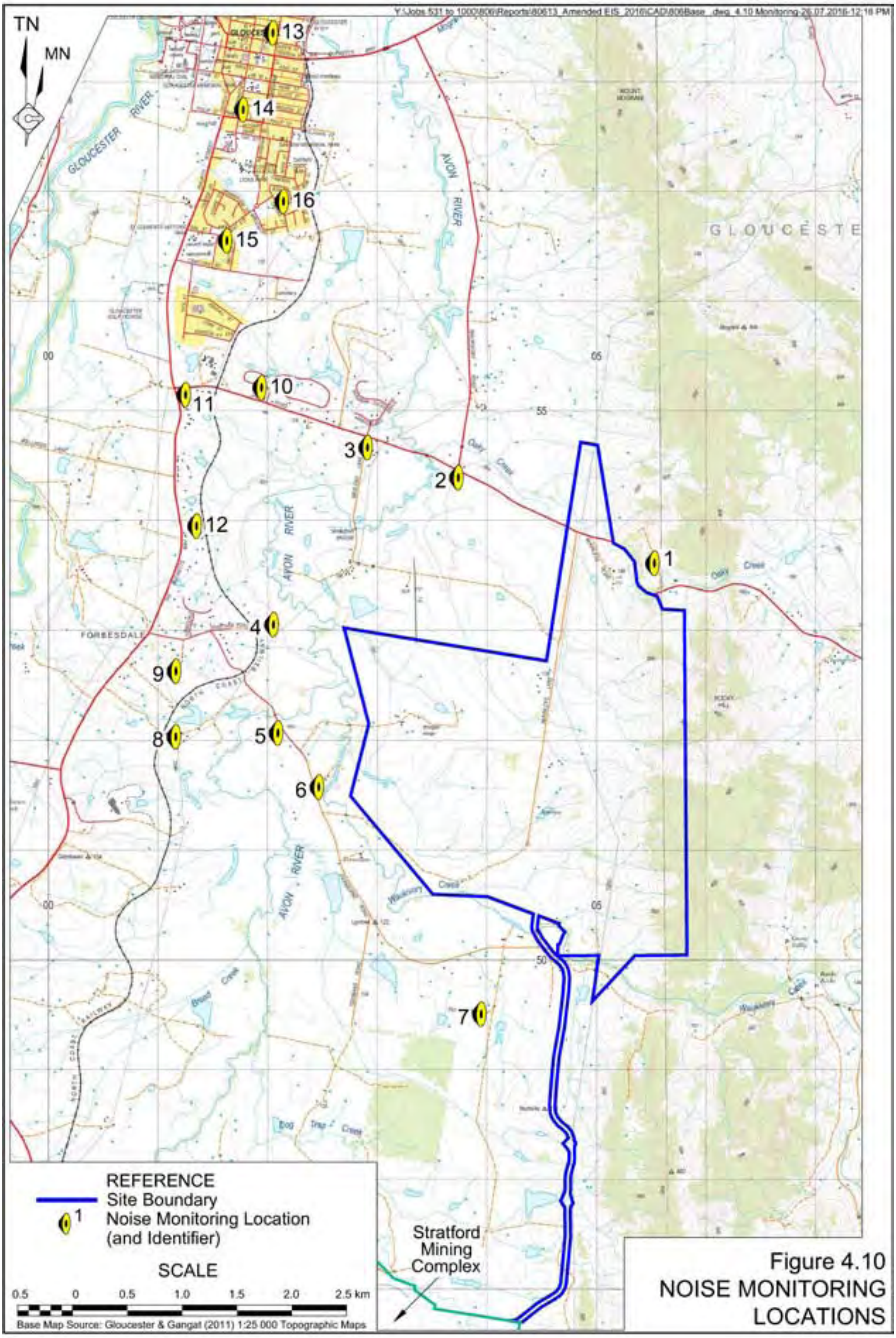


Figure 4.10
NOISE MONITORING LOCATIONS

Details of the monitoring results from the unattended monitoring are presented in Section 4.2.2.2 and 4.2.2.3. SLR (2016) notes that given there have not been any substantial change in land uses in the vicinity of the Site and associated background noise monitoring locations since 2012, except for the discontinued operation of the saw mill near the intersection of The Bucketts Way and Jacks Road, the noise measurement results remain valid and applicable to the amended Project.

Noise levels were recorded at:

- Locations 1 to 9 during July 2010;
- Locations 10 to 12 during March 2011;
- Locations 1, 3, 9 to 12 during July 2011; and
- Locations 10, 13 to 16 during July 2012.

Table 4.4 lists the measured background levels at all 16 locations. It is noted that in accordance with the INP, if RBL is below 30dB(A), then 30dB(A) shall be the RBL.

Table 4.4
Unattended Ambient Noise Environment

Area	Monitoring Location*3	Landowner Ref and Name or Address*5	Rating Background Level*1, *4 dB(A)		$L_{Aeq(Period)}$ Level*1, *4 dB(A)	
			Day	Evening	Day	Evening
Waukivory Road (east of Jacks Road)	1	6 Campbell	30	28	46	36
	2	3A GRL	27	28	46	43
Jacks Road (east of the railway line)	3	1D – GRL	26	25	46	42
	10*2	87 – Yates & Moore	31	27	48	42
Forbesdale Estate and Fairbairns Road	4	20 – GRL	30	28	47	42
	5	19A – Boorer	26	24	50	44
	6	1K – GRL	27	27	46	39
	7	13 – AGL	26	26	47	49
	8	22 – Harris	30	27	60	45
	9	160 – Toth	29	25	48	42
Corner of The Bucketts Way and Jacks Rd	11	99 – Maurer & Kilipikoski	38	29	58	53
Adjacent The Bucketts Way	12	129 – Galvin	35	27	52	50
Gloucester Suburban Area	13	35 Tyrrell Street	32	28	50	42
	14	80 Barrington Street	35	28	51	42
	15	44 Clement Street	32	28	50	42
	16	3 Beach Close	30	30	57	41

Notes *1: (dB(A) re 20µPa)
*2: 5 days duration
*3: See Figure 4.10
*4 Day = 7:00am to 6:00pm. Evening = 6:00pm to 10:00pm Monday to Saturday
*5 See Figure 4.7

Source: SLR (2016) – Modified after Table 14

The results of the monitoring have established that the Site is located in a typical rural area with few noise sources and generally low noise levels, particularly background noise levels. Noise monitoring undertaken during March 2011 showed higher noise levels than July 2010, July 2011 and July 2012, reflecting the presence of insects. While reliance was not placed upon the March 2011 noise levels when establishing the RBLs and noise criteria, the results identify the higher levels of background noise that are already present in the surrounding community during those periods of the year when noise-producing insects are present.

For the three monitoring locations near The Bucketts Way and/or local industry (Locations 11, 12 and 14), the daytime background noise levels were elevated above those recorded elsewhere due to the noise generated by local sources in their vicinity. It is noted that given the saw mill near the intersection of The Bucketts Way and Jacks Road has closed since the background noise measurements were taken, SLR (2016) has reduced the overall daytime rating background level by 3dB(A) at the residences adjacent to The Bucketts Way.

As daytime levels were higher at the four monitoring locations in Gloucester township (Locations 13, 14, 15 and 16), SLR (2016) has similarly reduced the daytime rating background level for Gloucester township residences by 3dB(A). A 1dB(A) reduction during the daytime has also been assigned to the residences that have a frontage onto Jacks Road. Evening background levels were at or below 30dB(A) at all locations.

Each of the reductions in rating background levels was taken into account when setting the project specific noise levels for the amended Project (see Section 4.2.4.3).

4.2.2.3 Attended Noise Monitoring

Attended noise monitoring was undertaken at all 16 monitoring locations over a number of rounds and during day and evening periods, generally at the beginning and end of the unattended noise monitoring program. Details of the number of operator-attended surveys are presented in Table 4.1 of Wilkinson Murray (2013).

These measurements were used largely to confirm the sources of noise measured in the unattended monitoring. At Locations 11, 12 and 14, noise from traffic and/or other industrial sources was a significant contributor to the measured ambient noise levels but invariably only in the daytime. However, in those cases, the estimated contribution from other industrial noise was well below levels requiring inclusion in an analysis of cumulative noise impacts under the INP.

4.2.2.4 Existing Traffic Noise

Noise attributed to existing traffic was established through the use of two unattended noise loggers positioned adjacent to The Bucketts Way (Location 11) and Waukivory Road east of Jacks Road (Location 2) – see **Figure 4.10**. The daytime $L_{Aeq(15\ hour)}$ noise level was established to be 46dB(A) at 54m at Location 2 (Waukivory Road, east of Jacks Road) and 57dB(A) at 72m at Location 11 (The Bucketts Way, south of Jacks Road). The night-time $L_{Aeq(9hour)}$ noise Level established at Location 11 was 52dB(A) and at Location 2 was 38dB(A). The daytime and night-time peak $L_{Aeq(1hour)}$ noise levels at Location 2 were 51dB(A) and 43dB(A) respectively. These levels have been used to calculate existing traffic noise levels at other locations adjacent to these roads.

4.2.3 Potential Noise Impacts

There is potential for the various activities associated with the amended Project to generate noise-related impacts at the surrounding residences and sensitive receivers within Gloucester township. The following activities associated with the amended Project have been identified as sources of potential noise-related impacts.

- Construction activities (on site and off site) during the site establishment and construction stage. (Daytime - Monday to Saturday and occasional evenings Monday to Friday).
- Mining operations (Daytime - Monday to Saturday: Years 1 to 3 and Daytime and Evening – Monday to Saturday Years 4 to 16).
- Breaker station operations (Daytime only – Monday to Saturday: Years 1 to 16)
- Coal transportation to Stratford Mining Complex (Daytime only – Monday to Saturday: Years 1 to 16).
- Traffic on local roads (both light and heavy vehicle movements) (predominantly Daytime and Evening – Monday to Saturday: Years 1 to 16).
- Mine closure/rehabilitation activities (Daytime and Evening – Monday to Saturday: Years 17 to 19).

It is noted that sleep disturbance of a night is not considered as a potential impact given there would be no night-time mining operations, breaker station operations nor sized coal transportation to the Stratford Mining Complex. This approach is consistent with the INP. However, notwithstanding the approach taken by the EPA, sleep disturbance is considered in this document given activities would be undertaken of an evening: it is common practice for young children and elderly persons to retire to bed before 10:00pm (see Section 4.2.7.7).

The extent to which noise from the Site operations can cause noise-related impacts is a function of many variables, each of which is discussed in this subsection.

4.2.4 Impact Assessment Criteria

4.2.4.1 Introduction

The following subsections summarise the noise criteria used by SLR (2016) to assess the noise impacts of the amended Project at privately-owned residences and land within the vicinity of the Site and at a range of sensitive receivers within Gloucester township. For the purposes of defining the relevant operational and traffic noise criteria, the following periods define daytime, evening and night-time.

- Daytime – 7:00am to 6:00pm (Monday to Saturday)
- Daytime – 8:00am to 6:00pm (Sunday and public holidays)
- Evening – 6:00pm to 10:00pm
- Night-time – 10:00pm to 7:00am (Monday to Saturday)
- Night-time – 10:00pm to 8:00am (Sunday and public holidays)

For the purposes of defining the relevant traffic noise criteria, the following periods define daytime and night-time.

- Daytime – 7:00am to 10:00pm, a period of 15 hours.
- Night-time – 10:00pm to 7:00am, a period of 9 hours.

It is noted that the only planned activities of a night-time would be the arrival and departure of workforce personnel, i.e. before 7:00am and after 10:00pm, and inaudible equipment pre-start checks and maintenance activities.

4.2.4.2 Construction Noise Assessment Criteria

Noise generated throughout the site establishment and construction stage has been assessed by SLR (2016) in accordance with the EPA's Interim Construction Noise Guideline (DECC, 2009) which nominates the following standard hours or time restrictions for construction activities that generate noise levels exceeding normal operational criteria.

- Monday to Friday – 7:00am to 6:00pm
- Saturday – 8:00am to 1:00pm
- No work on Sundays or Public Holiday

The Guideline recommends a construction noise management level (CNML) equivalent to the daytime Rating Background Level (RBL) + 10dB(A) during the standard hours and RBL + 5dB(A) outside the standard hours. The guideline also nominates a "highly noise affected level" (HNAL) daytime intrusive $L_{Aeq(15min)}$ noise level of 75dB(A), a level that is invariably approached for only short periods of time.

4.2.4.3 Intrusive and Amenity Assessment Criteria for Operational Noise

The INP specifies two noise criteria for operational noise, namely:

- an intrusiveness criterion which requires that the equivalent continuous noise level over a 15 minute period ($L_{Aeq,15\ minute}$) from a specific source (such as a mine) at a privately-owned residence should not exceed the RBL by more than 5dB(A); and
- an amenity criterion which aims to maintain noise amenity throughout a community over the whole daytime, evening or night-time periods and considers cumulative noise from all industrial sources. The amenity noise level should not exceed the specified "acceptable" or "maximum" criterion appropriate for the particular land use.

In order to establish the relevant noise criteria, the INP prescribes detailed calculation routines for establishing project specific noise levels (PSNLs) at potentially affected receivers.

Based on the existing RBLs for the daytime and evening periods presented in **Table 4.4**, i.e. those periods relevant to the amended Project, the derived intrusiveness criteria are presented in **Table 4.5**. The acceptable amenity level criteria for both daytime and evening are also included on **Table 4.5**.

Table 4.5
Project-specific Noise Levels and Intrusiveness and Amenity Assessment Criteria

Locality	INP Noise Amenity Zone[1]	Intrusive $L_{Aeq(15minute)}$[2]		Amenity $L_{Aeq(period)}$[2] Acceptable	
		Daytime	Evening	Daytime	Evening
Residences adjacent The Bucketts Way	Suburban Residential[3]	40	35	55	45
Gloucester urban residences (excluding residences located adjacent The Bucketts Way)		37	35		
Gloucester Jacks Road rural residences including the Thunderbolt and Avon River Estates	Rural Residential[3]	35	35	50	45
Other rural residences					
Forbesdale, Waukivory, Faulkland and Stratford rural residences (excluding residences located adjacent The Bucketts Way)					
Any, including the Gloucester general industrial receivers (north of Jacks Road and south of Oak Street)	Industrial	Intrusive noise criteria not applicable		External 70 when in use	
Any	Commercial			External 65 when in use	
Any	Active Recreation			External 55 when in use	
Any	Passive Recreation			External 50 when in use	
Any	Church, Cemetery			External 50 when in use[3]	
Any	Hospital			External 50 when in use	
Any	School			External 45 when in use[3]	

Note 1: In accordance with the INP Section 2 Industrial Noise Criteria.
Note 2: Daytime 7:00am to 6:00pm, Evening 6:00pm to 10:00pm.
Note 3: At the most-affected point within 30 m of the residential premises.
Note 4: External criteria equivalent to internal criteria plus 10dB(A).
Source: SLR (2016) – Tables 18 and 19

The INP states that the PSNLs are based on preserving the amenity of at least 90% of the population living in the vicinity of industrial noise sources such as mines by limiting the adverse effects of noise for at least 90% of the time. Provided the PSNLs are achieved, then most people would consider the resultant noise levels acceptable. In those cases where the PSNLs are not achieved, it does not automatically follow that all people exposed to the noise would find the noise "unacceptable". In subjective terms, the NSW Government's *Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Development* characterises noise impacts resulting from residual noise exceedances of the PSNLs generally as follows.

- If the residual noise exceedance is 0-2dB(A) above the PSNL, then noise impacts are considered to be negligible.
- If the residual noise exceedance is 3-5dB(A) above the PSNL, and the development would contribute less than 1dB to the total industrial noise level, then noise impacts are considered to be marginal.
- If the residual noise exceedance is 3-5dB(A) above the PSNL, and the development would contribute more than 1dB to the total industrial noise level, then noise impacts are considered to be moderate.
- If the residual noise exceedance is >5dB(A) above the PSNL, then noise impacts are considered to be significant.

In the event the noise generated by a development exceeds the PSNL at any residence on privately-owned land by more than 5dB(A), a consent authority is able to apply voluntary acquisition rights for the owner(s) of the subject property. This also applies where the >5dB(A) exceedance (of the INP's acceptable noise amenity criteria) occurs over more than 25% of any privately-owned land where there is an existing residence or where a residence could be built under current planning controls.

4.2.4.4 Low Frequency Noise Criteria for Operational Noise

Apart from satisfying the intrusiveness and amenity criteria for operational noise, it is also necessary to satisfy the criteria for certain noise characteristics including low frequency noise, i.e. noise with frequencies typically from 20 hertz (Hz) to 250Hz.

The INP recommends that the extent of low frequency noise is assessed in terms of the difference between C and A weighted noise levels. In the event a difference of >15dB exists between the C and A weighted noise levels, the INP recommends a 5dB correction should be applied.

SLR (2016) identifies that it is now recognised that the method of establishing the difference between the dB(C) and dB(A) weighted noise levels within the INP has limitations, principally because it has been established that the dB(C) – dB(A) level can exceed 15dB principally due to distance attenuation. For the purposes of the amended Project, SLR (2016) therefore proposes that in the event there is a 15dB or more difference using the dB(C) – dB(A) method, then the difference needs to be investigated to exclude any modifying factor adjustments for dominant low frequency content related to distance attenuation. If, and when the modifying factors relating to distance are removed, the criteria would be those set out in **Table 4.6**.

Table 4.6
Criteria for Assessment of Low Frequency Noise

Sensitive Receiver	Period	Range	Criteria L_{Aeq}
Residential	Night-time or Plant Operation 24/7	Desirable	60
		Maximum	65
	Daytime or Intermittent (1-2 hours)	Desirable	65
		Maximum	70
Commercial/Office/ Industrial	Night-time or Plant Operation 24/7	Desirable	70
		Maximum	75
	Daytime or Intermittent (1-2 hours)	Desirable	75
		Maximum	80
Source: Broner (2011)			

4.2.4.5 Cumulative Noise

The criteria for assessing the cumulative impacts of two or more operations are the acceptable daytime and evening amenity level criteria previously outlined in Section 4.2.4.3 (**Table 4.5**).

4.2.4.6 Road Traffic Noise Assessment Criteria

Criteria for the assessment of noise from traffic on public roads are set out in the NSW Road Noise Policy (DECCW, 2011). Under this policy, The Bucketts Way would be considered as a "sub-arterial" or regional road. Because of the planned upgrade of Jacks Road and the section of Waukivory Road east of Jacks Road and its use in providing access to two rural-residential estates, numerous rural properties and an alternate route to Bulahdelah, from a noise assessment perspective this section of road is similarly considered as a sub-arterial or regional road. Waukivory Road (north of Jacks Road) would be best classified as a "local" road. The relevant road traffic noise criteria are set out in **Table 4.7**.

Table 4.7
Road Traffic Noise Assessment Criteria for Residential Land Uses

Road	Project Type and Land Use	Total Traffic Noise Criteria[1,2,5]	Relative Increase Criteria[1,2,3,4]
The Bucketts Way	Land use developments generating additional traffic on existing sub-arterial roads	Daytime 60 $L_{Aeq(15hour)}$	Existing $L_{Aeq(15hour)}$[4] plus 12dB(A)
		Night-time 55 $L_{Aeq\ (9hour)}$	Existing $L_{Aeq(9hour)}$ plus 12dB(A)[4]
Jacks Road and Waukivory Road (east of Jacks Road)	Land use developments generating additional traffic on existing local roads, but upgraded to "principal access route"	Daytime 60 $L_{Aeq(15hour)}$	Existing $L_{Aeq(15hour)}$[4] plus 12dB(A)
		Night-time 55 $L_{Aeq(9hour)}$	Existing $L_{Aeq(9hour)}$ plus 12dB(A)[4]
Waukivory Road (north of Jacks Road)	Land use developments generating additional traffic on existing local roads	Daytime 55 $L_{Aeq(1hour)}$	Not Applicable
		Night-time 50 $L_{Aeq(1hour)}$	

Note 1: L_{Aeq} = equivalent continuous noise level.
Note 2: Daytime 0700 hrs to 2200 hrs, Night-time 2200 hrs to 0700 hrs.
Note 3: For Years 1 and 10 "existing" is the projected base (i.e. non-project related) traffic noise levels in Years 1 and 10.
Note 4: Relative increase noise level generated by the amended Project Years 1 and 10 for comparison with the criteria.
Note 5: Where the total traffic noise criteria is exceeded, then limit any increase to 2dB(A) or less.

Source: SLR (2016) – Table 45

The Road Noise Policy requires the road noise assessment to be carried out in three steps.

i) Calculate the total noise of the existing traffic and whether that complies with the total noise traffic criteria in **Table 4.7** for the road type/land use and time of day.

ii) In the event the total traffic noise level for the existing traffic is compliant with the criteria, then establish what the total noise level would be through the addition of the project-related traffic and compare the combined noise level with the total traffic noise criteria in **Table 4.7**. In the event the combined existing and project-related traffic noise satisfies the total traffic noise criteria, no further assessment is required.

iii) In the event that:

a) the total traffic noise level for the existing traffic exceeds the relevant criterion nominated in **Table 4.7**; or

b) the predicted total traffic noise level for the existing and proposed traffic exceeds the total relevant noise criterion nominated in **Table 4.7**,

an assessment then needs to be made of the relative increase to establish whether the increase in the traffic noise level attributable to a new project is 2dB(A) or less.

4.2.5 Management, Mitigation and Contingency Measures

4.2.5.1 Introduction

Given the proximity of some of the proposed activity areas to the three rural-residential estates to the west through to the north of the Mine Area, the Applicant, in conjunction with SLR, has developed a range of measures to contain the noise likely to be experienced at these locations to within the operational criteria under as many operational scenarios as possible and at as many residences/receivers as possible. In essence, SLR has carefully reviewed the mine plan sequence and identified what type of equipment can operate in what general locations under INP assessable meteorological conditions and comply with the intrusiveness criteria set out in **Table 4.5**. This was an iterative process that ultimately provided clarity for the Applicant to finalise the design of the amended Project.

This subsection outlines the suite of measures that would be adopted both from a management perspective and through the use of specific mitigation measures to minimise noise levels at the surrounding privately-owned residences and receivers. Details of the design features and the management measures would be documented in two Noise Management Plans namely, one for the site establishment and construction stage and one for all mining, breaker and transport operations.

4.2.5.2 Design Features

The principal design features of the amended Project that would contribute to the control of noise are as follows.

- Construction of a 10m to 40m high amenity (visibility and noise) barrier extending along most of the length of the western boundary of the Mine Area and a considerable proportion of the northern boundary of the Mine Area. The bulk of this barrier, referred to as the western and northern amenity barrier, would be constructed during the first 2 years of mining operations to provide both visual and noise protection from the active operational areas within the Mine Area throughout the life of the amended Project.
- Progressive construction of two interim amenity barriers within the out-of-pit permanent overburden placement to maximise acoustic (and visual) shielding of overburden emplacement activities being undertaken behind the barriers.
- Positioning internal haul routes for hauling both overburden and coal as much as possible at elevations below the surface within the western and northern sides of the open cut pits in order to maximize shielding provided by the adjacent walls in each pit.

- Positioning the ROM pad and breaker station as far as possible to the southeast (i.e. most distant from the rural-residential estates) to limit noise from the activities on the ROM pad and the rotary breaker and the trucks as they exit from the southern side of the open cut pits.
- Positioning the northern haul route to the interim overburden emplacement within the Main Pit at a level at least 10m below the natural land surface and/or behind a barrier of overburden or subsoil to maintain a vertical separation of at least 10m between the road surface and the top of the barrier and minimise acoustic exposure to the north and west.
- Positioning the internal haul route to the ROM pad and out-of-pit emplacements either on the eastern side within the former Avon Pit or as close as possible to the western section of the western and northern amenity barrier.
- Construction of a 10m high barrier around the ROM pad to shield noise from trucks delivering ROM coal, the front-end loader feeding the rotary breaker and the operation of the breaker.
- Construction of the private haul road along an alignment, much of which would be shielded by a local north-south trending ridge. The road itself would be a least 3.6km from the nearest privately-owned residence to the west and approximately 1.5km from a single rural residence southeast of the haul road.
- Selection of a noise-attenuated mobile equipment fleet that restricts the overall sound power level to approximately 130dB(A). All mobile mining equipment would be fitted with broadband "quacker" style reversing alarms rather than high frequency reversing alarms.

4.2.5.3 Management Measures

Operational Measures

The Applicant would adopt a comprehensive range of feasible and reasonable noise management measures throughout the life of the amended Project to control noise propagated from the Site. Central to the active noise management strategy would include the following.

- **Noise Source Control - use of noise attenuated mobile fleet and fixed plant**
  - Use of low noise mobile equipment and fixed plant where possible (i.e. Cat XQ mobile equipment with other noise control kits, etc.) aimed to achieve a total mine operational sound power level of approximately 130dB(A).
  - All Cat D10XQ and Cat D11XQ bulldozers (restricted to 1st gear operation dependent on the time and location of operation within the area of disturbance).
  - Installation of broadband noise emission "quacker" style reversing alarms on mobile equipment.

- **Noise Propagation Path - installation of acoustic barriers**
  - Western and northern amenity barrier.
  - Years 2 to 8 – Out-of-pit overburden placement, optimised overburden with haul route to maximise the shielding effect from the existing topography and interim amenity barriers within the permanent overburden emplacement.
- **Operational Controls – re-scheduling of intrusive activities to less sensitive times of the day**
  - Year 1 to 3 - Daytime operation only.
  - Year 4 to 16 - Daytime out-of-pit operations.
  - Year 4 to 16 - Evening in-pit operations dependent on the extent of noise enhancing weather conditions and equipment shutdowns.
  - Year 4 to 16 - Evening out-of-pit operations dependent on the extent of noise enhancing weather conditions and equipment shutdowns.
- **Noise and Weather Monitoring to identify plant and equipment shutdowns**
  - Implementation of real-time noise monitoring at key locations to identify plant and equipment shutdowns if required during noise enhancing weather conditions.
  - Implementation of a predictive meteorological forecasting regime to allow on-site personnel to understand the likely meteorological conditions on the following day that may influence noise propagation.
  - Implementation of continuous weather monitoring within the Site.

In addition to the above key management mitigation measures, the Applicant would ensure the following are adopted by all contractors and by equipment operators.

1. Wherever possible, equipment would not be idling unnecessarily.
2. Haul trucks are driven behind barriers whenever possible to maximise noise attenuation.
3. Avoiding dramatic changes in operations, and hence noise emissions, during the evening – such as through staggering meal breaks.
4. Strategically positioning the parking areas for earthmoving equipment during meal breaks in areas providing the greatest attenuation.
5. Selective shut-down procedures would be adopted to reduce the number of items of equipment to ensure the relevant noise criteria are satisfied.

Personnel Training

The Applicant would ensure that all contractors and equipment operators are fully informed (at their inductions, re-inductions and through toolbox talks) regarding the sensitivities relating to noise, the expectations of local residents and the Applicant's commitments. Emphasis would be placed upon undertaking a job safety and environmental analysis (JSEA) prior to the commencement of on-site and off-site activities to ensure all planning is streamlined and the appropriate resources/equipment are available to undertake the activities in the most efficient and least noisy manner as possible.

Communications

The Applicant would place considerable emphasis upon communications with landowners and occupiers in close proximity to all construction sites during the site establishment and construction stage, and with the local community throughout the life of the amended Project. This would be achieved through the adoption of the following measures.

1. Occupants of residences, within a distance nominated in the Construction Noise Management Plan, would be provided with details ahead of time regarding the type of activities, their duration and the specific measures to be adopted to minimise noise.
2. Good communications would be maintained between personnel and surrounding landowners and occupiers.
3. Surrounding landowners and occupiers would be made aware of the appropriate contact details for the most appropriate contact person for discussions/lodging complaints, if required.
4. Any legitimate complaints from surrounding landowners and occupiers would be responded to in a timely manner.

Documentation

The Applicant would document the procedures to be adopted to mitigate and minimise noise during the site establishment and construction stage within a Construction Noise Management Plan. Emphasis would be placed upon minimising the period of noise exceedances as much as possible.

The routine use of continuous real-time noise monitors during the operation of the mine would enable the Applicant to manage the locations where the various items of the mining fleet are operating at any time. This flexibility invariably removes the need to prescribe detailed controls on the location and operation of equipment. Rather, noise management would be undertaken through a range of specific procedures incorporated within the Noise Management Plan which would be updated annually. These procedures would record the operational areas within the Mine Area and the preferred times and meteorological conditions to operate in each operational area.

4.2.6 Assessment Methodology

4.2.6.1 Introduction

Noise modelling was undertaken by SLR (2016) for:

- on-site and off-site construction noise;
- site operational noise;
- cumulative operational noise; and
- road traffic noise.

Sections 4.2.6.2 to 4.2.6.5 present the approach to the modelling adopted by SLR (2016) and, where appropriate, the approach to assessing the implications of the predicted noise levels.

4.2.6.2 On-site and Off-site Construction Noise

SLR (2016) adopted a cumulative sound power level of 129dB(A) for the various items of earthmoving equipment when undertaking the on-site construction activities and 118dB(A) for the off-site construction activities. A total of three scenarios were modelled to assess noise generated during the site establishment and construction stage based on the nature of the activities and their proximity to residences.

- On site:
  - the construction of the private haul road (see Section 2.6.5);
  - various miscellaneous activities within the Mine Area (see Section 2.6.1); and
- Off site:
  - upgrading works for Jacks Road (see Section 2.6.6).

Noise levels at surrounding privately-owned residences and receivers were predicted using the Environmental Noise Model (ENM for Windows Version 3.06) and assuming daytime calm, isothermal meteorological conditions, i.e. in the manner nominated by DECC (2009) in the Interim Construction Noise Guideline.

SLR (2016) predicted the noise generated at both privately-owned residences and receivers and resource company-owned residences. A summary of potential construction noise impacts is provided in Section 4.2.7.2.

4.2.6.3 Site Operational Noise

Operational noise levels at residences or receivers in the vicinity of the Site and within Gloucester township have been predicted using the Environmental Noise Model (ENM for Windows Version 3.06) through the use of eight representative operational scenarios for activities to be undertaken in Year 0.5, Year 3, Year 4, Year 7 and Year 10. A brief overview of the scale of activity for each of the scenarios is as follows.

Scenario 1:	Year 0.5	Daytime operations in the Avon Pit, with annual overburden production of 4.7Mbcm and ROM coal production of 0.2Mt, together with the out-of-pit development of the western and northern amenity barrier.
Scenario 2:	Year 3	Daytime operations in the Main Pit, with out-of-pit overburden placement within the southern section of the disturbance area, with overburden production of 4.7Mbcm and ROM coal production of 0.5 Mt.
Scenarios 3 & 4:	Year 4	Daytime and evening mining operations in the Main Pit, with in-pit and out-of-pit overburden placement at the mid-section of the disturbance area, overburden production of 6.4Mbcm and ROM coal production of 1.1Mt.

Scenarios 5 & 6: Year 7 — Daytime and evening operations in the Main Pit, with in-pit and out-of-pit overburden placement at the northern section of the disturbance area, with the scheduled maximum overburden production of 9.8Mbcm and ROM coal production of 1.4Mt.

Scenarios 7 & 8: Year 10 — Daytime and evening operations representative of the maximum equipment operating (in-pit) in the Main Pit with the overburden production of 9.8Mbcm and ROM coal production of 1.7Mt.

The noise model predicts the total noise level that would be experienced at each residence or receiver from the proposed plant and equipment operating in the nominated locations or circuits, with the predicted operational noise levels then compared against the criteria nominated in **Table 4.5** for each residence or receiver. The extent of impact is then determined by comparing the numerical exceedances (if predicted) with the values listed in **Table 4.8**.

Table 4.8
Noise Impact Assessment Methodology (dB(A) re 20µPa)

<table>
<tr><th>Site Establishment and Construction Stage</th><th>Assessment Parameter</th><th>Assessment Criteria</th><th>Negligible to Moderate</th><th>Moderate to Appreciable</th><th>Significant</th></tr>
<tr><td>Affected residences</td><td>CNML Intrusive</td><td>RBL plus 10dB(A)</td><td>1 to 5dB(A) above assessment criteria</td><td>> 5dB(A) above assessment criteria</td><td>above HNAL 75dB(A)</td></tr>
<tr><td rowspan="2">Mine Operations</td><td rowspan="2">Assessment Parameter</td><td rowspan="2">Assessment Criteria</td><td colspan="2">Noise Management Zone[1]</td><td>Affectation Zone[2]</td></tr>
<tr><td>Negligible</td><td>Marginal to Moderate</td><td>Significant</td></tr>
<tr><td rowspan="2">Affected residences</td><td>PSNL Intrusive</td><td>RBL plus 5dB(A)</td><td rowspan="2">1 to 2dB(A) above assessment criteria</td><td rowspan="2">3 to 5dB(A) above assessment criteria</td><td rowspan="2">> 5dB(A) above assessment criteria</td></tr>
<tr><td>PSNL Amenity</td><td>INP acceptable</td></tr>
<tr><td>Affected Land</td><td>PSNL Amenity</td><td>INP acceptable</td><td>Not applicable</td><td>Not applicable</td><td>> 5dB(A) above assessment criteria[3]</td></tr>
<tr><td>All industrial noise affected residences</td><td>Cumulative Amenity Level</td><td>INP acceptable</td><td>1 to 2dB(A) above assessment criteria</td><td>3dB(A) above assessment criteria</td><td>> 3dB(A) above assessment criteria</td></tr>
<tr><td colspan="6">Note 1: Noise Management Zone - depending on the range of exceedance of the PSNL assessment parameters, potential project noise impacts range from negligible to moderate in accordance with the VLAMP.
Note 2: Noise Affectation Zone - noise exceedances greater than 5dB(A) above the PSNL assessment parameters may result in significant project noise impacts in accordance with the VLAMP.
Note 3: Noise Affectation Zone - equivalent to a noise exceedance of the INP's maximum noise amenity level on more than 25% of any privately-owned land where there is an existing residence or a residence could be built on that land under existing planning controls in accordance with the VLAMP.</td></tr>
<tr><td colspan="6">Source: SLR (2016) – Table 21</td></tr>
</table>

The indicative layout of the Mine Area for each of the above scenarios is presented on **Figures 2.11** and **2.12**. Further information about the scenarios is included in Section 4.2.7.3.

In the event that coal production increases to a maximum of 2.0Mt from Year 10, then this would be accommodated by an approximate 0.1Mbcm reduction in overburden handling, with the number and type of mobile equipment items remaining unchanged, but rather re-allocated to coal production, particularly during the daytime period.

During Years 17 and 18, when the interim overburden emplacement is removed to provide backfill for the Main Pit, it is considered the noise emissions would be comparable to out-of-pit operations in Years 4 and 7. Similarly, mine closure and rehabilitation activities during Years 18 and 19 involving the progressive removal of the western and northern amenity barrier would result in noise emissions comparable to those in Year 0.5 and out-of-pit operations in Year 3.

The layout and topography of the Mine Area, the location of equipment and contour plots of the modified outcomes for four of the assessed operational scenarios are presented in Section 4.2.7.3. Similar figures for all scenarios assessed are presented in Appendices I, J, K, L and M in SLR (2016).

A key input to the noise model is the source noise for the mobile earthmoving equipment. **Tables 4.9** and **4.10** present the schedule of mobile equipment and fixed plant used in the noise modelling, their respective sound power levels and the number of each type of plant and equipment operating during the nominated year during the day (Years 1 to 3) or day/evening (Year 4 onwards). During the daytime, the overall sound power level would range from 127dB(A) in Year 0.5 to 130dB(A) in Year 7. Similarly, during the evening, the overall sound power level would range from 127dB(A) in Year 4 to 129dB(A) in Year 7. It is noted that while the individual and total sound power levels are nominated for the purposes of the assessment, minor changes may occur. However, the critical requirement is that the Applicant ensures the combined received noise level of all items of equipment is within the nominated criteria at each privately-owned residence or receiver. It should be noted that adoption of the sound power levels listed in **Tables 4.9** and **4.10** in the modelling is conservative as it is assumed that all equipment modelled is operating at maximum capacity for an entire 15 minute period.

The topography within the Mine Area used in the modelling is based on mine plans for each representative scenario, with equipment generally placed in typical worst-case locations for noise propagation. In some cases, the mine plans themselves were refined to provide additional shielding for noisy items.

The INP requires that noise modelling takes into account meteorological conditions that are a feature of the area in which a noise is proposed to be generated. Wind is considered to be a feature of an area when the source to receiver wind speeds (at 10m height) of 3m/s or below occur for 30% or more of the time in any assessment period in any season.

The meteorological data used in the noise assessment has been drawn from the Applicant's on-site meteorological station during the period January 2011 to November 2015. SLR (2016) identified that winds less than or equal to 3m/s occurred from the south for 28.9% (with 5.8% between 2m/s to 3m/s) of an evening during the winter months and therefore conservatively considered this wind is a feature of the area around the Rocky Hill Mine Area. **Table 4.11** lists the calm and noise enhancing meteorological parameters determined in accordance with the INP that SLR (2016) has relied upon in the modelling of operational noise.

Table 4.9
Daytime Plant and Equipment Sound Power Levels (SWL) (dB(A) re 1ρW)

Item	Indicative Type[3]	SWL per Item	Year 0.5		Year 3		Year 4		Year 7		Year 10	
			Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL
Drill	Terex SKF 12/15	118	2	121	2	121	2	121	2	121	2	121
Excavator	Komatsu PC850	106	-	-	1	106	1	106	1	106	1	106
	Komatsu PC1250	109	-	-	2	112	2	112	2	112	2	109
	Liebherr 994-200	113	1	113	1	113	1	113	1	113	1	113
	Hitachi EX3600	115	1	115	1	115	1	115	2	118	2	118
Haul Trucks	CAT 789XQ	113	3	118	5	120	5	120	9	123	9	123
	Haulmax 3900EQ	116	5	123	6	124	6	124	9	125	9	125
Scraper	CAT 657G	111	2	114	2	114	2	114	2	114	2	114
Grader	CAT 14H	108	1	108	1	108	1	108	1	108	1	108
Frond-end-loader	CAT 992	113	-	-	1	113	1	113	1	113	1	113
Dozer	CAT D10XQ	109	1	109	1	109	1	109	1	109	1	109
	CAT D11XQ	112	2	115	2	115	2	115	3	117	3	117
Rubber Tyre Dozer	Tiger 690	113	1	113	1	113	1	113	1	113	1	113
Water Trucks	Volvo F724	106	1	106	1	106	1	106	1	106	1	106
	CAT 777XQ	112	1	112	1	112	1	112	1	112	1	112
Fuel Truck	Road Truck	106	1	106	1	106	1	106	1	106	1	106
Haul Trucks (to Stratford)	Multi-combination	107	-	-	4	113	7	115	9	116	10	117
Overall Mobile Plant			22	127	33	128	36	128	47	130	48	130
Feeder/Hopper/ Grizzly	1,000tph	107	-	-	1	107	1	107	1	107	1	107
Rotary Breaker	1,000tph	112	-	-	1	112	1	112	1	112	1	112
Generator	400kVA	103	-	-	1	103	1	103	1	103	1	103
Sized Coal Bin	500t	103	-	-	1	103	1	103	1	103	1	103
Conveyor (per 100m)	1,200tph	95	-	-	1	95	1	95	1	95	1	95
Conveyor Drive	150kW	92	-	-	1	92	1	92	1	92	1	92
Overall Fixed Plant			-	-	6	114	6	114	6	114	6	114
Overall Mobile and Fixed Plant			22	127	39	129	42	129	53	130	54	130

[3] List of equipment indicative only – subject to change

Table 4.10
Evening Plant and Equipment Sound Power Levels (SWL) (dB(A) re 1ρW)

Item	Indicative Type[4]	SWL per Item	Year 0.5		Year 3		Year 4		Year 7		Year 10	
			Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL	Total Fleet	Total SWL
Drill	Terex SKF 12/15	118	-	-	-	-	-	-	2	121	2	121
Excavator	Komatsu PC850	106	-	-	-	-	-	-	-	-	1	106
	Komatsu PC1250	109	-	-	-	-	1	109	2	112	2	109
	Liebherr 994-200	113	-	-	-	-	1	113	1	113	1	113
	Hitachi EX3600	115	-	-	-	-	1	115	2	118	2	118
Haul Trucks	CAT 789XQ	113	-	-	-	-	5	120	9	123	9	123
	Haulmax 3900EQ	116	-	-	-	-	6	124	6	124	9	125
Scraper	CAT 657G	111	-	-	-	-	-	-	-	-	-	-
Grader	CAT 14H	108	-	-	-	-	1	108	1	108	1	108
Frond-end-loader	CAT 992	113	-	-	-	-	-	-	-	-	-	-
Dozer	CAT D10XQ	109	-	-	-	-	1	109	1	109	1	109
	CAT D11XQ	112	-	-	-	-	2	115	3	117	3	117
Rubber Tyre Dozer	Tiger 690	113	-	-	-	-	1	113	1	113	1	113
Water Trucks	Volvo F724	106	-	-	-	-	1	106	1	106	1	106
	CAT 777XQ	112	-	-	-	-	1	112	1	112	1	112
Fuel Truck	Road Truck	106	-	-	-	-	1	106	1	106	1	106
Haul Trucks (to Stratford)	Multi-combination	107	-	-	-	-	-	-	-	-	-	-
Overall Mobile Plant			-	-	-	-	22	127	31	129	35	129
Feeder/Hopper/ Grizzly	1,000tph	107	-	-	-	-	-	-	-	-	-	-
Rotary Breaker	1,000tph	112	-	-	-	-	-	-	-	-	-	-
Generator	400kVA	103	-	-	-	-	-	-	-	-	-	-
Sized Coal Bin	500t	103	-	-	-	-	-	-	-	-	-	-
Conveyor (dB(A) per 100m)	1,200tph	95	-	-	-	-	-	-	-	-	-	-
Conveyor Drive	150kW	92	-	-	-	-	-	-	-	-	-	-
Overall Fixed Plant			-	-	-	-	-	-	-	-	-	-
Overall Mobile and Fixed Plant			-	-	-	-	-	127	31	129	35	129

Table 4.11
Calm (Neutral) and Noise Enhancing Meteorological Modelling Parameters

Period	Meteorological Parameter	Air Temperature	Relative Humidity	Wind Velocity	Temperature Gradient
Daytime	Calm	20°C	66%	0m/s	0°C/100m
Evening	Calm	19°C	74%	0m/s	0°C/100m
	Wind Only	13°C	77%	South 3m/s[1]	0°C/100m
Night-time	Not applicable				
Note 1: The majority of winter southerly wind speeds are between 0.5m/s to 2m/s (i.e. approximately 23%) with an appreciably lower occurrence of wind speeds between 2m/s to 3m/s (i.e. approximately 6%). However, a wind speed of 3m/s has been conservatively adopted for assessing potential noise impacts.					
Source: SLR (2016) – Table 13					

[4] List of equipment indicative only – subject to change

4.2.6.4 Low Frequency Noise

SLR (2016) selected the following three rural residences to undertake a low frequency analysis (see **Figure 4.7**).

- Residence 25C – Green.
- Residence 33 – Seal.
- Residence 36 – Doherty.

The analysis involved predictions of the C and A weighted intrusive noise levels of an evening under a southerly wind for three operational scenarios, namely:

- Year 4 – Out-of-pit;
- Year 7 – Out-of-pit; and
- Year 10 – In-pit.

The calculations also considered the noise levels without any equipment shutdowns and with two example equipment shutdowns.

4.2.6.5 Cumulative Operational Noise

Cumulative noise impacts resulting from the concurrent operation of the amended Project, the Stratford Extension Project and Duralie Modification were assessed against the INP recommended acceptable amenity criteria as discussed in Section 4.2.4.3. The noise impact from the potential cumulative operation of all three projects has been conservatively assessed at each residence or receiver in the vicinity of the Site. The cumulative noise amenity level has been determined by identifying the maximum noise amenity level (at each residence or receiver) from each project that is predicted to occur at any time throughout the mine life of each project. The three maximum noise amenity levels (at each residence or receiver) were then summed to conservatively derive the cumulative noise amenity level.

4.2.6.6 Road Traffic Noise

The approach adopted by SLR (2016) to establish the potential impacts of increased traffic levels on public roads in the vicinity of the Site involved the following.

1. The potentially affected roads were identified, i.e. sections of The Bucketts Way, north and south of Jacks Road, Jacks Road and Waukivory Road east and north of Jacks Road.
2. All residences and sensitive receivers adjacent to the above roads were identified.
3. Existing and projected base traffic flows (i.e. without traffic associated with the amended Project) for Year 1 and Year 10 of the proposed mining operation were determined.
4. Noise levels of projected base traffic flows and the increased traffic flow attributed to the amended Project were calculated based upon the measurements discussed in Section 4.2.2.4. These calculated levels were then compared to the relative increase criteria nominated in **Table 4.7**.

5. The predicted cumulative traffic noise levels, i.e. the projected base plus amended Project traffic levels (at Years 1 and 10) were then compared against the total traffic noise criteria.

As discussed in Section 4.2.2.4, noise attributed to existing traffic was established through the use of two unattended noise loggers positioned adjacent to The Bucketts Way (Location 11) and Waukivory Road east of Jacks Road (Location 2) – see **Figure 4.10**. These measured traffic levels have been used to calculate existing traffic noise levels at other locations adjacent to these roads, as well as the projected base traffic noise levels and cumulative traffic noise levels (at Years 1 and 10).

4.2.7 Assessment of Impacts

4.2.7.1 Introduction

This subsection presents the predicted noise levels associated with the amended Project. Emphasis has been placed upon predicting noise levels at the privately-owned residences within the three rural-residential estates and surrounding rural and roadside residences together with eight representative sensitive receivers in Gloucester township. SLR (2016) has also predicted the noise levels at 33 resource company-owned residences. The discussion in this subsection focusses upon the predicted noise levels at the privately-owned residences. Sections 4.2.7.2 to 4.2.7.5 present the results of the predictions arising from the three noise modelling scenarios for the site establishment and construction stage, and the eight mine operational scenarios, together with the cumulative impact assessment and the calculations for road traffic noise (see Section 4.2.7.8).

4.2.7.2 Site Establishment and Construction Stage

The results for the three construction scenarios are outlined below.

Private Haul Road

SLR (2016) predicts that the construction noise levels at all 156 privately-owned residences and receivers in the vicinity of the Site would comply with the construction noise management level (CNML) during the construction of the private haul road.

On-Site Miscellaneous Works

The on-site miscellaneous construction activities would result in an exceedance of the CNML of 40dB(A) at two residences to the northeast of the Mine Area near the entrance to the Mine Area off McKinleys Lane (see **Figure 4.7**), namely:

- Residences 23 – Yarnold (41dB(A)); and
- Residences 6 – Campbell (49dB(A)).

These exceedances would occur for a duration of approximately 1 month.

Jacks Road Upgrade Construction

The noise levels during the most intensive period of road upgrade construction works along Jacks Road would exceed the CNML of 40dB(A) by up to 5dB(A) at 12 residences and exceed the CNML of 40dB(A) by more than 5dB(A) at approximately 56 residences for a duration of approximately 1 week. The levels would remain well below the high noise affected level (HNAL) of 75dB(A) at all residences. The predicted noise levels at each of the residences or receivers during the Jacks Road upgrade construction are listed in Section 6 of SLR (2016). The comparatively short duration of noise exceedances is considered acceptable given the roadworks would benefit not only the Applicant and its workforce but the motorists using the road, including most of the residents potentially affected by the elevated noise levels.

4.2.7.3 Operational Noise

As discussed in Section 4.2.6.3, SLR (2016) has predicted noise levels under eight operational scenarios, i.e. during Year 0.5, Year 3, Year 4, Year 7 and Year 10 for:

- daytime intrusive noise levels under calm meteorological conditions – $L_{Aeq\ 15minutes}$.
- daytime amenity noise levels under calm meteorological conditions $L_{Aeq\ 11\ hours}$ (i.e. 7:00am to 6:00pm).
- evening intrusive noise levels under calm and southerly wind meteorological conditions - $L_{Aeq\ 15minutes}$.
- evening amenity noise levels under calm and southerly wind meteorological conditions - $L_{Aeq\ 4\ hours}$ (i.e. 6:00pm – 10:00pm).

Residences and Receivers

The predicted noise levels at each of the residences and receivers in the vicinity of the Site are listed in Section 7 of SLR (2016). **Table 4.12** records that the project specific noise level (PNSL) of 35dB(A) would be exceeded at three residences during the five operational years modelled, namely:

- Residence 19A – Boorer (1dB(A) exceedance) – Year 0.5 only
- Residence 7 – Ansell and Murray (1dB(A) exceedance) – of an evening during Year 4 and Year 7 (out-of-pit), and Year 4 and 7 (in-pit).
- Residence 6 – Campbell – in the daytime during Year 7 (out-of-pit) – 2dB(A) exceedance and of an evening during Years 4 and 7 (out-of-pit) – 4dB(A) and 5dB(A) exceedances respectively.

Figures 4.11 to **4.18** display the layout plan for Year 0.5 Daytime, Year 4 Evening (Out-of-Pit), Year 7 Evening (Out-of-Pit) and Year 10 Daytime (Out-of-Pit) scenarios modelled and the corresponding $L_{Aeq\ 15\ minute}$ noise contour plots of the modelled outcomes. Appendices I, J, K, L and M within SLR (2016) also present the detailed indicative mine layouts used for the noise modelling for the four scenarios referred to above.

Table 4.12
Privately-owned Residences in the vicinity of the Site with PSNL Exceedances

Operational Year	Period	Noise Management Zone[1] Negligible 1 to 2dB(A) above PSNL	Noise Management Zone[1] Marginal to Moderate 3 to 5dB(A) above PSNL	Affectation Zone[1] Significant > 5dB(A) above PSNL
Year 0.5	Daytime	19A Boorer (36dB(A))	-	-
	Evening	Not applicable		
Year 3	Daytime	-	-	-
	Evening	Not applicable		
Year 4 Out-of-pit	Daytime	-	-	-
	Evening	7 Ansell & Murray (36dB(A))	6 Campbell (39dB(A))	-
Year 4 In-pit	Daytime	-	-	-
	Evening	7 Ansell & Murray (36dB(A))	-	-
Year 7 Out-of-pit	Daytime	6 Campbell (37dB(A))	-	-
	Evening	7 Ansell & Murray (36dB(A))	6 Campbell (40dB(A))	-
Year 7 In-pit	Daytime	-	-	-
	Evening	7 Ansell & Murray (36dB(A))	-	-
Year 10	Daytime	-	-	-
	Evening	-	-	-
Note 1: In accordance with the noise impact assessment methodology presented in SLR (2016) **Table 21**.				
Source: SLR (2016) – Table 38				

The predicted operational noise levels would be below the daytime and evening amenity PSNLs at all residences and receivers including the eight sensitive receivers assessed in Gloucester township, i.e. industrial, commercial, active and passive recreation, places of worship, hospitals and schools.

It is noted that the presentation of the noise contours involves numerical interpolation of a noise level array with a graphical accuracy of up to approximately ±2dB(A). This means that in some cases the noise contours would differ slightly from the values for each residence/receiver listed in SLR (2016), which are calculated at the individual residential/receiver locations and are therefore the more accurate predictions.

Privately-owned Land

SLR (2016) undertook an assessment of the impacts on privately-owned land without residences through the use of a set of $L_{Aeq\ 15\ minute}$ noise contours for:

- Year 0.5 – daytime (**Figure 4.12**);
- Year 4 – evening (**Figure 4.14**);
- Year 7 – evening (**Figure 4.16**); and
- Year 10 – daytime (**Figure 4.18**).

For each of the assessments undertaken, SLR (2016) established that the criterion contour on the subject figures falls short of the nearest privately-owned land in the three surrounding rural-residential estates.

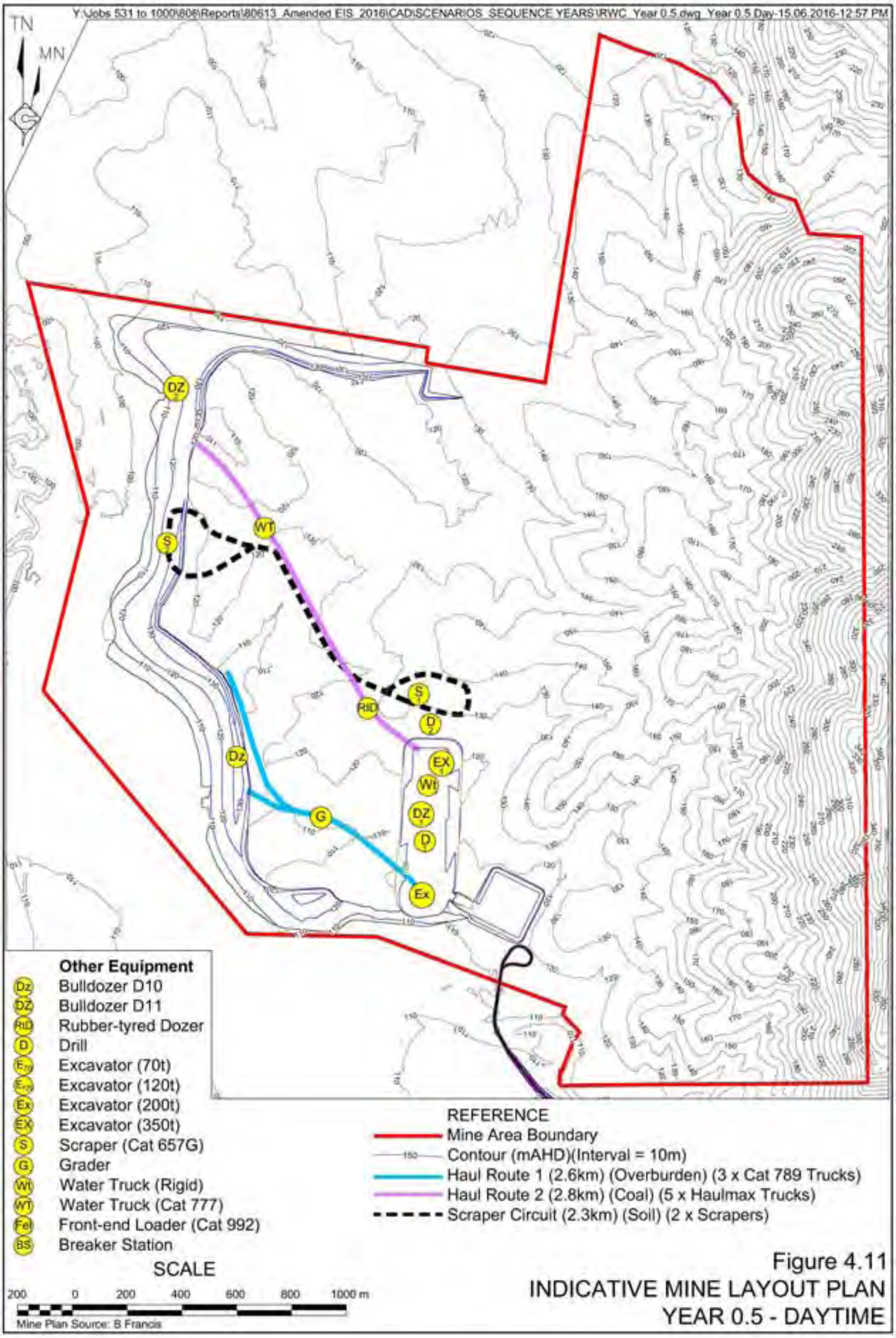


Figure 4.11
INDICATIVE MINE LAYOUT PLAN
YEAR 0.5 - DAYTIME

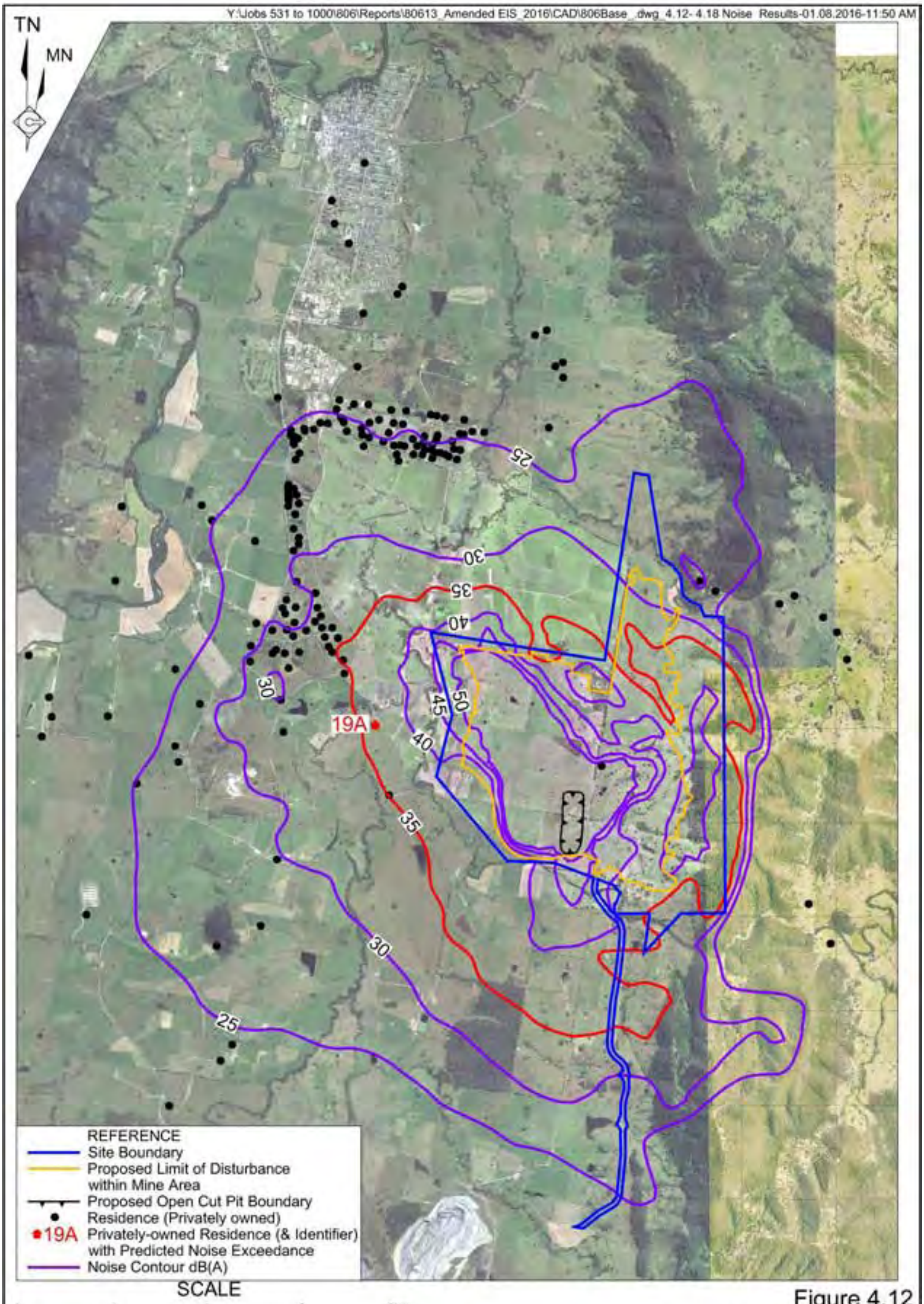


Figure 4.12
INTRUSIVE $L_{Aeq15min}$
NOISE CONTOURS - YEAR 0.5 DAYTIME

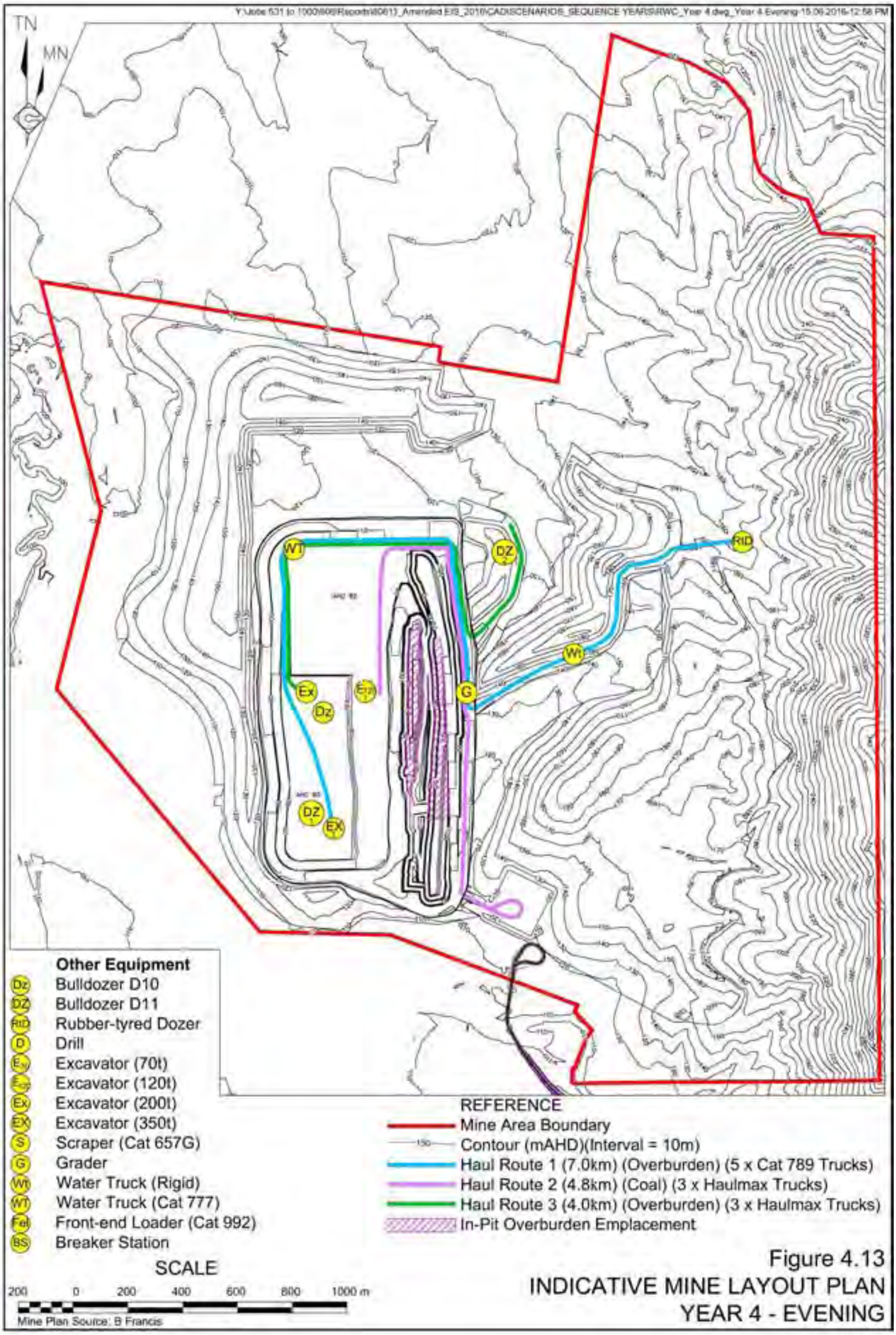


Figure 4.13
INDICATIVE MINE LAYOUT PLAN
YEAR 4 - EVENING

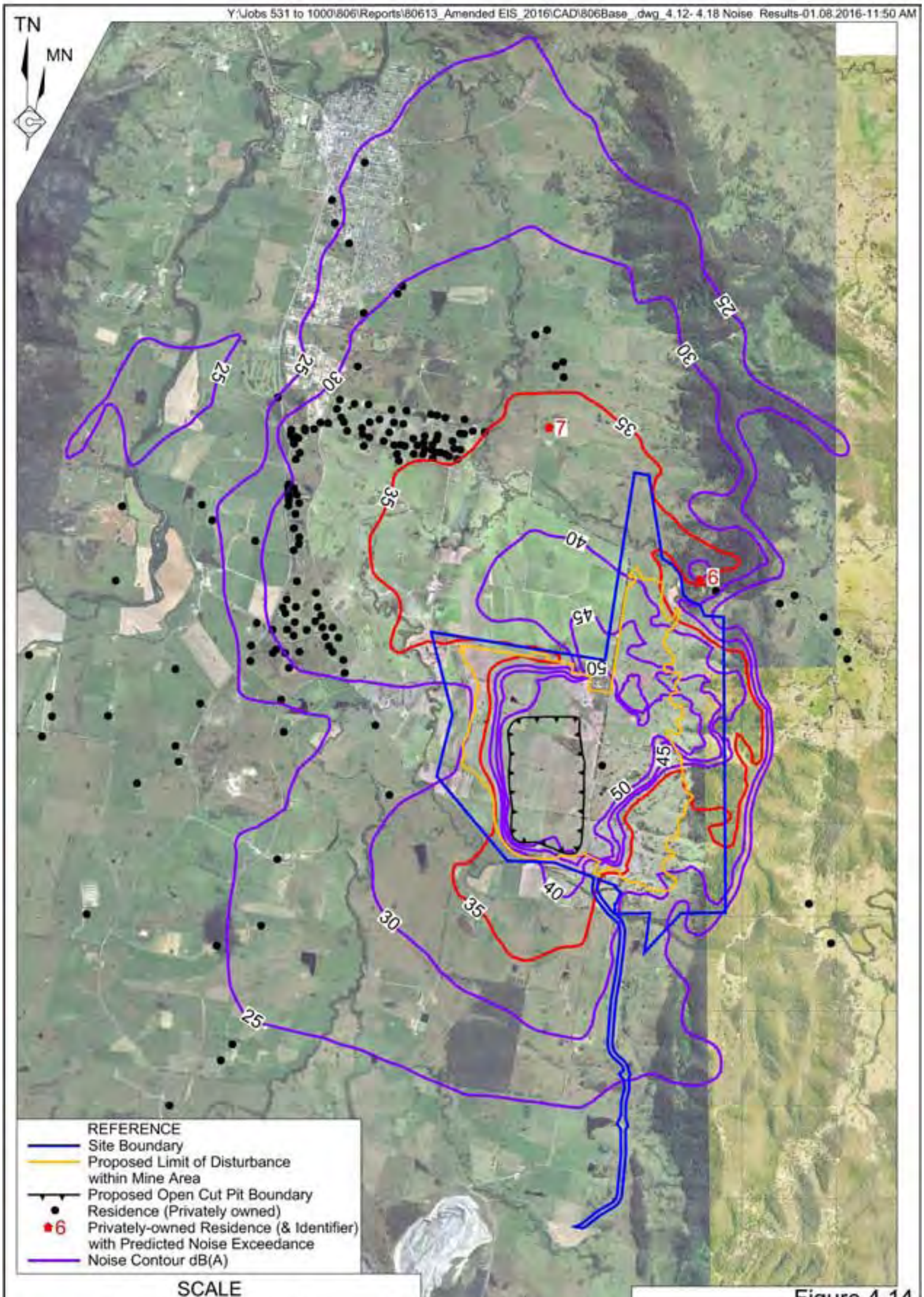


Figure 4.14
INTRUSIVE $L_{Aeq15min}$
NOISE CONTOURS - YEAR 4 EVENING

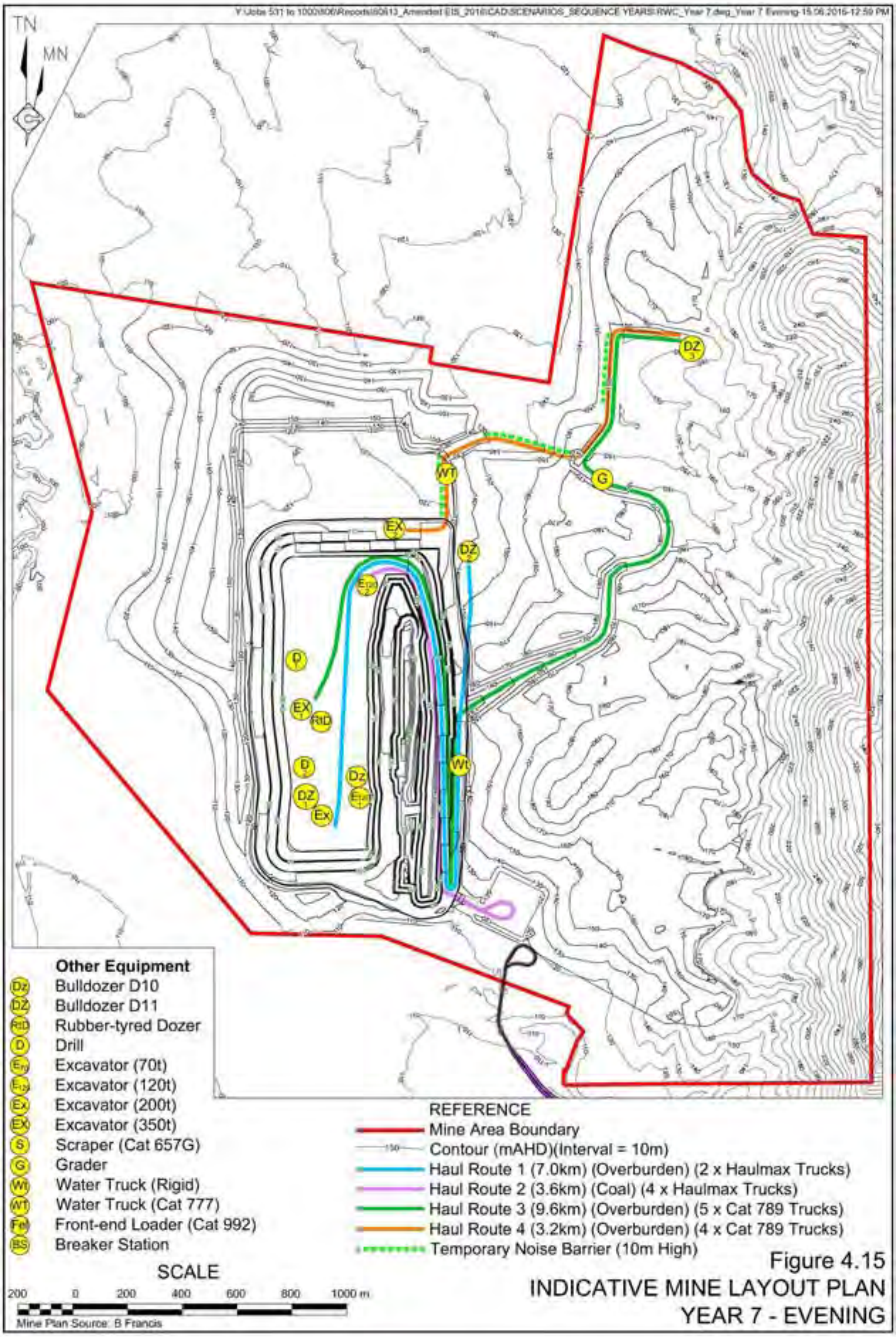


Figure 4.15
INDICATIVE MINE LAYOUT PLAN
YEAR 7 - EVENING

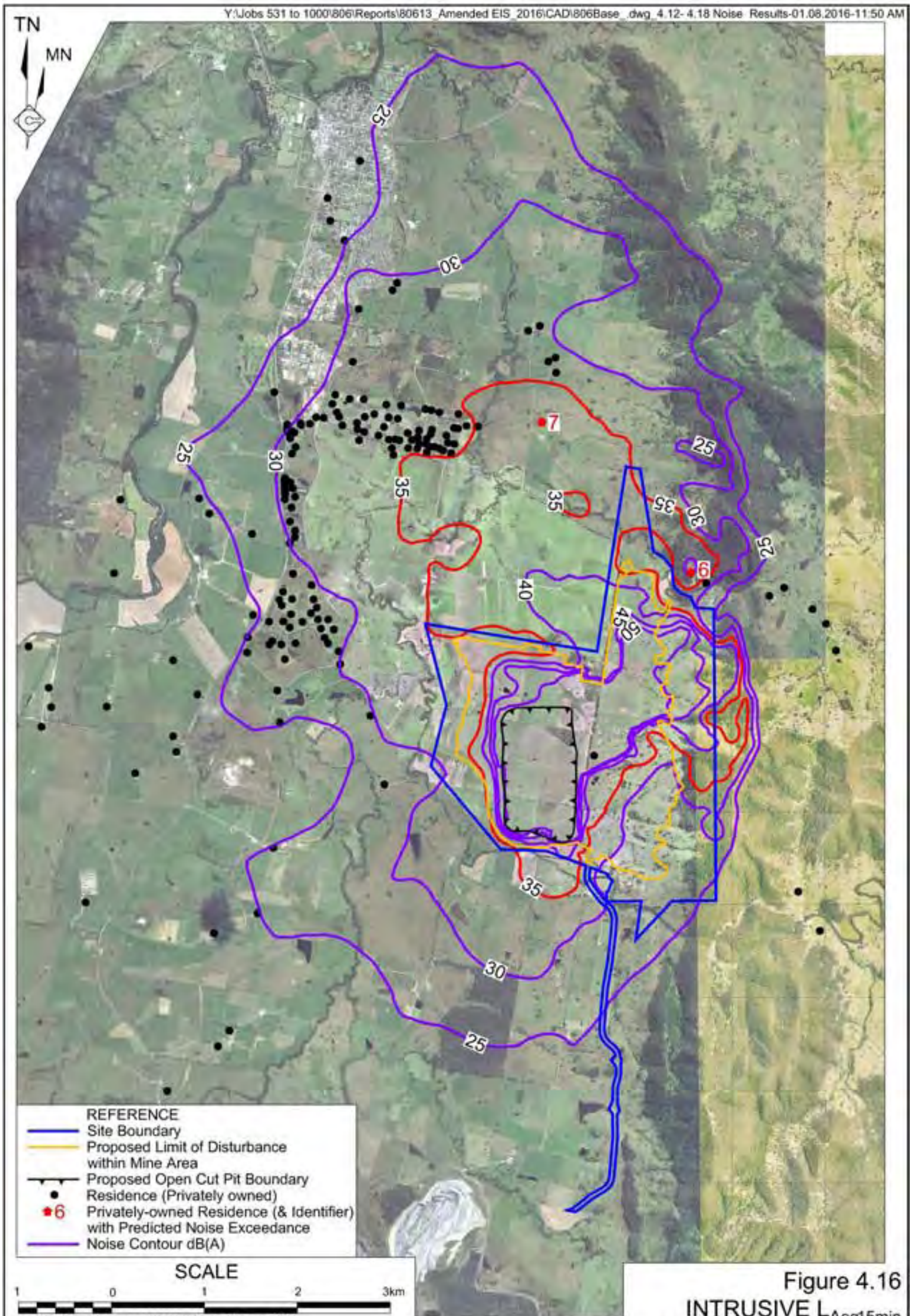


Figure 4.16
INTRUSIVE $L_{Aeq15min}$
NOISE CONTOURS - YEAR 7 EVENING

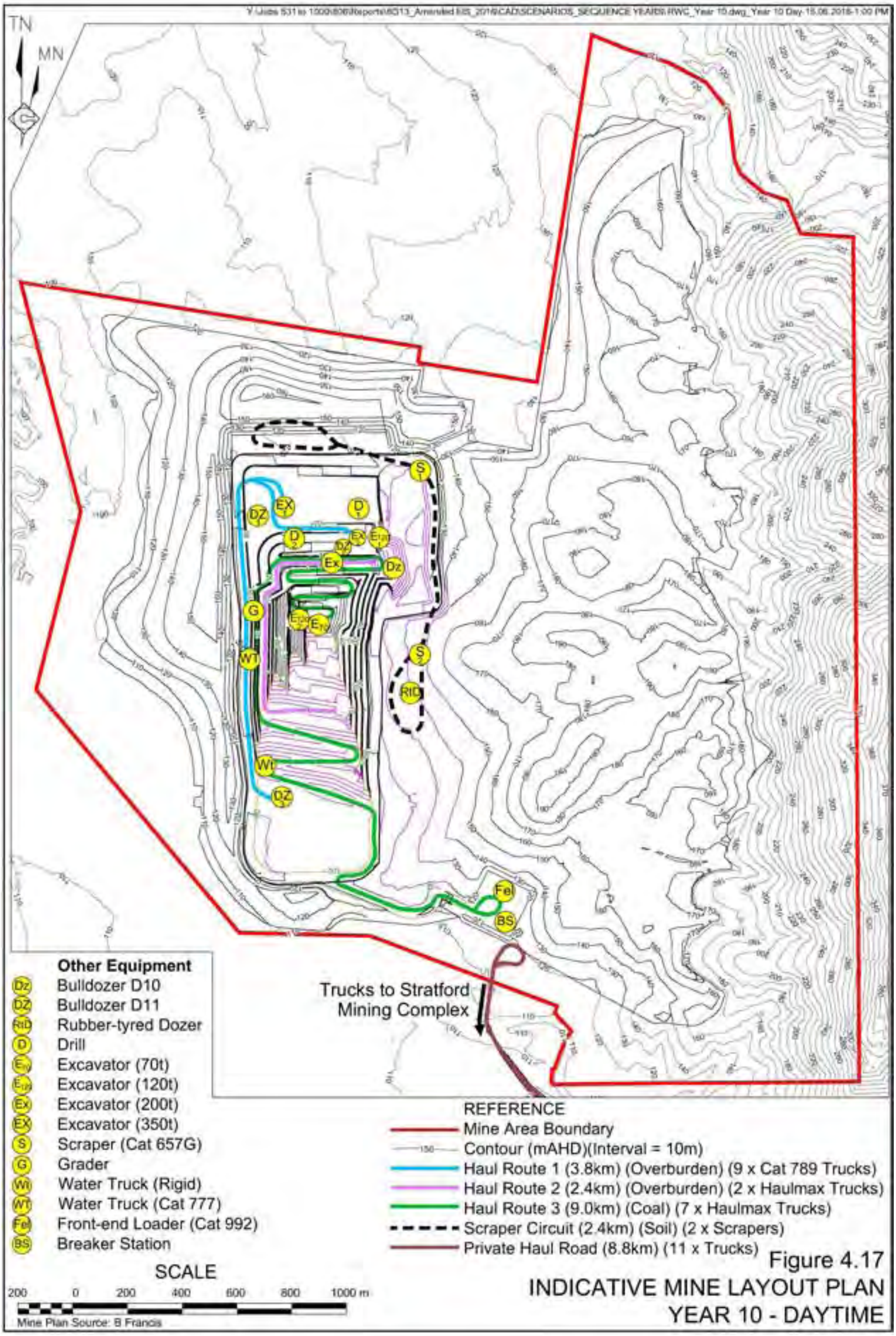


Figure 4.17
INDICATIVE MINE LAYOUT PLAN
YEAR 10 - DAYTIME

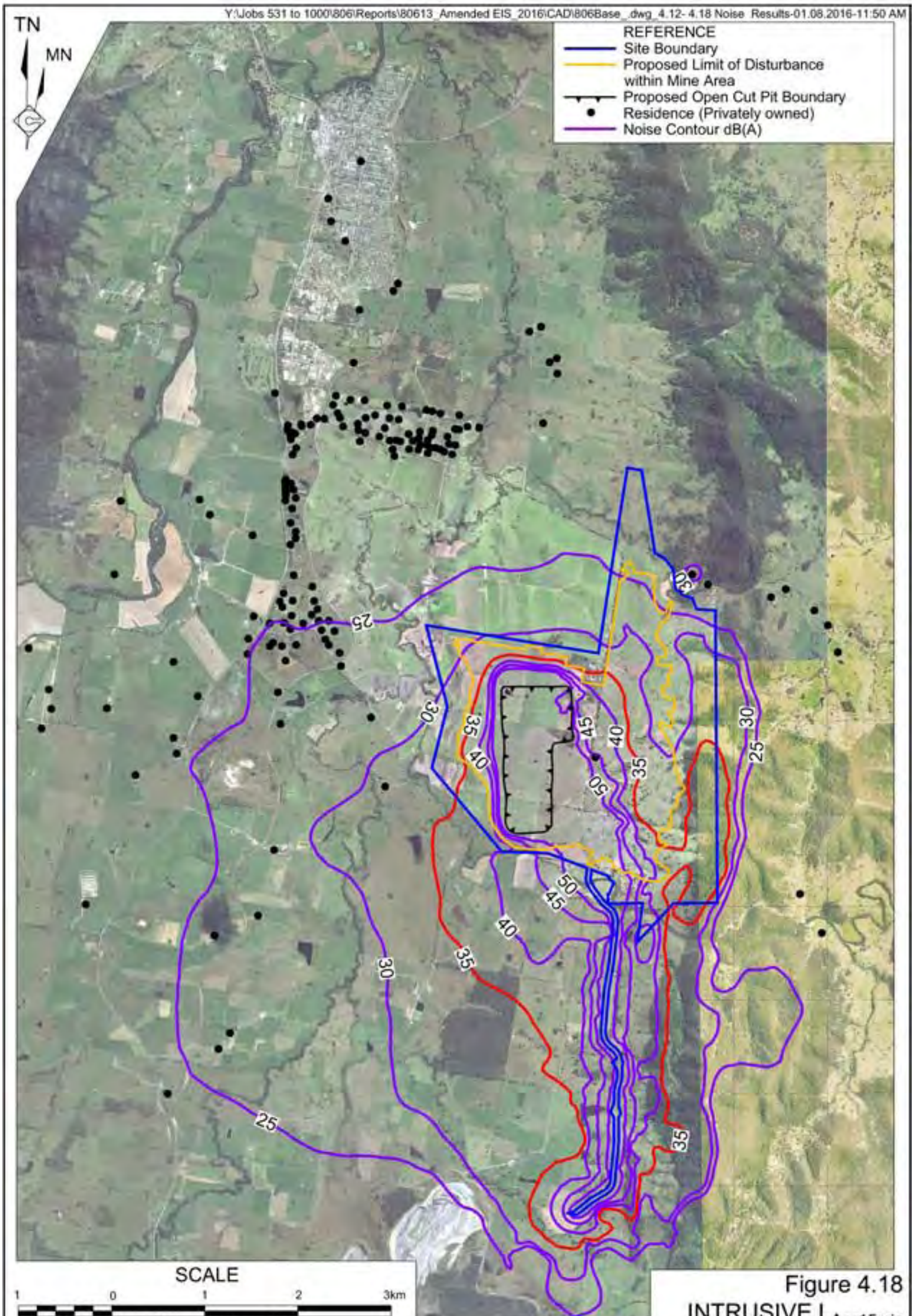


Figure 4.18
INTRUSIVE $L_{Aeq15min}$
NOISE CONTOURS - YEAR 10 DAYTIME

4.2.7.4 Low Frequency Noise

SLR (2016) calculated the differences between the C and A weighted intrusive noise levels in the manner described in Section 4.2.6.5, the results of which are displayed in **Table 4.13**.

Table 4.13
C and A Weighted Intrusive Noise Level Differences (dB re 20μPa)

Operational Year	Evening Operating Intrusive Noise Levels - Southerly wind with no equipment shut downs								
	Year 4 Out-of-pit			Year 7 Out-of-pit			Year 10 In-pit		
Residence	25C Green	33 Seale	36 Doherty	25C Green	33 Seale	36 Doherty	25C Green	33 Seale	36 Doherty
C Weighted	49.5	48.9	47.7	50.1	49.7	49.3	47.9	47.8	47.7
A Weighted	37.0	36.7	35.6	37.1	36.9	36.6	34.9	34.9	35.6
Difference	12.5	12.1	12.1	12.9	12.8	12.6	13.1	12.9	12.1
Operational Year	Evening Operational Intrusive Noise Levels - Southerly wind with alternative 2 equipment shut downs								
	Year 4 Out-of-pit			Year 7 Out-of-pit			Year 10 In-pit		
Residence	25C Green	33 Seale	36 Doherty	25C Green	33 Seale	36 Doherty	25C Green	33 Seale	36 Doherty
C Weighted	45.9	48.2	47.6	46.5	47.2	46.7	47.1	47.4	47.3
A Weighted	33.7	35.2	35.1	34.6	34.9	34.4	35.1	34.2	34.2
Difference	12.2	13.0	12.5	11.9	12.3	12.3	12.0	13.2	13.1

Note 1: Representative residences 25C Green, 33 Seale and 36 Doherty
Note 2: Predicted $L_{Aeq(15minute)}$ noise level complies with the intrusive PSNL 35dB(A)
Note 3: Predicted negligible noise exceedance 1 to 2dB(A) above intrusive PSNL 35dB(A)
Source: SLR (2016) – Table 26

The resulting differences between the C and A weighting noise levels range from 12dB to 13dB, i.e. less than the 15dB that would necessitate a 5dB(A) correction to the predicted operational intrusive noise level under the INP.

4.2.7.5 Cumulative Noise

The cumulative noise assessment undertaken in the manner described in Section 4.2.6.5 established that the combined noise from the amended Project and the operations within the Stratford Mining Complex (and Duralie Modification) would comply with the daytime and evening criteria nominated in **Table 4.5** at all privately-owned residences. Some exceedances were predicted at resource-company owned residences, however, compliance is not required at these residences.

4.2.7.6 New Mine Noise

In the correspondence provided with the DGRs, the EPA requested that the noise assessment detail the number and location of residences at which mine noise would be able to be heard for the first time as a result of the amended Project. This largely relates to audibility, which in turn depends on details of the spectrum of both the noise source and the background noise levels.

For the area in the vicinity of the Mine Area and in the township of Gloucester, SLR (2016) considers an appropriate threshold of audibility is in the order of 25dB(A). The operational intrusive $L_{Aeq(15\ minute)}$ noise contours for Year 0.5 daytime, Year 4 evening, Year 7 evening and Year 10 daytime are presented in **Figures 4.12**, **4.14**, **4.16** and **4.18**. The contours were prepared for these scenarios as the noise levels resulting from these scenarios were invariably higher than the other four scenarios and therefore provided the more conservative approach to identifying the presence of a 25dB(A) contour further from the Mine Area.

During the evening, Year 4 and Year 7 intrusive $L_{Aeq(15\ minute)}$ noise levels range from 50dB(A) (within the Mine Area) down to 25dB(A) within the Gloucester urban area. It is noted that buildings within the Gloucester urban area have not been incorporated into the noise model, so operational noise levels (in the urban area) are likely to be demonstrably lower by comparison with those shown on the noise contour plans. Notwithstanding, operational noise levels may be audible (but unlikely to be noticeable) to an individual during noise enhancing 2m/s to 3m/s southerly winds (i.e. appropriately 6% of winter evenings) external to a residential building enclosed by the 25dB(A) noise contour (i.e. the eastern portion of the Gloucester township as shown on **Figure 4.14**) but are unlikely to be audible (or noticeable) within any residential building within the Gloucester township.

4.2.7.7 Sleep Disturbance

As discussed in Section 4.2.3, it is not a requirement under the Industrial Noise Policy to consider sleep disturbance of an evening. However, given the feedback to the 2013 Project regarding sleep disturbance for children and elderly persons who retire to bed before 10:00pm, SLR (2016) has examined this issue.

The EPA suggests that the $L_{A1(1minute)}$ level of 15dB(A) above the RBL is a suitable screening criterion for sleep disturbance for the night-time period, however, no specific screening criterion is provided for the evening period (6:00pm to 10:00pm). In the absence of any alternative, the EPA's recommended approach for night-time can be also applied to the evening period. Based on the background levels recorded in **Table 4.4**, an evening rating background level of 30dB(A) is applicable to all five general residential localities, producing a $L_{A1(1minute)}$ sleep disturbance screening criterion of 45dB(A).

SLR (2016) explains that field noise measurement results from similar mining operations show the difference between the (night-time) mine-contributed intrusive $L_{Aeq(15minute)}$ and the $L_{A1(1minute)}$ noise levels is typically 10dB(A) (or less). Hence, if the evening intrusive PSNL of 35dB(A) (see Section 4.2.4.3), i.e. 30dB(A) plus 5dB(A) is achieved, then the evening sleep disturbance screening criterion of 45dB(A) (i.e. 30dB(A) plus 15dB(A)) would also be met.

Given this outcome, sleep disturbance of an evening should not be a concern for any person living in the vicinity of the Mine Area.

4.2.7.8 Road Traffic Noise Assessment

The traffic noise levels calculated in the manner described in Section 4.2.6.6 firstly considered the total noise level of projected base, i.e. non project-related traffic, and then with the addition of project-related traffic. Where necessary, the relative increase in traffic noise as a result of the project-related traffic was assessed. SLR (2016) undertook the traffic noise assessment for traffic on The Bucketts Way, Jacks Road, Waukivory Road (east of Jacks Road) and Waukivory Road (north of Jacks Road) and compared the calculated level to the criteria outlined in Section 4.2.4.6. Details of the calculated traffic noise levels are presented in Section 9.1 of SLR (2016).

The Bucketts Way

The total traffic noise assessment established that a number of residences adjacent to The Bucketts Way north and south of Jacks Road currently experience noise levels in excess of the criteria, i.e. those residences within 74m of The Bucketts Way north of Jacks Road and those residences within 63m of The Bucketts Way south of Jacks Road. As such, reliance for impact assessment was placed upon the relative increase assessment criteria.

The maximum relative increase in traffic flow on The Bucketts Way (north of Jacks Road) due to the amended Project would occur in Year 10 resulting in an increase in traffic levels of 2% (daytime) and 12% (night-time). This increase corresponds to a negligible <0.1dB(A) (daytime) and 0.2dB(A) (night-time) increase in the projected base traffic noise levels.

Hence, traffic generated by the amended Project would easily satisfy the traffic noise criteria relevant to The Bucketts Way.

Jacks Road and Waukivory Road (East of Jacks Road)

The total traffic noise assessment established that none of the residences adjacent to Jacks Road or Waukivory Road East are within 15m of the centreline of either roads, i.e. the distance at which the total traffic noise criterion applies. Therefore, traffic travelling to and from the Mine Area at any time of day would satisfy the relevant traffic noise criteria.

Waukivory Road North

The total traffic noise assessment established that a total of six residences adjacent to Waukivory Road (north of Jacks Road) currently experience noise levels in excess of the daytime criteria, i.e. those residences within 46m of the road. As such, reliance for impact assessment was placed upon relative increase assessment criteria.

The maximum relative increase in peak hour traffic flows on Waukivory Road (north of Jacks Road) due to the amended Project would be approximately 39% in Year 1 and 27% in Year 10. These correspond with negligible increases of 1.4dB(A) in Year 1 and 1.0dB(A) in Year 10, both of which satisfy the 2dB(A) relative increase assessment criterion.

Hence, traffic generated by the amended Project and travelling to and from the Mine Area via Waukivory Road (north of Jacks Road) would satisfy the relevant traffic noise criteria.

4.2.8 Monitoring

Permanent, continuous real-time noise monitors would be installed at a minimum of two locations, being representative of Forbesdale and Avon River Estates. Additional portable or permanent monitors may be utilised pending a review during preparation of the Operational Noise Management Plan or during the life of the amended Project.

The noise monitoring system(s) selected would be capable of identifying noise from the amended Project, as distinct from extraneous noise such as traffic or other industrial sources, and provide real-time information to mine management in a simple, interpretable format.

The Operational Noise Management Plan for the amended Project would identify:

- the locations and protocols for noise monitoring;
- operations that may only be performed under particular meteorological conditions and, where applicable, identify alternatives for that operation or plant;
- a method for interfacing noise management with predictive meteorological systems;
- a system for sampling A-weighted and C-weighted noise levels to establish the extent of any low frequency noise content;
- the methods for monitoring the success of operational controls through continuous real-time noise monitoring, including the mechanism for feedback from such systems to influence operational decisions in the shortest timeframe practical; and
- noise trigger levels that prompt certain predetermined operational modes or require that the mine operationally respond in some manner to manage noise emissions.

Reliance would be placed upon monitoring externally at residences or receivers as preferred by the EPA. However, the Applicant would consider internal noise measurements for low frequency noise, as suggested by the BGSPA, in the event it is justified and supported by the respective landowner(s).

The Applicant would review and update, if necessary, the monitoring component of the Operational Noise Management Plan on an annual basis to reflect the experience/results of the monitoring undertaken during the preceding 12 months.

4.2.9 Conclusion

Management of potential operational noise impacts from the amended Project would involve a commitment to the use of a regime of continuous real-time noise monitoring, predictive meteorological systems and site management procedures to ensure that noise criteria are not exceeded under adverse meteorological conditions. This assessment indicates that with such a commitment, it would be possible to satisfy the noise criteria for the amended Project. It remains important to note that whilst compliance is predicted to occur at all (except three of the nearest residences), noise from the Site is likely to be audible periodically at a number of residences around the Site. However, the level of mine noise and associated impact would be considered generally acceptable.

4.3 BLASTING AND VIBRATION

The blasting and vibration assessment for the amended Project was undertaken by SLR Consulting (Australia) Pty Ltd as part of the overall Noise, Vibration and Blasting Assessment. The full assessment is presented in Sections 9.2 and 10 in Volume 1 Part 1 of the Specialist Consultant Studies Compendium and is referenced throughout this document as SLR (2016), with a summary of the assessment presented in the following subsections. This section addresses the impacts of both blasting and the vibration caused by heavy vehicles on the public road network in the vicinity of the Site.

4.3.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to blasting and vibration and their risk rankings after the adoption of standard mitigation measures are as follows.

- Ground vibration and airblast overpressure resulting in amenity impacts on residential or other sensitive receivers (low).
- Rock propelled outside the designed blast envelope, i.e. flyrock (causing damage on privately-owned property) (medium).
- Rock propelled outside the designed blast envelope, i.e. flyrock (causing injury and/or death) (low).
- Airblast overpressure and flyrock impacting upon airborne aircraft and aerial operations (low).

In addition, the Director-General's Requirements issued by the then DP&I (now DPE) identified "Blasting and Vibration" as key issues requiring assessment. The principal assessment requirements from DP&I relating to blasting and vibration include the following.

- Blasting impacts on people, livestock and property.
- Identification of reasonable and feasible mitigation measures.

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA, the former Gloucester Shire Council, NSW Health – Hunter New England Local Health District, and BGSPA. The additional matters identified in the additional correspondence by these agencies or organisations are generally consistent with the DGRs.

This section considers the blasting proposed within the Mine Area to fragment the overburden and interburden and transport-related vibration.

4.3.2 Potential Blasting and Vibration Impacts

The potential impacts from blasting relate to airblast, ground vibration, flyrock and fume emissions. Subject to their magnitude, these factors can, in turn, impact upon amenity, the structural integrity of surrounding buildings and infrastructure e.g. power lines, and pose comfort or health risks to surrounding persons and stock through a startle effect and/or flyrock and fume. Discussion regarding blast fume is presented in Section 4.4.9.12.

Potential impacts arising from vibration caused by heavy vehicles travelling on the public road network in the vicinity of the Site relate primarily to the annoyance risk for occupants of residential buildings located adjacent to the mine access routes.

4.3.3 Impact Assessment Criteria

4.3.3.1 Blasting

Criteria relating to blasting have been established by a range of organisations for the potential impacts discussed above. This subsection summarises the criteria relevant to each potential impact. A number of the criteria are referenced in Australian Standard (AS) 2187: Part 2 – 2006 Explosives – Storage and Use – Part 2: Use of Explosives.

Human Comfort Airblast and Vibration Criteria

The EPA defers to the Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration prepared by the Australian and New Zealand Environment Council (ANZEC) (1990) for blast-related vibration. The human comfort or annoyance criteria for blasting for any privately-owned residence or other sensitive location require that the:

- maximum overpressure due to blasting should not exceed 115dB(L) for more than 5% of blasts in any year, and should not exceed 120dB(L) for any blast; and
- maximum peak particle ground velocity (PPV) should not exceed 5 millimetres per second (mm/s) for more than 5% of blasts in any year, and should not exceed 10mm/s for any blast.

Livestock Comfort Airblast and Vibration Criteria

SLR (2016) cite references for criteria considered appropriate for cattle, namely 125dB(L) for airblast overpressure and 200mm/sec for vibration levels affecting animal health.

Residence / Building Damage

AS 2187.2-2006 recommends the adoption of a maximum airblast overpressure criterion of 133dB(Linear) Peak. SLR (2016) has adopted a conservative vibration peak component particle velocity of 12.5mm/s for all privately-owned residences in the vicinity of the Site.

Infrastructure Vibration Damage Criteria

Criteria to minimise vibration effects on railways, roadways and electricity infrastructure are drawn from a number of sources including the German Standard DIN 4150-3:1999 Structural Vibration Part 3: Effect of Vibration. SLR (2016) has adopted a vibration peak component particle velocity of 100mm/s for railway infrastructure, 80mm/s for roadway infrastructure and 50mm/s for power lines.

Archaeological / Geological Vibration Damage Criteria

SLR (2016) has adopted a conservative safe blast design vibration criteria of 250mm/s (5% exceedance) for archaeological / geological and Aboriginal heritage sites. It is noted that no known or potential archaeological sites that could be affected by blasting are located within or in the vicinity of the Site. Hence, this issue is not covered further.

It is noted that of all of the above criteria, the most stringent criteria relate to human comfort. Hence, this would invariably be the controlling factor in the design of all blasts, i.e. with the exception of any mine infrastructure near the open cut pits.

Flyrock Criteria

The Division of Resources and Energy (within the Department of Industry) requires that public roads within 500m of blasting sites within a coal mine need to be closed and public access restricted during blasting events, i.e. through the use of road closure signs and sentries at both ends of the roadway. **Figure 4.19** displays the 500m setback distance from the edge of the combined open cut pits and shows that no public roads would require closure during any blasting event.

4.3.3.2 Road Vibration

Vibration from passing vehicles, particularly heavy vehicles, has the potential to cause both nuisance and, at higher levels, damage to structures. The EPA's 2006 *Assessing Vibration: A technical guideline* focuses on criteria for the protection of human comfort i.e. vibration levels associated with a "low probability of adverse comment". **Table 4.14** lists the applicable vibration velocity criteria for continuous daytime and night-time traffic. It is noted that the criteria for night-time traffic are provided as some light vehicles would be travelling to the Mine Area between 6:00am and 7:00am and from the Mine Area between 10:15pm and 10:45pm, i.e. outside the daytime period.

Table 4.14
Continuous Vibration Velocity Levels Annoyance Risk Criteria

Receiver Area	Daytime Annoyance Risk[1] (mm/s)		Night-time Annoyance Risk[1] (mm/s)	
	Horizontal	Vertical	Horizontal	Vertical
Residences	1.2	0.45	0.6	0.2
Commercial/Offices	1.6	0.6	1.6	0.6
Industrial/Workshops	3.2	1.2	3.2	1.2

Note 1: BS6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)"
Daytime = 7:00am to 10:00pm Night-time = 10:00pm to 7:00am
Source: SLR (2016) – Table 55

Invariably the vertical vibration criterion is the controlling criterion. It is noted that the Applicant would not be requiring any truck deliveries during the night-time period. Similarly, there would be no night-time (or evening) transportation of sized coal on the private haul road.

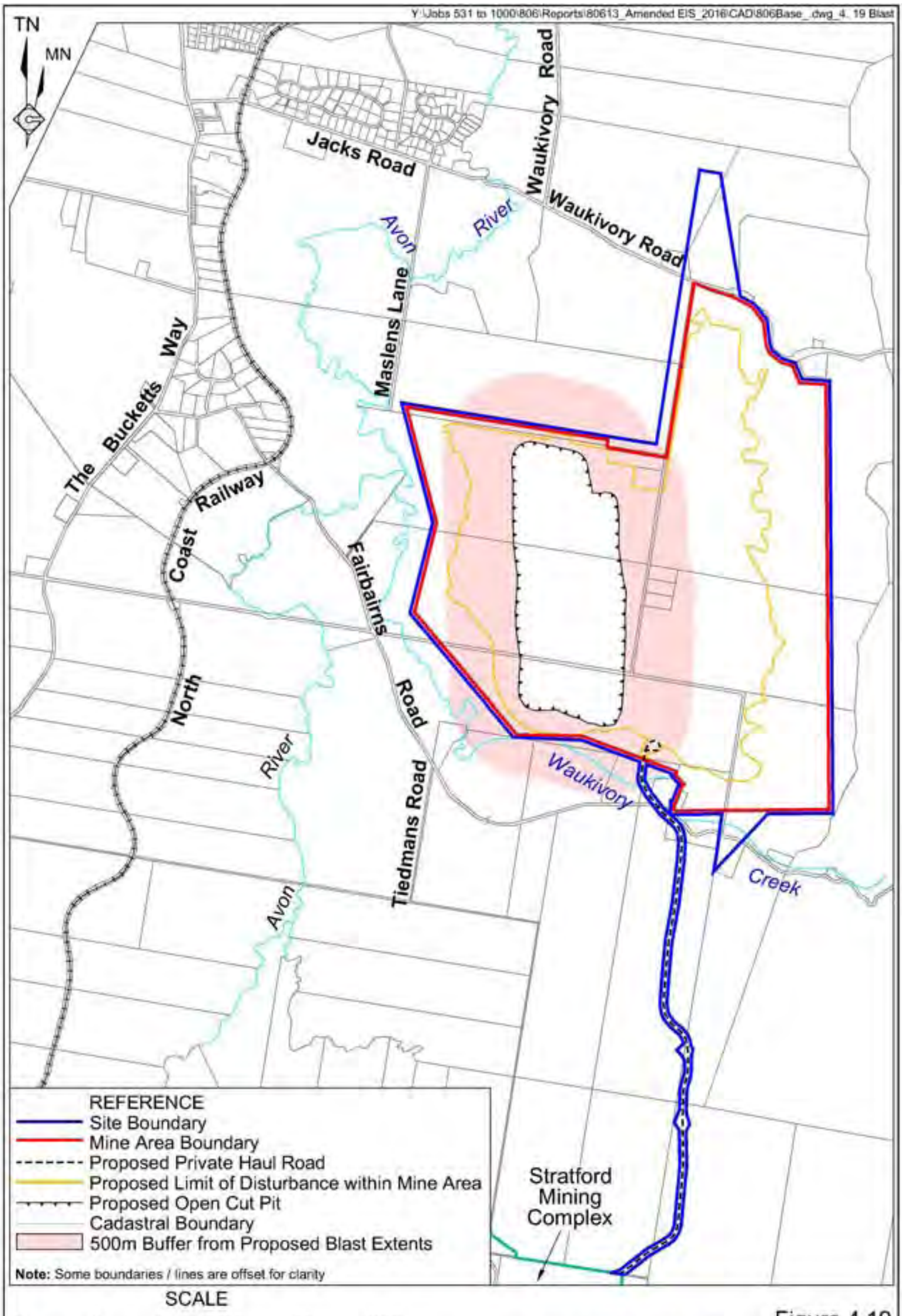


Figure 4.19
500m SETBACK FROM BLAST EXTENTS

4.3.4 Management, Mitigation and Contingency Measures

4.3.4.1 Blasting

Residents in the Vicinity of the Mine Area

The Applicant would control the adverse effects of blasting within the open cut pits principally through the design of each blast. The approach to the design of each blast and the variables that need to be considered in the design would be incorporated within a Blast Management Plan where the focus would be upon minimising both airblast overpressure and ground vibration, within practical and operational constraints, through measures such as:

- definition of appropriate burden distances and stemming lengths;
- design of blast sequences; and
- decking charges (where warranted).

The Applicant would ensure that the initial blasts are conservatively designed such that the levels of both airblast overpressure and ground vibration from proposed blasting activities are well within recommended criteria at all potentially-affected privately-owned residences or receivers. It is proposed that blasting would initially be conducted within the southern end of the Avon Pit, i.e. at least 2km from the nearest potentially-affected privately-owned residences, and that monitoring of airblast overpressure and ground vibration levels would be undertaken consistent with industry standards and any specific conditions within a development consent or environment protection licence. The outcome of this monitoring would then be used in the development and subsequent refinement of a specific site law for blasting within the Mine Area.

The Applicant would adopt the following measures to complement the design-related issues for blasting. Many of these measures relate to providing further protection for residences/receivers and the Applicant's proactive approach to its communications with nearby residents.

- A blast exclusion zone of 500m would be routinely implemented during blasts within the Mine Area.
- Maintaining a hotline advising nearby residents of blasting schedules.
- Undertaking structural surveys of residences within a 2km radius of the open cut pits, i.e. prior to the first blast, subject to landowners'/occupant's permission.

It is noted that all blasts would invariably be initiated on operational benches facing southwards, i.e. away from the rural-residential areas to the west through to the north of the Mine Area. The southerly direction of the blast envelope would focus the airblast overpressure and any fly rock in that direction.

The Applicant would also conduct a detailed airblast and ground vibration monitoring program to confirm that all blast-related criteria are being satisfied at all privately-owned residences or receivers. Details of the approach to the monitoring of each blast would be set out in the Blast Management Plan.

The Blast Management Plan would be reviewed annually to reflect the monitoring results and improved practices developed throughout the life of the amended Project.

Livestock

No specific management or mitigation measures would be required to avoid adverse impacts upon stock given the considerable distance between privately-owned land and the proposed blasts.

The Applicant would liaise regularly with the operator of the Speldon Dairy to alert him about planned locations and times of blasts and to enable the reactions of dairy cattle to be monitored to avoid any adverse reactions. In the unlikely event any impact is noted, livestock would be moved further away for future blasts, consistent with maintaining their welfare.

Residences and Buildings

No specific management or mitigation measures would be required, other than the implementation of optimised blast designs and development of site specific site laws, to ensure blast criteria are satisfied at all privately-owned residences and buildings in the vicinity of the Mine Area.

The buildings within the administration area are predicted to experience worst-case vibration levels potentially above the criterion for building damage. All existing buildings would be inspected by a structural engineer, and if necessary, either additional building support installed or controls on MIC implemented when blasting close to the buildings.

Infrastructure

There would be no need for any specific management or mitigation measures to protect the re-located 132kV power line as it would be at least 700m from the closest blast. This distance exceeds the 284m distance at which the 50mm/s criterion identified in Section 4.3.3 would be satisfied from the largest planned blast, i.e. with a maximum instantaneous charge of 848kg. No other public infrastructure is located within the Mine Area that requires protection.

Flyrock

The containment of rock propelled from the active blast beyond the designed blast envelope would be controlled principally through good blast design and practices. A video would be taken of all blasts to identify potential causes of any rock propelled beyond the designed blast envelope.

Cumulative Impacts

Dialogue with Stratford Coal Pty Ltd would be undertaken to ensure that blasting at the Stratford Mining Complex and within the Rocky Hill Mine Area do not occur simultaneously. This would ensure that blasting and vibration criteria are not exceeded due to coincident blasts.

4.3.4.2 Road Vibration

Vibration from trucks travelling on public roads is generally found to be insignificant except where the roads are in poor repair. The Applicant would monitor the road surfaces to ensure that the roads used by vehicles travelling to and from the Mine Area are kept in good repair and, if necessary, draw Council's attention to maintenance work required.

4.3.5 Assessment Methodology

4.3.5.1 Blasting

SLR (2016) undertook the assessment of the potential ground vibration and airblast emissions arising from overburden blasting based upon the indicative blast design parameters summarised in **Table 4.15**. Predicted blast emission impacts from blasting within the proposed open cut pit boundary were calculated with the key variable being the Maximum Instantaneous Charge (MIC) of either 414kg or 828kg. In the event that the blast criteria would be exceeded by the higher MIC, SLR (2016) back-calculated to identify the MIC required to achieve compliance.

Table 4.15
Indicative Overburden Blast Design Parameters

Parameter	**Typical Ranges**
Bench Height	15m or 30m
Burden and Spacing	6m x 6m
Stemming	4m (aggregate)
Hole Diameter	125mm to 229mm
Number of Holes	Typically between 80 and 160 holes
Holes per Delay	Typically 1 to 3 holes
Explosive Type	Wet (Powergel), Dry (ANFO)
Effective Powder Factor	Typically 0.8kg/m^3
Maximum Instantaneous Charge (MIC)	Typically 414kg to 828kg
Source: SLR (2016) – Table 59	

In order to determine the levels of airblast overpressure and ground vibration at the residences in the vicinity of the Mine Area, conservative 50% and 5% exceedance airblast and ground vibration site laws established in the Stratford Extension Project Noise and Blasting Assessment (SLR, 2012), were adopted.

$$\text{PVS (50\% exceedance)} = 529*(R/Q^{1/2})^{-1.42}$$
$$\text{PVS (5\% exceedance)} = 1{,}297*(R/Q^{1/2})^{-1.42}$$
$$\text{SPL (50\% exceedance)} = 140 - 14*(\log(R) - \tfrac{1}{3}\log(Q))$$
$$\text{SPL (5\% exceedance)} = 146 - 14*(\log(R) - \tfrac{1}{3}\log(Q))$$

where,

PVS = Vibration velocity Peak Vector Sum (PVS) (mm/s)
SPL = Airblast Level Linear Peak (dBLpk re 20µPa).
R = Distance between charge and receiver (m)
Q = Charge mass per delay (kg)

4.3.5.2 Road Vibration

In order to establish if the traffic travelling to and from the Mine Area satisfies the criteria nominated in Section 4.3.3.2, SLR (2016) calculated the nominal offset distances(s) from the centreline of the subject roads at which compliance would be achieved.

4.3.6 Assessment of Impacts

4.3.6.1 Blasting

Residents in the Vicinity of the Mine Area

The calculations undertaken by SLR (2016) have established the MIC required to achieve compliance at the closest blast to each residence. The Applicant would design each blast to achieve airblast overpressure and ground vibration lower than the criteria to maintain the comfort of the residents. For example, SLR (2016) calculated that in order to satisfy the criteria at Residence 18 from the closest blast, an MIC of 575kg or less would be appropriate.

Livestock

Blasting is not proposed within 1km of the boundary of any privately-owned land used for grazing dairy or beef cattle. Hence, there would be no requirement for any owner of any privately-owned property to move their stock while blasting is undertaken to avoid the possibility of flyrock impacts or excessive ground vibration or airblast overpressure levels.

Notwithstanding, it is also the objective of the Applicant to maintain the existing dairying activity on land located to the west and north of the Mine Area.

The effects of blasts on dairy cattle are not known in detail, however, in a court case (Fig Tree Hill PC vs Cleary Bros, 2006) evidence from a veterinary scientist (accepted by the presiding judge) indicated his belief that vibration levels of 200mm/sec Peak Particle Velocity will not have adverse effects on dairy cattle or their milk production. With the maximum proposed MIC for the amended Project (828kg), this would correspond to a minimum distance of 90m from a blast. It is noted that the closest land used for dairying is approximately 180m from the northern end of the Main Pit, a location that would not be approached until about Year 14. The planned monitoring of the dairy cattle throughout the life of the amended Project would ensure that the welfare of the dairy cattle and milk production is not compromised by the blasting activities within the Mine Area.

Similarly, flyrock would be monitored during the initial 3 years of operations so as to ensure that when blasting is ultimately undertaken near the boundary of the Main Pit any cattle in the adjacent areas are not at risk of injury from flyrock.

Given the Applicant’s proposed approach to managing the design of blasts and co-ordination with the operator of Speldon Dairy, no adverse impacts are anticipated to the welfare or production capacity of the dairy cows on the dairy.

Residences and Buildings

Criteria for the damage of residences and buildings are higher than those for human comfort. Satisfaction of the human comfort criteria would thereby ensure that no privately-owned buildings are predicted to experience vibration levels above building damage criteria.

Infrastructure

As discussed in Section 4.3.3.1, criteria for the damage of rail and road infrastructure as well as power lines have been established and are higher than those for residences and buildings. As a result, no blast impacts are predicted to occur at the nearest rail and road locations. Similarly, no impacts would occur to the re-located 132kV power line nor at the 11kV power line to be constructed to the administration area, a distance of approximately 300m from the Main Pit.

Flyrock

Given that no blasts within the Mine Area would occur within 500m of any public road, no issue would occur with flyrock.

Cumulative Impacts

The only mine with potential to result in cumulative blast impacts with the amended Project is the Stratford Mining Complex. Current criteria allow for blasting once per day at any given mine, and hence assessment of potential cumulative impacts is restricted to ensuring that blasts are not simultaneous. This would be achieved through dialogue with Stratford Coal Pty Ltd.

4.3.6.2 Traffic Vibration Impact Assessment

The nominal offset distances to residences for compliance with the vibration annoyance risk criterion on public roads (i.e. Jacks Road) from 30t capacity heavy vehicle movements and the private haul road from 60t capacity heavy vehicle movements are presented in **Table 4.16** based on the heavy vehicle vibration level contained in the Transportation Noise Reference Book (Nelson, 1987).

Table 4.16
Nominal Offset Distances to Residences to Comply with Vibration Annoyance Risk Criteria

Traffic Area	Daytime Residential Annoyance Risk		Night-time Residential Annoyance Risk	
	Horizontal	Vertical	Horizontal	Vertical
Public Road (30t capacity heavy vehicles)[1]	5m	10m	8m	16m
Private Haul Road (60t capacity heavy vehicles)[1]	8m	15m	13m	25m
Note 1: Assumes 30t capacity heavy vehicle and 60t capacity heavy vehicle travelling at 60kph				
Source: SLR (2016) – Table 56				

All residences adjacent to the proposed primary access route to the Mine Area (i.e. Jacks Road and Waukivory Road east of Jacks Road) are located at distances well beyond the 10m distance required to achieve compliance of a daytime. Therefore, no adverse impact would occur at residences adjacent to this route.

Vibration from trucks travelling along the private haul road would comply within 15m distance offset, particularly given the closest privately-owned residence to the haul road is 1.5km to the southeast of the road.

4.3.7 Monitoring

Monitoring of blasting is an important process to ensure that blast-related environmental objectives and criteria are achieved.

A permanent blast monitoring network would be established around the Mine Area. This network would enable:

- monitoring of airblast overpressure in dBL peak using a microphone and meter; and
- measurement of PPV vibration levels using a 3-directional transducer connected to the monitoring equipment.

With the agreement of residents, ground vibration and airblast overpressure monitoring will be carried out at a minimum of two selected residential locations with potential for being affected by the higher levels expected in the area.

A video would be maintained for each blast to obtain general information about flyrock and fume emissions.

The results of each blast would be summarised in a brief report which will be retained on site during the life of the amended Project.

4.3.8 Conclusion

Ground vibration and airblast overpressure would be controlled to meet the criteria recommended in the Australian & New Zealand Environment Council Guideline by well controlled blast design and execution, and by restrictions on the MIC where this is found necessary. Initial blast designs would be conservative and, from these the appropriate blast design, including MIC limits, would be developed to satisfy the blast criteria for individual blasts.

A conservative process would ensure that flyrock from blasting would not cause damage to property or injury to persons or stock.

The movement of delivery trucks on public roads would not generate vibration levels with potential to cause damage to buildings, but maintenance of the roads on a regular basis will be necessary to minimise vibration.

4.4 AIR QUALITY

The air quality and health risk assessments of the amended Project were undertaken by Pacific Environment Limited (Pacific Environment). The full assessments are presented in Volume 1 Part 2 of the Specialist Consultant Studies Compendium and are referenced throughout this section as Pacific Environment (2016a) for the air quality assessment and Pacific Environment (2016b) for the Health Risk Assessment with a summary of both assessments presented in the following subsections. This section also references the results of a peer review of the air quality and health risk assessments undertaken by Associate Professor David McKenzie, Respiratory and Sleep Physician at the Prince of Wales Private Hospital and Medical Director of Medicine and Integrated Care at the Prince of Wales Hospital, Randwick, NSW.

It is noted that Pacific Environment has also undertaken the air quality assessment of the Stratford Extension Project and is therefore well positioned to undertake the required cumulative air quality impact assessment of both mining operations.

4.4.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to air quality and their risk rankings after the adoption of standard mitigation measures are as follows.

- Community concern regarding dust collection in drinking water tanks and rain water collection storages (low).

- Odour from spontaneous combustion of coal impacting on residents and other sensitive receivers (low).
- Amenity impacts on residents due to generation of blasting fume (low).
- Health impacts on residents due to generation of blasting fume (low).
- Emissions of TSP, PM_{10}, $PM_{2.5}$, and deposited dust from construction operations, mining operations, processing, storage, loading and haulage causing health or amenity impacts on residents and other sensitive receivers (low).
- Deposited dust causing unacceptable dust load on crops and on surrounding agricultural land (low).
- Climate change impact locally, regionally, and worldwide from amended Project due to GHG emissions (low).

In addition, the Director-General's Requirements issued by the then DP&I (now DPE) identified "air quality" and "greenhouse gases" as key issues requiring assessment. The principal requirements relating to air quality include the following.

- Construction and operational impacts, with a particular focus on dust emissions (including $PM_{2.5}$ and PM_{10} emissions, and dust generation from coal transportation), as well as diesel, spontaneous combustion and blast fume emissions.
- Reasonable and feasible mitigation measures to minimise dust, diesel, spontaneous combustion and blast fume emissions, including evidence that there are no such measures available other than those proposed.
- Monitoring and management measures, in particular real-time air quality monitoring and predictive meteorological forecasting.

The principal requirements relating to greenhouse gases include the following.

- A quantitative assessment of potential Scope 1, 2 and 3 greenhouse gas emissions.
- A qualitative assessment of the potential impact of these emissions on the environment.
- An assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency.

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA, the former Gloucester Shire Council, NSW Health – Hunter New England Local Health District, and the BGSPA. The matters identified in the additional correspondence are generally consistent with the DGRs, although NSW Health – Hunter New England Local Health district specified the need for management and mitigation measures for SO_x production and the BGSPA requested that monitoring of tank water quality be undertaken regularly, and tank cleaning be provided for residents with a 5km radius of the Mine Area.

4.4.2 Overview of the Environment Influencing Assessment of Air Quality

Pacific Environment (2016a) has assembled the following overview of the existing environment and the approach to the assessment of air quality based upon site specific data collected on behalf of the Applicant, from the Stratford Mining Complex and Pacific Environment's experience with numerous other coal mining projects.

Topography plays an important role in steering winds, generating turbulence and large scale eddies, and in generating drainage flows at night and upslope flows in the day. Regional topography in the Stroud-Gloucester Valley has a strong influence on prevailing meteorology. The major topographical features that would be expected to influence air movements in the valley are displayed in **Figures 4.1** and **4.6**.

Figures 4.1 and **4.6** also show that, on a broad scale, the Stroud-Gloucester Valley is orientated north-south near Gloucester, while closer to the Stratford Mining Complex, the orientation of the valley changes slightly to a north-northeast to south-southwest alignment. The margins of the valley contain complex structures that influence air movement close to those margins.

Meteorological data, including wind speed, wind direction, temperature, humidity and sigma-theta, have been collected at the Applicant's meteorological station since it was established in June 2010. Additional meteorological data has also been sourced from the meteorological station at the Stratford Mining Complex.

An overview of the wind speed and direction data recorded at both the Applicant's and Stratford Mining Complex's meteorological stations has previously been presented in Section 4.1.3.

4.4.3 Explanation of Particulate Matter and Dust Deposition

Particulate matter has the capacity to affect health and to cause nuisance effects, and is categorised by its size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as follows.

- Total suspended particulates (TSP) – refers to all suspended particles in the air. In practice, the upper size range is typically 30μm to 50μm as larger particles would usually remain in the air for only a few minutes and settle near the source.
- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10μm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10μm and with a unit density. PM_{10} particles are a sub-component of TSP.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5μm diameter. These are often referred to as the fine particles and are a sub-component of PM_{10}.
- $PM_{2.5}$ – PM_{10} are referred to as coarse particles and defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations.

The health risk from the increased concentrations of particulate matter as a result of the amended Project has been assessed and is presented in Section 4.4.10 following the assessment of the impact on air quality.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including native vegetation and crops. Dust deposition can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts. Dust deposition is assessed independently of particulate matter.

Dust deposition includes all particle sizes however, as described for TSP, typically particles larger than 30μm to 50μm usually remain in the air for only a few minutes and settle near its source.

4.4.4 Existing Air Quality Environment

4.4.4.1 Introduction

In July 2010, the Applicant initiated an air quality monitoring program to monitor dust deposition rates and dust concentrations (as PM_{10} and later $PM_{2.5}$) in the vicinity of the Site to establish a baseline for later comparison and to understand existing air quality. This program, which is ongoing, has enabled the Applicant to compile baseline data for use in the various environmental assessments of the amended Project. The monitoring, including site selection, sampling and analyses, were undertaken in accordance with the Approved Methods for the Sampling and Analysis of Air Pollutants in NSW. The locations of the current monitoring locations within and in the vicinity of the Site are shown on **Figure 4.20** and are described in **Table 4.17**. The locations of the TEOMs monitoring PM_{10} and $PM_{2.5}$ were selected on the basis of the directions of the prevailing winds in the vicinity of the Mine Area, i.e. generally northerly and southerly. These locations have provided a very clear understanding of the air quality both upwind and downwind from the Mine Area from a baseline perspective.

Table 4.17
Overview of Rocky Hill Air Quality Monitoring Program

Parameter	Monitoring Method	Number of Locations	Date Commenced
Dust Deposition	Dust Deposition Gauges (DDG)	8	01/07/2010 (GA01-GA07) 03/12/12 (GA08)
PM_{10}	High Volume Air Sampler (HVAS)	2	19/07/2010
	TEOM	2	19/05/2011
$PM_{2.5}$	TEOM	2	19/05/2011
Source: Pacific Environment (2016a) – Table 5.3			

Air quality data is also collected at the nearby Stratford Mining Complex by way of seven deposited dust gauges, five high volume air samplers and a TEOM.

The following subsections provide an analysis and summary of the air quality monitoring data collected within and in the vicinity of the Site.

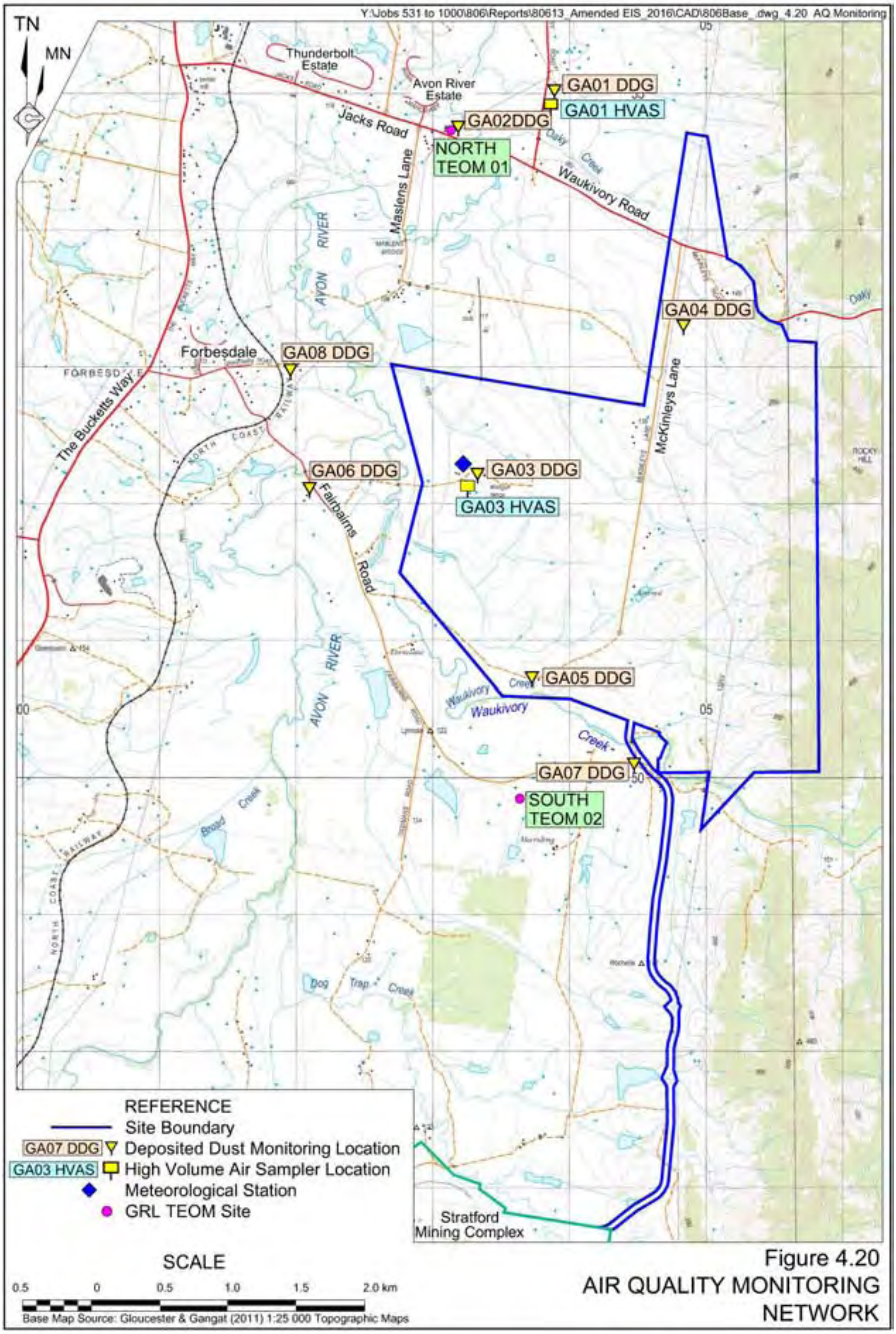


Figure 4.20
AIR QUALITY MONITORING NETWORK

4.4.4.2 Existing Deposited Dust Levels

Table 4.18 provides a summary of the annual average dust deposition data collected within and in the vicinity of the Site. The average across all monitoring locations for all available monitoring data to December 2015 is 1.0g/m^2/month, which indicates that dust deposition levels for the area are low. These levels are comparable to the measurements collected over 14 years around the Stratford Mining Complex where the average level for deposited dust in the seven gauges is 0.9g/m^2/month.

Table 4.18
Annual Dust Deposition Data (Insoluble Solids) (g/m^2/month)

Date	DDG – GA01	DDG – GA02	DDG – GA03	DDG – GA04	DDG – GA05	DDG – GA06	DDG – GA07	DDG – GA08
2010[(a)]	0.3	0.3	0.4	1.0	1.3	1.6	0.7	N/A
2011	0.4	0.5	0.5	1.7	0.8	1.4	0.8	N/A
2012	1.2	0.8	1.0	0.9	0.6	0.9	1.1	N/A
2013	1.3	0.7	1.2	0.8	1.0	1.0	1.0	0.6
2014	0.9	0.7	0.8	1.3	1.4	2.1	1.2	0.6
2015	1.6	0.7	0.8	0.7	3.5	1.8	1.1	0.9
Average	**0.9**	**0.6**	**0.8**	**1.1**	**1.4**	**1.5**	**1.0**	**0.7**
Average across all sites								**1.0**

N/A = Not Available
Notes: (a) Monitoring available from July 2010 for GA01-GA07 therefore average based on less than 6 months of data.
Source: Pacific Environment (2016a) – Table 5.4

Of note, the average deposited dust of 3.5g/m^2/month recorded at GA05 during 2015 is elevated compared to remainder of the monitoring network. In 2015, an extensive area immediately to the west of GA05 was subject to intensive agricultural activity using machinery including spraying, ploughing, seeding and harvesting.

4.4.4.3 Existing PM_{10} and $PM_{2.5}$ Concentrations

Table 4.19 provides a summary of the existing annual average PM_{10} and $PM_{2.5}$ concentration data collected for the amended Rocky Hill Coal Project.

Table 4.19
Annual Average PM_{10} Concentrations (µg/m^3)

Period	GA01 HVAS	GA03 HVAS	North TEOM01		South TEOM02	
	PM_{10}	PM_{10}	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
2010	10[(a)]	10[(a)]	N/A	N/A	N/A	N/A
2011	9	8	9[(b)]	6[(b)]	8[(b)]	4[(b)]
2012	9	8	11	5	9	4
2013	10	11	15	7	10	4
2014	9	9	9	4	10	4
2015	7	8	11	5	7	3

N/A = Not Available
Notes: (a) Monitoring commenced in July 2010 therefore average based on less than 6 months of data.
(b) Monitoring commenced in May 2011 therefore average based on less than 8 months of data.
Source: Pacific Environment (2016a) – Table 5.5

PM_{10} concentration data collected using the HVASs and TEOMs are consistent and the monitoring data indicates that the annual average PM_{10} concentration for the area ranges between 7µg/m^3 and 15µg/m^3. The North TEOM is located closer to the town of Gloucester and concentrations are slightly higher at this location. The North TEOM is also located in the proximity of Jacks Road and experiences higher traffic levels than the South TEOM site adjacent to Fairbairns Road. This observation is supported by the fact that the lowest annual PM_{10} (and $PM_{2.5}$) concentrations at the North TEOM site occurred in 2014 when traffic levels along Jacks Road were reduced whilst the bridge over the Avon River was closed.

The average PM_{10} concentration for all Rocky Hill sites is 9µg/m^3. For comparative purposes, the average PM_{10} concentration at the five HVAS sites surrounding the Stratford Mining Complex is 11µg/m^3 and at the TEOM site is 13.4µg/m^3.

Annual average $PM_{2.5}$ concentration recorded at the North and South TEOM sites range from 3µg/m^3 to 7µg/m^3 with an average $PM_{2.5}$ concentration of 4.6µg/m^3 for all years across both sites. The ratio of $PM_{2.5}$ / PM_{10} is 0.4 at the South TEOM and 0.5 at the North TEOM. These ratios are comparable with ratios observed in the Hunter Valley. For comparative purposes, the average $PM_{2.5}$ concentration at the Stratford Mining Complex TEOM site is 7.3µg/m^3. Given that the Stratford Mining Complex is an operational site, this average would include contributions from the mining and related activities.

The highest 24-hour average PM_{10} and $PM_{2.5}$ concentrations for all sites are shown in **Table 4.20**, along with the corresponding concentrations recorded at the other monitoring locations on those days.

Table 4.20
Highest 24-Hour Average PM Concentrations (µg/m^3)

Date	GA01 HVAS	GA03 HVAS	North TEOM01		South TEOM02	
	PM_{10}	PM_{10}	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
31/10/2014[(a)]	**52**	**42**	40	29	40	27
25/08/2013	18	27	22	17	**52**	**43**
18/10/2013	41	41	**48**	**28**	45	27
Note: (a) The maximums at HVAS – GA01 and HVAS – GA02 occurred on the same day.						
Source: Pacific Environment (2016a) – Table 5.6						

Over the 6 year monitoring period at GRL's monitoring sites, there have been two exceedances of the 50µg/m^3 24-hour PM_{10} impact assessment criterion, i.e. on 25 August 2013 and 31 October 2014. Observations during sampling on 31 October 2014 noted heavy smoke from bushfires, which explains the exceedance at GA01 HVAS and the elevated levels recorded across all sites. There were no known significant weather or other events to explain the exceedance recorded at South TEOM02 on 25 August 2015. As measurements at the other monitors during this time were comparatively low, the results may be explained by a local dust-generating event. It is noted that Yancoal experienced similar elevated levels of PM_{10} attributed to bushfire events which contribute to increasing the overall mean PM_{10} result.

Over the period since May 2011, the 24-hour $PM_{2.5}$ concentrations recorded at the North and South TEOM sites exceeded the advisory reporting standard of 25µg/m^3 on six and seven occasions respectively. The recorded data indicates that $PM_{2.5}$ concentrations peak around the spring months, during which these exceedances also occurred. These high values may be explained by regional events including bushfires such as observed on 31 October 2014.

4.4.4.4 TSP Concentrations

No TSP concentration data is available in the vicinity of the Site. However, annual average TSP concentrations can be estimated from the PM_{10} measurements by assuming that 40% of the TSP is PM_{10}. This relationship was obtained from data collected by co-located TSP and PM_{10} monitors operated for long periods of time in the Hunter Valley (NSW Minerals Council, 2000).

Use of this relationship indicates that, when taking the PM_{10} average over all sites, the annual average TSP concentration is approximately 23µg/m^3, i.e. a concentration well below the assessment criterion of 90µg/m^3.

4.4.4.5 Existing Air Quality for Assessment Purposes

The monitoring data collected for the amended Project is unlikely to include a significant contribution from the existing Stratford Mining Complex operations to the south and therefore provides a good indication of existing background levels for all other sources of particulate matter for the area. This is demonstrated in **Table 4.19** where higher PM_{10} concentrations are recorded at the North TEOM site (closer to Gloucester township) than the South TEOM site (which is closer to the Stratford operations). This may suggest that domestic wood burning and vehicle emissions contribute more to particulate matter concentrations in the vicinity of the Site than the mining and related activities at the Stratford Mining Complex.

Based on the information presented in Sections 4.4.4.2 to 4.4.4.4, the following annual background levels have been assumed for sources other than the proposed mining activity.

- Annual average TSP concentration of 23µg/m3.
- Annual average PM_{10} concentration of 9µg/m^3.
- Annual average $PM_{2.5}$ concentration of 4.6µg/m^3.
- Annual average dust deposition of 1g/m^2/month.

4.4.5 Potential Air Quality Impacts

The development and operation of the amended Project could have a range of potential air quality-related impacts which have previously been recognised in the risks identified in Section 4.4.1. Each of the potential impacts outlined below has been studied in detail by Pacific Environment in conjunction with the Applicant to ensure appropriate design and operational safeguards are in place to avoid or minimise adverse environmental impacts (see Section 4.4.9).

- Emissions of TSP, PM_{10}, $PM_{2.5}$, and deposited dust from site establishment and construction activities, mining operations, coal sizing, storage, loading and coal transportation causing health or amenity impacts on residents and other sensitive receivers.
- Odour from spontaneous combustion of coal impacting on residents and other sensitive receivers.
- Emissions from blast fume causing health impacts on residents and other sensitive receivers.

- Dust deposition on roofs impacting domestic tank water supply.
- Deposited dust causing impact on stock, agricultural productivity and dairying in particular.
- Climate change impact from the amended Project due to greenhouse gas (GHG) emissions.

It is noted that the low sulphur content of Australian diesel, in combination with the fact that mining equipment is widely dispersed over the Mine Area, is such that the ambient air quality criterion for SO_2 would not be exceeded, even in mining operations that use large quantities of diesel. For this reason, Pacific Environment has concluded that no detailed study is required to demonstrate that emissions of SO_2 from the amended Project would not significantly affect ambient SO_2 concentrations.

4.4.6 Environmental Air Quality Criteria and Goals

The Approved Methods (DEC, 2005) specify the air quality assessment criteria relevant for assessing impacts from air pollution. These criteria are in fact health-based (i.e. they are set at levels to protect against health effects) and are consistent with:

- the *National Environment Protection (Ambient Air Quality) Measure* (referred to as the Ambient Air-NEPM as amended February 2016) (NEPC, 2016); and
- the Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments (NSW Government, 2014).

However, the EPA's criteria include averaging periods which are not included in the Ambient Air-NEPM, namely TSP and dust deposition.

Table 4.21 summarises the air quality criteria for concentrations of particulate matter that are relevant to the investigations undertaken by Pacific Environment.

Table 4.21
Air Quality Standards/Criteria for Particulate Matter Concentrations

Pollutant	Averaging Period	Standard/Criteria	Agency
TSP	Annual mean	90μg/m^3	NSW DEC (2005) (assessment criteria)
PM_{10}	Maximum 24-hour average	50μg/m^3	NSW DEC (2005) (assessment criteria) NSW Government (2014)^
	Annual mean	30μg/m^3	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	Annual Mean	8μg/m^3	NEPC (2016)
	Maximum 24-hour average	25μg/m^3	

Notes: μg/m^3 – micrograms per cubic metre. ^ Policy provides for incremental increase, i.e., 'Project Only' concentration and up to 5 exceedances over the life of the development.

Source: Pacific Environment (2016a) – Table 4.1

It is important to note the TSP, PM_{10} and $PM_{2.5}$ criteria relate to the total dust burden in the air and not just the dust from proposed activities such as coal mining, i.e. background dust levels need to be considered when using these criteria to assess potential impacts.

Table 4.22 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance or amenity impacts (DEC, 2005).

Table 4.22
EPA Criteria for Dust (Insoluble Solids) Deposition

Pollutant	Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Deposited Dust	Annual	$2g/m^2$/month	$4g/m^2$/month
Notes: g/m^2/month – grams per square metre per month.			
Source: Pacific Environment (2016a) – Table 4.2			

In December 2014, the NSW Government released the *Voluntary Land Acquisition and Mitigation Policy For State Significant Mining, Petroleum and Extractive Industry Developments*. The policy sets out voluntary mitigation and land acquisition rights where it is not possible to comply with the EPA air quality assessment criteria, even with the implementation of all reasonable and feasible avoidance and/or mitigation measures. The criteria are the same as those listed within **Tables 4.21** and **4.22** with the exception of maximum 24 hour PM_{10}. The policy provides for an incremental 24 hour PM_{10} criteria of $50\mu g/m^3$ for acquisition which represents the 'project only' emissions.

Nitrogen Dioxide (NO_2)

The NSW EPA prescribes 1-hour and annual average goals for NO_2 of 0.12ppm or $246\mu g/m^3$ (1-hour average) and 0.03ppm or $62\mu g/m^3$ (annual average), respectively.

4.4.7 Management, Mitigation and Contingency Measures

4.4.7.1 Introduction

The following subsections summarise the proposed management, mitigation and contingency measures the Applicant would adopt to reduce the impact of air quality emissions at surrounding privately-owned residences or receivers and at sensitive residences or receivers within Gloucester township, and greenhouse gas emissions.

The proposed measures incorporate all practical and/or feasible best practice measures as recommended within the NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining (Donnelly *et al*, 2011). Section 7.1 of Pacific Environment (2016a) provides a tabulated summary of each recommended measure, its application to the amended Project and effectiveness of each reduction measure.

4.4.7.2 Site Establishment and Construction

Procedures for controlling dust impacts during the site establishment and construction activities would include, but are not necessarily limited to the following. Where relevant, these measures would also be implemented throughout the operational stage.

Emissions from vegetation clearing, soil stripping and excavation can occur, particularly during dry and windy conditions. Emissions can be effectively controlled by increasing the moisture content of the soil / surface. Other controls that would be implemented would include:

- modifying working practices by limiting soil stripping and excavation during periods of high winds; and
- limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction, and appropriate staging of any clearing.

Vehicles travelling over unsealed surfaces invariably produce wheel-generated dust. The following measures would be implemented during the site establishment and construction stage to minimise dust emissions from these activities.

- All vehicles on site would be confined to designated routes with appropriate speed limits enforced.
- Trips and trip distances would be controlled and reduced where possible, for example, by coordinating delivery and removal of materials and equipment to avoid unnecessary trips.
- Water trucks (for water spraying of travel routes and exposed surfaces) would be used on site when required, particularly during dust generating activities.

Wind erosion from exposed surfaces during the site establishment and construction stage would be controlled as part of the best practice environmental management of the Site. Wind erosion from exposed ground would be limited by avoiding unnecessary vegetation clearing and ensuring rehabilitation of available areas occurs as quickly as possible. Wind erosion from interim stockpiles would be limited by minimising the number of stockpiles on site; minimising the number of work faces on stockpiles; spraying/watering stockpiles and/or stockpile revegetation. All soil stockpiles not required for revegetation of roadside batters or other areas of disturbance for a period of 3 months or more would be sown with a pasture mix and fertiliser to promote growth.

All earthmoving equipment would be fitted with standard exhaust emission equipment.

4.4.7.3 Operations

An Air Quality and Greenhouse Gas Management Plan (AQGGMP) would be prepared with the following measures to be employed for the duration of the amended Project's operational stage.

- Use of water carts/trucks to control emissions from active haul roads.
- Use of additional water application and/or surfactants, if required, on active haul roads.
- Progressive revegetation.
- Application of water at conveyor transfer points, including water sprays at the feeder/hopper.
- Minimising travel speed and the distance travelled by bulldozers.
- Delay of blasts if unfavourable weather prevails.

- Watering of active overburden emplacements with water trucks and/or irrigators using excess saline water (see Section 4.7.4).
- Minimising drop heights when unloading material.
- Use of water sprays, water injection and/or dust aprons for drilling.

An additional component of proactive dust (and noise) management throughout all operations would be a meteorological forecasting system. This system would predict meteorological conditions for the following day to determine, one day in advance, when the risk of excessive dust emissions and dispersal may occur (e.g. based on wind speed, direction, rainfall, temperature and atmospheric stability). The predictive meteorological forecasting system would be used in operational planning and subsequently work in conjunction with the real-time monitoring system, providing an alert for the appropriate on-site personnel to review the real-time data and manage the location(s) and intensity of activities, increase controls or limit activity to various areas of the Site.

The predictive meteorological forecasting system would provide simple indicators of the following day's risk of impact, based on meteorological conditions that are known to have adverse impacts, and would allow mine personnel to put measures into place in advance. Examples of such preparatory measures would include:

- scheduling additional water carts and operators;
- planning for modifying or relocating certain activities; and/or
- scheduling maintenance on equipment.

The real-time dust monitoring system would then be used to trigger when the respective controls need to be instigated. Reactive triggers would be set and used to alert supervisors/mine management when monitoring data for short term average periods indicate that the 24-hour air quality criteria may be exceeded.

Corrective measures would be instigated when alerts are triggered by the real-time dust management system. Corrective measures may include activities such as:

- relocating water carts to dusty activity areas;
- relocation of overburden emplacement away from elevated areas; and/or
- limiting dozer activity on the out-of-pit emplacements.

All earthmoving equipment would be fitted with standard exhaust emission equipment.

These management measures are, to the extent practicable, consistent with those recommended in "NSW Coal Benchmarking Study: International Best Practice Measures to prevent and/or minimise emissions of particulate matter from Coal Mining" (Donnelly *et al*, 2011) commissioned by the NSW EPA.

4.4.7.4 Blast Fume Emissions

Measures to minimise or avoid imperfect blasts would be implemented with due regard to the Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting (Australian Explosives Industry and Safety Group Inc., 2011) and documentation in preparation by DPE regarding the control and reporting of blast fume. These measures would be identified in a Blast Fume Management Strategy which would be appended to the Blast Management Plan for the amended Project. The Blast Fume Management Strategy would address factors known to contribute to fume generation, including: geology; meteorological conditions; blast design; product selection and quality, as well as blast crew education, on-bench practices and emergency response procedures.

4.4.7.5 Spontaneous Combustion

The careful management of operational conditions would ensure that minimal impacts to air quality occur as a result of spontaneous combustion. The Applicant would control the potential for spontaneous combustion through the implementation of a stockpile management and slope stability management protocol. The key items of this protocol would include:

- inspection regimes for ROM coal stockpiles, and breaker reject and coal conveyors;
- maintenance and removal of fine coal build up around any coal transfer points;
- coal stockpile parameters, including compaction (stockpile porosity), maximum allowable slope angle of the stockpile sides and water diversion; and
- Trigger Action Response Plans.

Over time, the mitigation measures would be continually refined in response to the correlation between measured reactivity, site experience with respect to stockpile performance, mining operations and coal haulage.

4.4.7.6 Greenhouse Gas

The Applicant would implement all reasonable and feasible measures to minimise GHG emissions from its operations, with energy efficiency being a key consideration in the selection of equipment and the development of the mine plan. For example, significant savings of GHG emissions (through increased energy efficiency) would be achieved by mine planning decisions which minimise haul distances for ROM coal and overburden transportation, and therefore fuel use. Other mechanisms for energy efficiency such as the use of LED lighting within enclosed areas for task lighting would also be investigated.

The effectiveness of these measures would be monitored as the Applicant would annually estimate GHG emissions and energy consumption in accordance with National Greenhouse and Energy Reporting System (NGERS) and Energy Efficiency Operations requirements.

4.4.8 Approach to Air Quality Assessment

4.4.8.1 Introduction

The following subsections provide a summary of the methodology used by Pacific Environment (2016a) to assess the impacts of suspended particulate matter and dust deposition arising as a consequence of the amended Project. A key component of this methodology has been the compilation of an emissions inventory for representative years during the mining operation and completion of dispersion modelling for those years. Representative years have been selected to represent years when coal and overburden production are likely to be approaching the maximum levels, when extraction or wind erosion areas are likely to be the largest or where operations are likely to be located closest to residences or receivers. The GHG methodology is also presented.

4.4.8.2 Particulate Matter and Dust Deposition

The approach taken for the particulate matter and dust deposition assessment involved the following.

- The assembly of estimated annual TSP, PM_{10} and $PM_{2.5}$ emissions of each activity associated with the operations.
- Provision of emissions and meteorological information for inclusion in a computer-based dispersion model used to predict dust concentrations in the local area and at the nearest residences or receivers.
- A comparison of predicted concentrations with relevant air quality criteria.

Off-site dust levels due to the amended Project have been predicted using TAPM and the CALMET/CALPUFF modelling systems. These modelling systems are consistent with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005).

TAPM is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research and was used to generate upper air information through the use of the in-built prognostic 3D data. This data was then incorporated into a CALMET model developed for the amended Project, a meteorological pre-processor that includes a wind-field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The model also incorporated observed hourly surface meteorological data from the Site, as well as from the Stratford Mining Complex. Cloud amount and cloud heights were sourced from the closest available hourly observations (BoM Automatic Weather Station at Murrurundi Gap).

CALMET used the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region. This was then used by CALPUFF, a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (Scire *et al*., 2000).

Four operational scenarios based on the staged mine plans for quantitative dispersion modelling were input into CALPUFF. The years, along with their rationale for selection, are as follows.

- Year 1: Representative of the development of the open cut pit and the western and northern amenity barrier. Minimal ROM coal production and operations restricted to day time only.
- Year 4: Representative of operations at the commencement of day and evening operations and ramping up of overburden and ROM coal production.
- Year 7: Representative of operations at maximum overburden production, 80% of maximum coal production and a wide geographic spread of activities across the Mine Area.

- Year 10: Representative of operations at maximum overburden production and 85% of maximum coal production but with mining activities occurring at depth and overburden emplacement predominantly occurring in-pit.

The Year 10 scenario was also re-run assuming that sufficient coal is exposed to enable the volume of coal extracted to reach 100% of the maximum coal production, i.e. 2.0Mtpa. Further details relating to this 'maximum production' scenario, including estimate emissions, are provided in Section 4.4.9.10.

It is noted that the reference to Years 1, 4, 7, and 10 relate to an indicative layout of the Mine Area and scheduled production during those particular years. The indicative layout of the Mine Area during each of these years is shown in **Figures 2.11** and **2.12** whilst the emission source locations (representing the proposed activities) are shown in Appendix D of Pacific Environment (2016a).

Estimates of emissions from each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was calculated using emission factors developed both within NSW and by the US EPA, together with the operational descriptions, mine plan drawings, material characteristics, etc. **Table 4.23** displays the total estimated emissions for each year modelled whilst full details of the estimated emissions for each year modelled are presented in Pacific Environment (2016a) – Section 8.4.

Table 4.23
Estimated TSP Emissions

Year	Estimated TSP Emissions (kg/yr)	Estimated PM_{10} Emissions (kg/yr)	Estimated $PM_{2.5}$ Emissions (kg/yr)
Site Establishment and Construction	47 054	NA	NA
Year 1	267 818	82 651	14 433
Year 4	740 503	211 325	30 690
Year 7	1 049 915	292 754	40 454
Year 10	807 789	227 262	32 450
Source: Pacific Environment (2016a) – Modified after Tables 8.2 to 8.5 and 10.2			NA = Not Assessed

In order to model the effect of pit retention for emissions within the open cut pits and the effects of other mine landforms, detailed mine terrain was also incorporated into the modelling for each modelled year.

As the estimated TSP emissions for the site establishment and construction stage would be significantly less than the estimated emissions for the four operational years modelled, further assessment of the site establishment and construction stage emissions was not considered necessary.

4.4.8.3 Cumulative Particulate Emissions

In October 2012, Pacific Environment (then PAEHolmes) completed an air quality and greenhouse gas assessment for the Stratford Extension Project (PAEHolmes, 2012). In May 2016, Pacific Environment provided a semi-quantitative assessment[5] to Yancoal for the

[5] The assessment involved calculation of the revised total emissions and comparative review against the emissions for the Stratford Extension Project without completion of additional dispersion modelling.

Stratford Mining Complex – Modification 1 which includes the section of the private haul road located within the northeastern part of the Stratford mining tenements, from which point haul trucks would use existing Stratford internal haul roads to allow the transportation of sized ROM coal from the Rocky Hill Mine Area to the proposed extended ROM pad within the Stratford Mining Complex (see **Figure 1.5**).

The modelled emissions from the Stratford Mining Complex – Modification 1 were combined with the amended Rocky Hill Coal Project as follows.

- Stratford Year 2 emissions were combined with Rocky Hill Year 1 emissions.
- Stratford Year 6 emissions were combined with Rocky Hill Year 4 emissions.
- Stratford Year 6 emissions were combined with Rocky Hill Year 7 emissions.
- Stratford Year 10 emissions were combined with Rocky Hill Year 10 emissions.

These scenarios reflect a range of geographic spread of activities on both sites and production levels for the two latter scenarios at or near maximum production levels for both overburden and coal extraction. The source locations of both the amended Rocky Hill Coal Project and the Stratford Mining Complex – Modification 1 for these cumulative years are presented within Appendix D of Pacific Environment (2016a).

Table 4.24 lists the estimated TSP, PM_{10} and $PM_{2.5}$ emissions for the Stratford Mining Complex as used in the cumulative assessment for the amended Project. Modelling for the Stratford Extension Project was completed using the same approach as described in Section 4.4.8.2.

Table 4.24
Estimated Emissions for the Stratford Mining Complex as used in the Cumulative Assessment

Year	Estimated TSP Emissions (kg/yr)	Estimated PM_{10} Emissions (kg/yr)	Estimated $PM_{2.5}$ Emissions (kg/yr)
Stratford Year 2	1 406 672	402 499	64 762
Stratford Year 6	1 571 610	504 761	70 308
Stratford Year 10	1 503 511	399 717	61 213
Source: Pacific Environment (2016a) – Table 8.6.			

4.4.8.4 Greenhouse Gas

GHG emissions have been estimated based on the methods outlined in the following documents.

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition (WRI/WBCSD, 2004).
- National Greenhouse and Energy Reporting (Measurement) Determination, 2008.
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) National Greenhouse Accounts (NGA) Factors 2012 (DCCEE, 2012).

The GHG Protocol (WRI/WBCSD, 2004) establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organization for Standardization, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (Scope 1, Scope 2 and Scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity, with indirect Scope 2 and Scope 3 emissions for one entity being reportable as direct Scope 1 emissions from another entity.

- Scope 1, or direct GHG, emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity.
- Scope 2 emissions are a category of indirect emissions that account for GHG emissions arising from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.
- Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of Scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potential of each gas. The estimated emissions are referred to in terms of CO_2 equivalent (CO_2-e) emissions by applying the relevant global warming potential. For example, as methane (CH_4) has a global warming potential of 21, the CO_2-e of one unit of CH_4 would be equivalent to 21 units of CO_2-e. The GHG assessment has been conducted using the NGA Factors (DotE, 2015).

Sources of GHG emissions from the amended Project which are included in the assessment are as follows.

- Fuel consumption (diesel) during mining operations – Scope 1.
- Release of fugitive CH_4 during mining – Scope 1.
- Vegetation stripping (release of CO_2 from vegetative biomass following clearing) – Scope 1.
- Indirect emissions associated with on-site electricity use – Scope 2.
- Indirect emissions associated with the production and transport of fuels – Scope 3.
- Emissions from coal transportation – Scope 3.
- Emissions from the use of the product coal – Scope 3.

Emissions from the shipping of product coal are not included in this assessment due to the uncertainties in emission estimates, including uncertainty in future export destinations and limited data on emission factors and/or fuel consumption for ocean-going vessels.

A summary of the GHG emissions arising from the amended Project for the maximum, minimum and average year throughout the life of the amended Project, is provided in **Table 4.25**.

Table 4.25
Summary of Estimated CO_2-e (tonnes) – All Scopes

Emission Type*	Maximum Year (t/CO_2-e)	Minimum Year (t/CO_2-e)	Average (t/CO_2-e)	Life of Mine (t/CO_2-e)
Scope 1				
Diesel	28 994	10 839	22 006	418 110
Fugitive Methane	97 200	0	71 213	1 139 400
Vegetation Stripping	706	0	706	9 175
Total Scope 1	**125 274**	**10 839**	**82 457**	**1 566 685**
Scope 2				
Electricity	18 623	0	12 731	241 891
Total Scope 2	**18 623**	**0**	**12 731**	**241 891**
Scope 3				
Diesel	1 487	556	1 129	21 442
Electricity	2 660	0	1 819	34 556
Energy Production	3 159 959	0	1 904 599	36 186 627
Rail	3 541	0	2 134	40 546
Total Scope 3	**3 167 564**	**556**	**1 909 641**	**36 283 171**
Note* Totals provided represent the maximum, minimum and average year totals over the life of the amended Project.				
Source: Pacific Environment (2016a) – Modified after Table 18.1				

4.4.9 Assessment of Impacts

4.4.9.1 Introduction

Subsections 4.4.9.2 to 4.4.9.7 provide a summary of the results for each modelled year at a representative number of the privately-owned residences in the vicinity of the Site. The results are presented for the predicted concentrations from the amended Project itself, and cumulative concentrations which include modelled emissions from both the amended Project and the Stratford Mining Complex, and the background concentrations outlined in Section 4.4.4.

Contour plots of suspended particulate concentrations and dust deposition levels show the areas that are predicted to be affected at different levels. It is important to note that the contour figures are presented to provide a visual representation of the predicted impacts. In order to produce the contours, it is necessary to make interpolations and, as a result, the contours do not always match exactly with predicted impacts at any specific location.

Section 4.4.9.8 specifically considers sensitive receivers in the Gloucester township including the Gloucester High School, Gloucester Hospital and Captain Cook Park. Section 4.4.9.9 considers impacts on privately-owned land.

Predicted concentrations at each of the residences identified on **Figure 4.7** are presented in Section 9 of Pacific Environment (2016a)**.**

Subsections 4.4.9.11 to 4.4.9.17 discuss a range of other potential air quality contaminants and their impacts arising from the amended Rocky Hill Coal Project including:

- spontaneous combustion;
- blast fume;
- diesel fume;
- cumulative NO_2 emissions;
- domestic tank water supplies;
- stock, agricultural productivity and dairying; and
- greenhouse gases.

4.4.9.2 Annual Average TSP

The "Project-only" contributions to annual average TSP concentrations are presented in **Figure 4.21** for each modelled year.

A summary of the "Project-only" and cumulative annual average TSP concentrations at four representative residences is provided in **Table 4.26**. There are no privately-owned residences or receivers at which an exceedance of the annual average impact assessment criteria of 90µg/m^3 is predicted to occur either as a result of the Project-only or cumulatively.

Table 4.26
Annual Average TSP Concentrations (µg/m^3)

Residence ID	Project-only Predicted Impacts				Cumulative Predicted Impacts#			
	Year 1	Year 4	Year 7	Year 10	Year 1	Year 4	Year 7	Year 10
6	0.66	3.75	6.20	2.90	24.08	27.13	29.58	26.18
18	2.02	9.13	13.85	13.70	26.91	33.97	38.69	37.86
19A	1.42	5.47	8.24	8.60	25.89	29.94	32.71	32.60
36	0.66	2.00	3.02	2.81	24.35	25.66	26.68	26.24

Criterion: 90µg/m^3
Cumulative = as a consequence of emissions from the amended Project + Stratford Mining Complex + existing ambient.
Source: Pacific Environment (2016a) – Modified after Table 9.1

4.4.9.3 Maximum 24-hour Average PM_{10}

Figure 4.22 shows contour plots for the predicted maximum 24-hour average PM_{10} concentrations for the "Project-only" for each modelled year. The contour for the maximum 24-hour average DPE voluntary mitigation and land acquisition criterion of 50µg/m^3 is also identified.

The maximum 24-hour PM_{10} contours do not represent a single worst case day, but rather represent the potential worst case 24-hour average PM_{10} concentration that could be reached at any particular location across the entire modelling year.

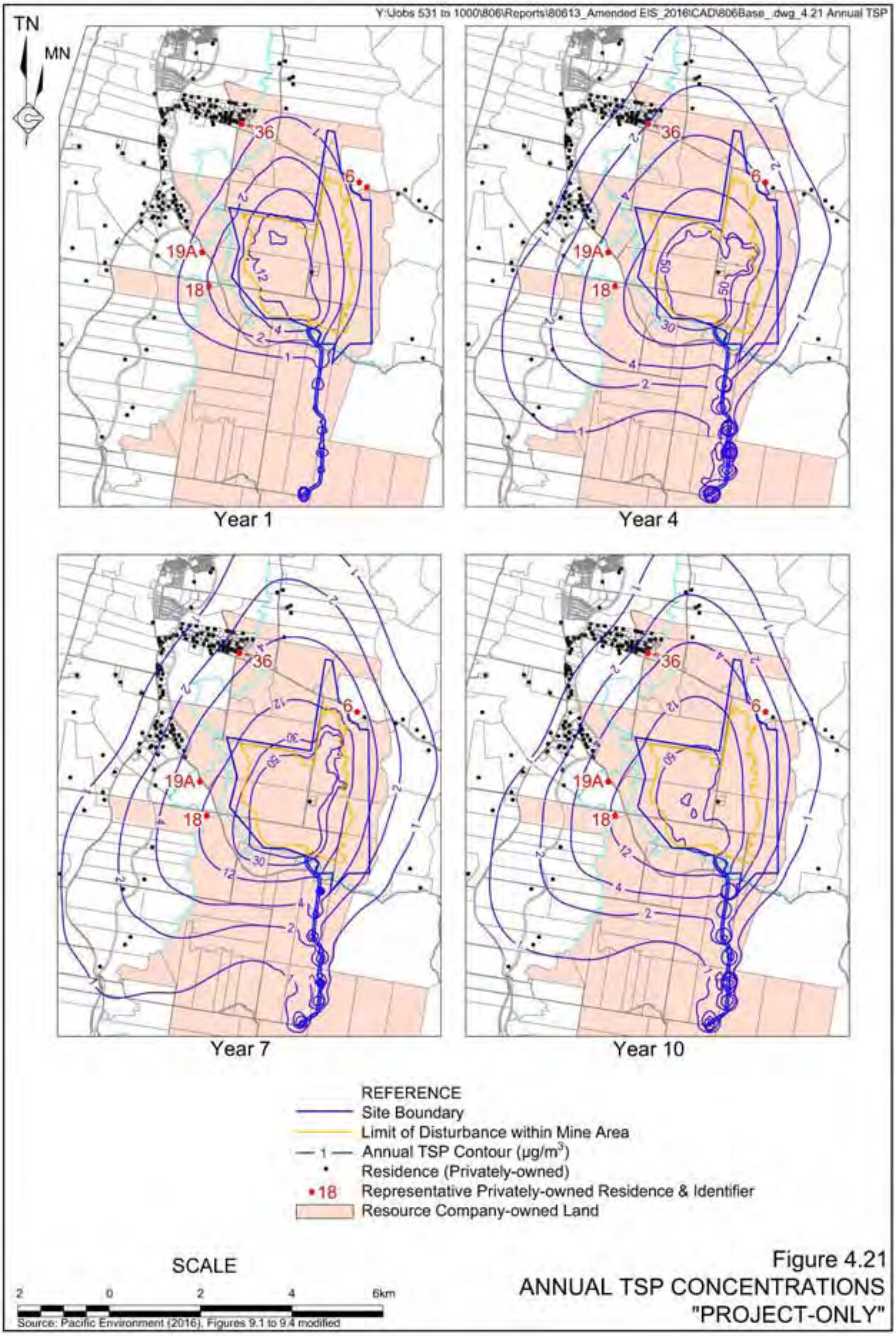


Figure 4.21
ANNUAL TSP CONCENTRATIONS
"PROJECT-ONLY"

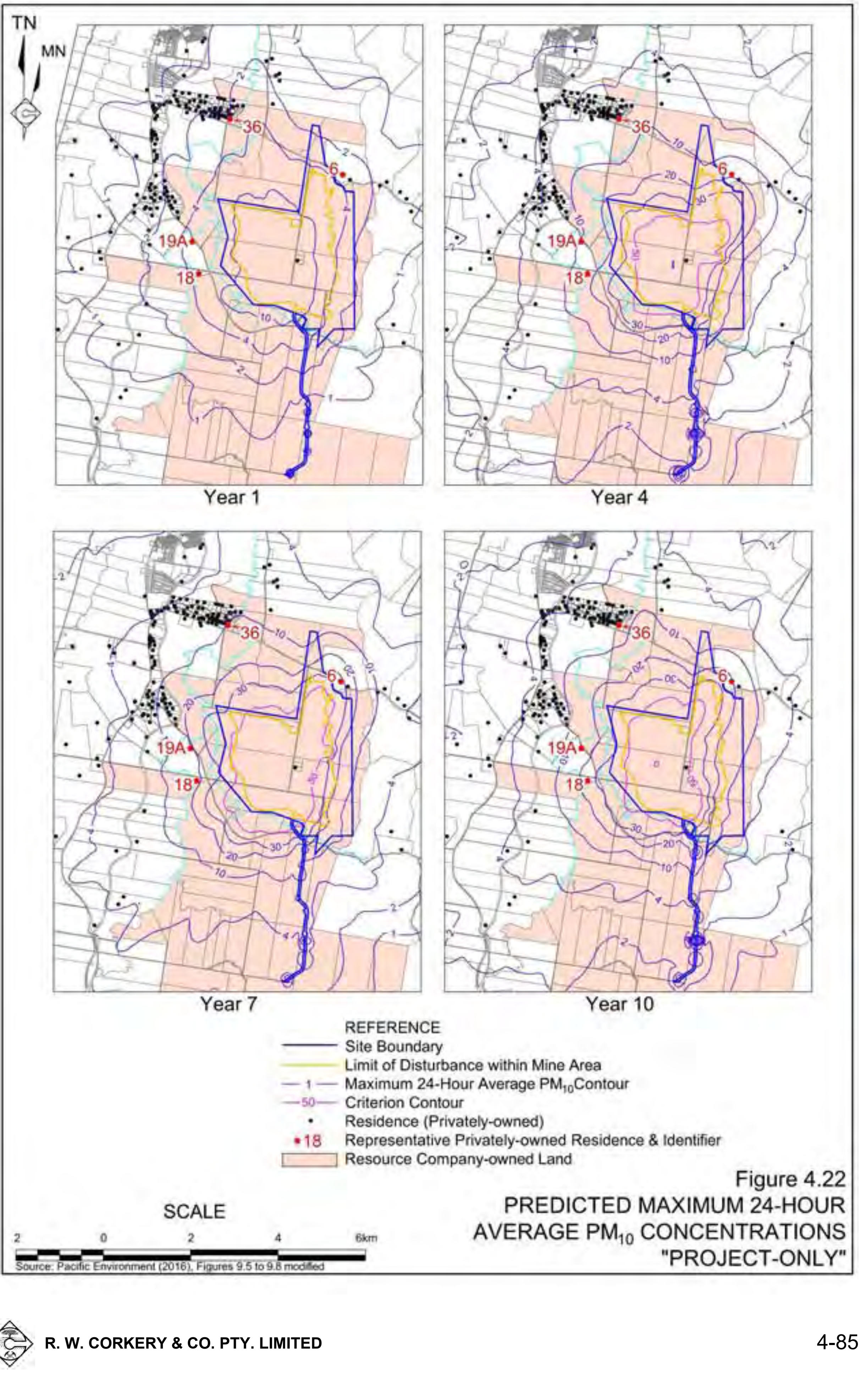


Figure 4.22
PREDICTED MAXIMUM 24-HOUR AVERAGE PM_{10} CONCENTRATIONS "PROJECT-ONLY"

A summary of the predicted maximum 24-hour average PM_{10} concentrations at four representative privately-owned residences is provided in **Table 4.27**. There are no privately-owned residences or receivers at which an exceedance of the maximum 24-hour average PM_{10} DPE voluntary mitigation and land acquisition criteria is predicted to occur as a result of the Project-only emissions.

Table 4.27
Predicted Maximum 24-hour Average PM_{10} Concentrations ($\mu g/m^3$)

Residence ID	Project-only Predicted Impacts			
	Year 1	**Year 4**	**Year 7**	**Year 10**
6	3.39	18.82	35.35	21.03
18	5.42	16.60	24.30	24.91
19A	4.82	10.36	15.12	14.01
36	2.13	6.00	8.08	7.42
Criterion, 50µg/m³, exceedances highlighted in bold				
Source: Pacific Environment (2016a) – Modified after Table 9.5				

It is difficult to accurately predict cumulative 24-hour impacts due to the day to day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity e.g. agricultural activity, bushfires, etc., and mining in the future. The highest 24-hour PM_{10} concentrations are often strongly influenced by regional events such as bushfires and dust storms, which are essentially unpredictable.

Cumulative air quality impacts have therefore been evaluated using a statistical approach known as a Monte Carlo Simulation. This approach was adopted to achieve the objectives of a Level 2 Assessment (Section 11.2 of DEC, 2005). The cumulative assessment focusses on representative residences in key areas in the vicinity of the Site boundary. This statistical approach is outlined in Section 9.8 of Pacific Environment (2016a).

Five private residences (Residences 6, 18, 19A, 23 and 36) were selected for the cumulative analysis based on their proximity to the proposed mining operations, spatial variability and also the magnitude of their Project-only predictions. **Table 4.28** presents a summary of the number of days over the criterion for each of the selected residences for the Project-only and cumulative scenarios.

Table 4.28
PM_{10} Summary of Days over 50µg/m³ for "Project-only" and Cumulative Scenarios

Year	Residence ID (see **Figure 4.7**)	Predicted Days Over 50µg/m³ (Project-only)	Predicted Days Over 50µg/m³ (cumulative)#
Year 1	6, 18, 19A, 23 & 36	0	0
Year 4	6, 18, 19A, 23 & 36	0	0
Year 7	6	0	0
	18	0	<1*
	23	0	<1*
	36	0	0
Year 10	6	0	<1*
	18, 23 & 36	0	0
* Reported as less than one day due to statistical determination of cumulative frequency of exceedance of 50µg/m³ calculated as less than 1. # Cumulative = as a consequence of emissions from the amended Project + Stratford Mining Complex + existing ambient.			
Source: Pacific Environment (2016a) – Modified after Table 9.7			

As shown in **Table 4.28**, for the residences evaluated, there is a very low probability that cumulative 24-hour PM_{10} concentrations would result in any additional days over 50µg/m^3 than would occur anyway due to background concentrations in the absence of the amended Project.

4.4.9.4 Annual Average PM_{10}

The “Project-only” contributions to annual average PM_{10} concentrations are presented in **Figure 4.23** for each modelled year.

A summary of the “Project-only” and cumulative annual average PM_{10} concentrations at representative residences is provided in **Table 4.29**. There are no privately-owned residences or receivers at which an exceedance of the annual average impact assessment criterion of 30µg/m^3 is predicted to occur either as a result of the Project-only or cumulative impacts during the modelled years of the amended Project.

Table 4.29
Annual Average PM_{10} Concentrations (µg/m^3)

Residence ID	Project-only Predicted Impacts				Cumulative Predicted Impacts#			
	Year 1	Year 4	Year 7	Year 10	Year 1	Year 4	Year 7	Year 10
6	0.26	1.40	2.29	1.05	9.44	10.59	11.47	10.18
18	0.79	3.39	4.94	4.95	10.57	13.25	14.80	14.50
19A	0.54	2.09	3.03	3.20	10.16	11.79	12.74	12.68
36	0.26	0.80	1.16	1.10	9.58	10.14	10.50	10.33

Criterion: 30µg/m^3.
Cumulative = as a consequence of emissions from the amended Project + Stratford Mining Complex + existing ambient.
Source: Pacific Environment (2016a) - Modified after Table 9.2.

4.4.9.5 Maximum 24-hour Average $PM_{2.5}$

The “Project-only” contributions to the predicted maximum 24-hour average $PM_{2.5}$ concentrations are presented in **Figure 4.24** for each modelled year.

A summary of the “Project-only” $PM_{2.5}$ concentrations predicted to occur at representative residences is provided in **Table 4.30**. There are no privately-owned residences or receivers at which exceedance of the maximum 24-hour average standard of 25µg/m^3 is predicted to occur as a result of the amended Project alone.

Table 4.30
Predicted Maximum 24-hour Average $PM_{2.5}$ Concentrations (µg/m^3)

Residence ID	Project-only Predicted Impacts			
	Year 1	Year 4	Year 7	Year 10
6	0.75	3.27	6.32	3.48
18	1.32	2.75	3.98	4.61
19A	1.26	1.67	2.36	2.47
36	0.54	1.13	1.48	1.41

Source: Pacific Environment (2016a) – Modified after Table 9.6

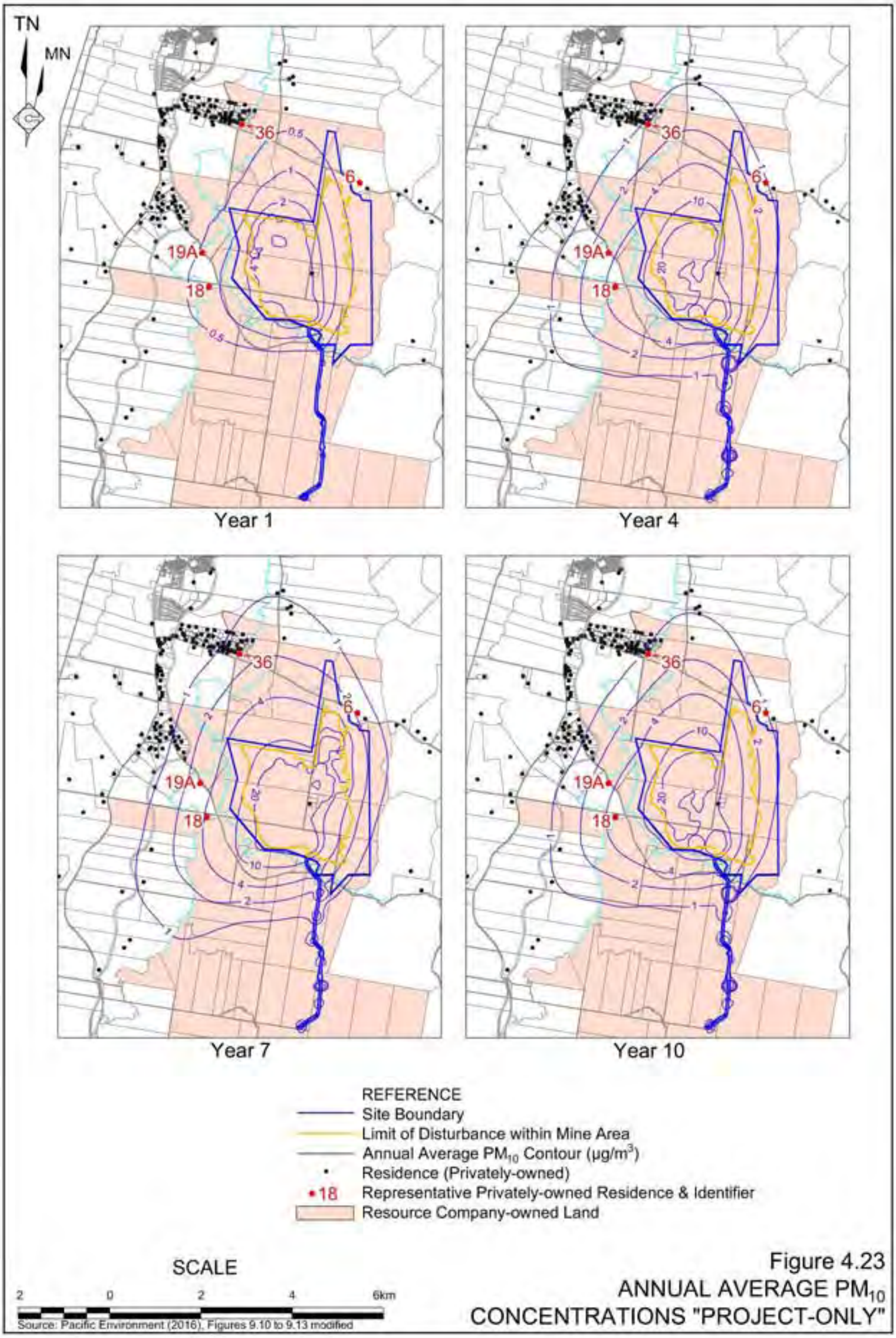
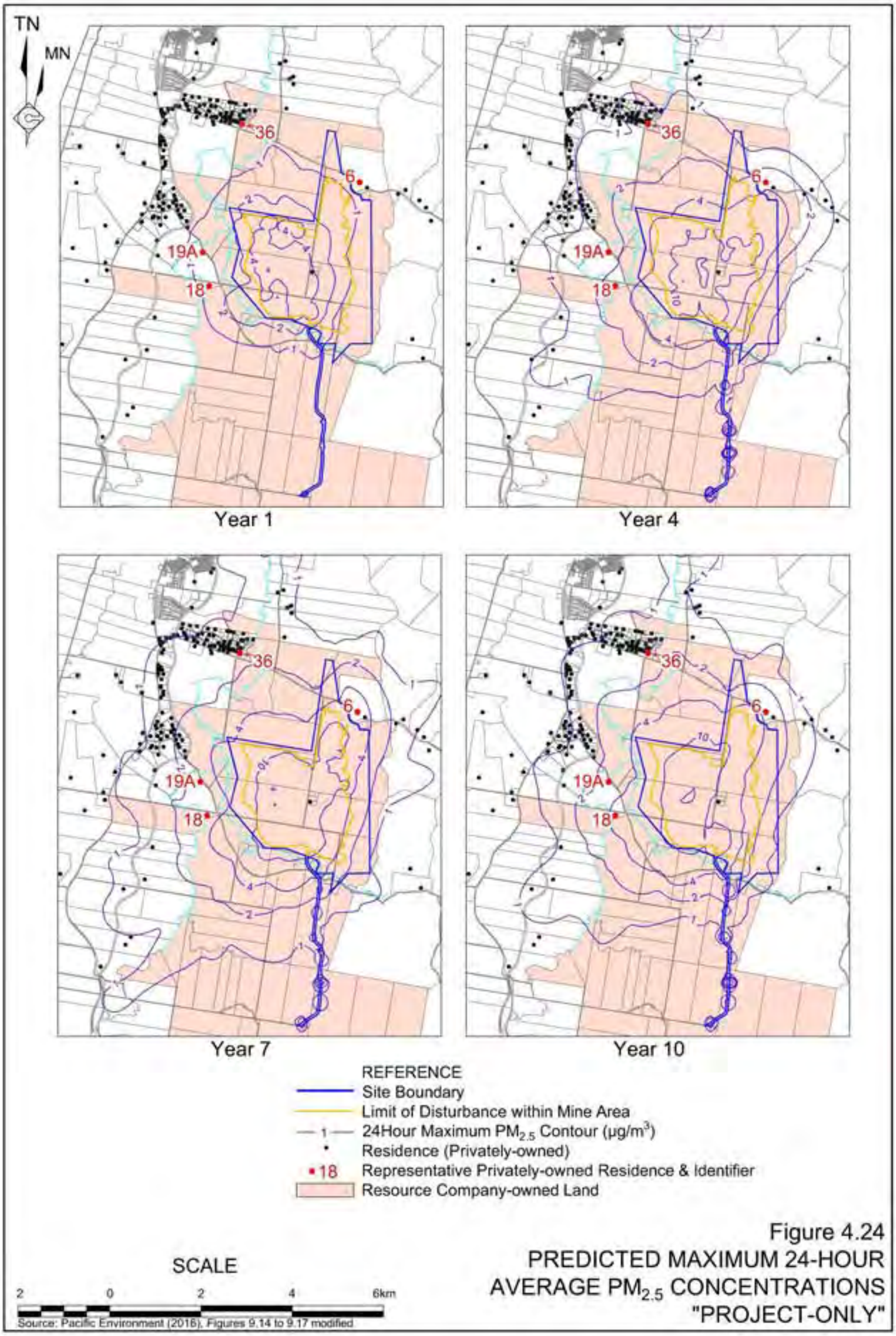


Figure 4.23
ANNUAL AVERAGE PM_{10}
CONCENTRATIONS "PROJECT-ONLY"



Source: Pacific Environment (2016), Figures 9.14 to 9.17 modified

Figure 4.24
PREDICTED MAXIMUM 24-HOUR AVERAGE $PM_{2.5}$ CONCENTRATIONS "PROJECT-ONLY"

As outlined in Section 4.4.9.3, it is difficult to accurately predict cumulative 24-hour impacts, due to the day to day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity. Cumulative air quality impacts for 24-hour PM_{10} have therefore also been evaluated using a Monte Carlo Simulation.

The Monte Carlo Simulation predicts that there would be no additional exceedances as a result of the Project-only emissions. However, there is an increased probability at each of the representative residences that cumulative 24-hour $PM_{2.5}$ concentrations would result in two additional days of average 24-hour $PM_{2.5}$ concentrations over 25µg/m^3 than would occur due to background concentrations in the absence of the amended Project.

4.4.9.6 Annual Average $PM_{2.5}$

The "Project-only" contributions to annual average $PM_{2.5}$ concentrations are presented in **Figure 4.25** for each modelled year.

A summary of the "Project-only" and cumulative annual average $PM_{2.5}$ concentrations at representative residences is provided in **Table 4.31**. There are no privately-owned residences or receivers at which an exceedance of the annual average standard of 8µg/m^3 is predicted to occur, either as a result of the amended Project only or cumulatively.

Table 4.31
Annual Average $PM_{2.5}$ Concentrations (µg/m^3)

Residence ID	Project-only Predicted Impacts				Cumulative Predicted Impacts#			
	Year 1	Year 4	Year 7	Year 10	Year 1	Year 4	Year 7	Year 10
6	0.05	0.26	0.42	0.19	4.70	4.90	5.06	4.82
18	0.17	0.52	0.75	0.83	4.95	5.28	5.51	5.55
19A	0.13	0.33	0.48	0.55	4.87	5.07	5.22	5.25
36	0.06	0.14	0.21	0.21	4.74	4.81	4.88	4.86

Cumulative = as a consequence of emissions from the amended Project + Stratford Mining Complex + existing ambient.

Source: Pacific Environment (2016a) - Modified after Table 9.3

4.4.9.7 Annual Average Deposited Dust

The "Project-only" contributions to annual average dust deposition levels are presented in **Figure 4.26** for each modelled year. The contour for the annual average (incremental) criterion of 2g/m^2/month is shown in bold.

A summary of the "Project-only" and cumulative annual average dust deposition at the four representative residences is provided in **Table 4.32**. There are no privately-owned residences or receivers at which an exceedance of the annual average impact assessment criterion of 2g/m^2/month as a result of the amended Project only, or the annual average cumulative level of 4g/m^2/month is predicted to occur.

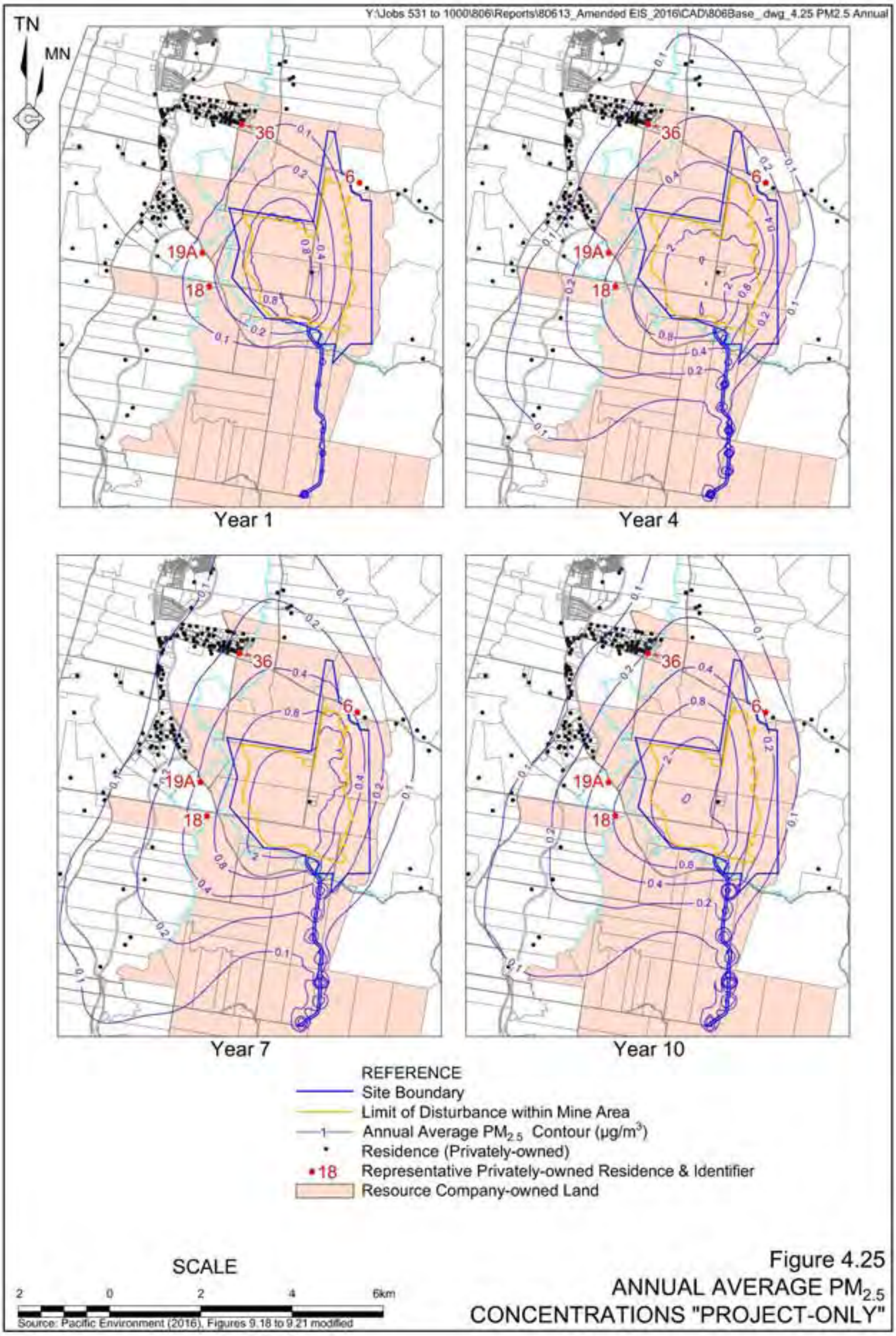


Figure 4.25
ANNUAL AVERAGE $PM_{2.5}$ CONCENTRATIONS "PROJECT-ONLY"

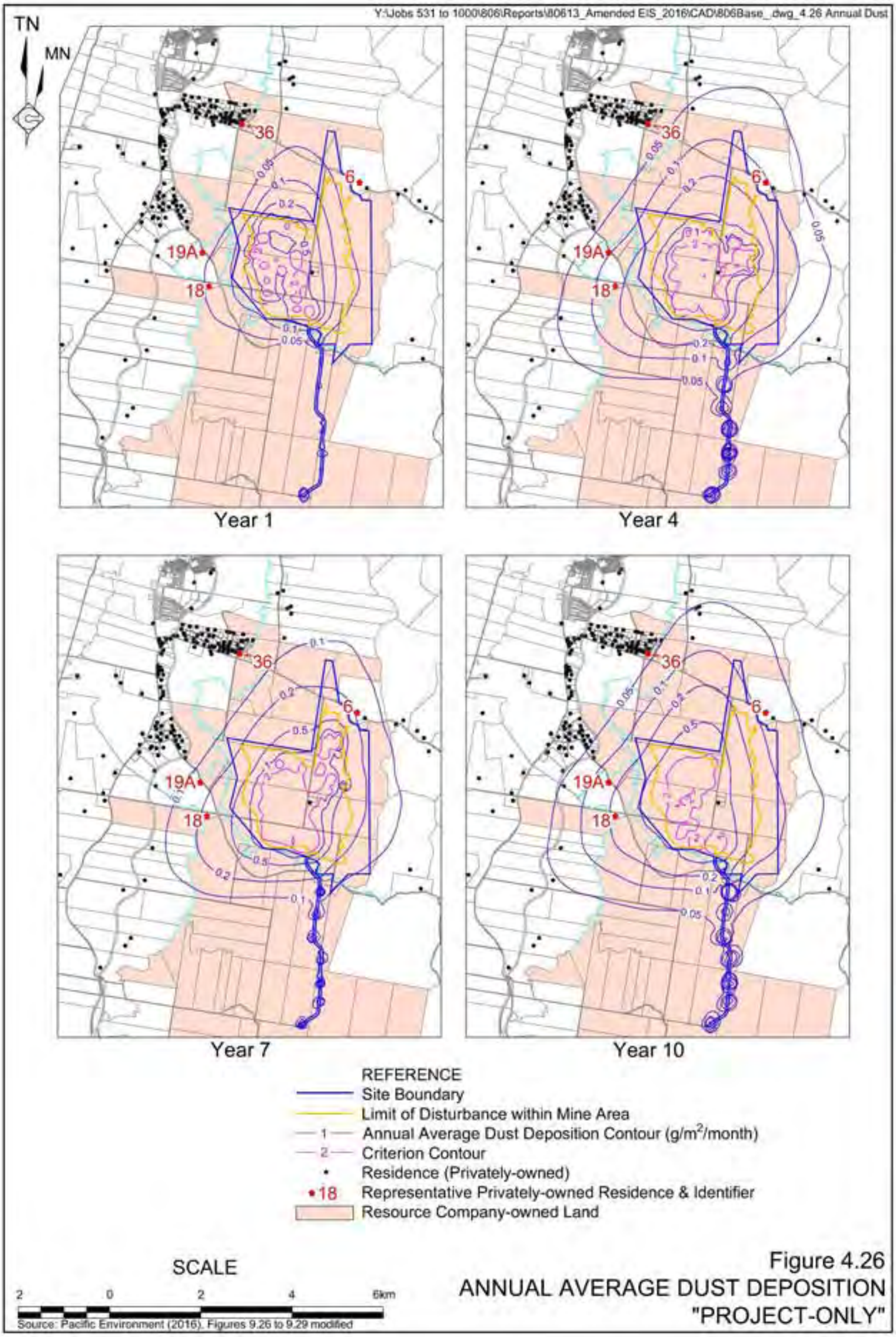


Figure 4.26
ANNUAL AVERAGE DUST DEPOSITION
"PROJECT-ONLY"

Table 4.32
Annual Average Dust Deposition (g/m^2/month)

Residence ID	Project-only Predicted Impacts				Cumulative Predicted Impacts[#]			
	Year 1	Year 4	Year 7	Year 10	Year 1	Year 4	Year 7	Year 10
6	0.03	0.11	0.18	0.08	1.04	1.12	1.19	1.09
18	0.05	0.16	0.24	0.23	1.11	1.22	1.29	1.26
19A	0.04	0.10	0.14	0.16	1.08	1.14	1.19	1.19
36	0.01	0.03	0.05	0.04	1.03	1.05	1.06	1.06
Criteria: 2g/m²/month (amended Project), 4g/m²/month (cumulative).								
[#] Cumulative = as a consequence of emissions from the amended Project + Stratford Mining Complex + existing ambient.								
Source: Pacific Environment (2016a) – Modified after Table 9.4								

4.4.9.8 Consideration of Sensitive Receivers within Gloucester Township

The ground level concentrations for residences or receivers located within Gloucester township would be less than the predictions outlined for the representative residences in Sections 4.4.9.2 to 4.4.9.7.

Nevertheless, additional analysis has been provided for particularly sensitive receivers located within the Gloucester township, as shown in **Figure 4.8**. The focus is on PM_{10} and $PM_{2.5}$ as the key measures of health impacts.

Modelling predictions for maximum 24-hour PM_{10} and annual average PM_{10} concentrations were analysed for Gloucester High School, Gloucester Hospital and Captain Cook Park and are shown in **Tables 4.33** and **4.34** respectively.

Table 4.33
Maximum 24-hour Average PM_{10} Concentrations (µg/m³)

Receiver ID	Project-only Predicted Impacts			
	Year 1	Year 4	Year 7	Year 10
Gloucester High School	0.6	1.4	2.0	1.6
Gloucester Hospital	0.5	1.2	1.7	1.4
Captain Cook Park	0.8	1.7	2.4	2.1
Source: Pacific Environment (2016a) – Table 9.11				

Table 4.34
Annual Average PM_{10} Concentrations (µg/m³)

Receiver ID	Project-only Predicted Impacts			
	Year 1	Year 4	Year 7	Year 10
Gloucester High School	0.05	0.2	0.2	0.2
Gloucester Hospital	0.04	0.1	0.2	0.2
Captain Cook Park	0.07	0.2	0.3	0.3
Source: Pacific Environment (2016a) – Table 9.12				

Modelling predictions for maximum 24-hour average and annual average $PM_{2.5}$ concentrations are shown in **Tables 4.35** and **4.36**.

Table 4.35
Maximum 24-hour Average $PM_{2.5}$ Concentrations (µg/m^3)

Residence ID	Project-only Predicted Impacts			
	Year 1	Year 4	Year 7	Year 10
Gloucester High School	0.2	0.3	0.5	0.4
Gloucester Hospital	0.1	0.3	0.5	0.4
Captain Cook Park	0.2	0.4	0.6	0.5
Source: Pacific Environment (2016a) – Table 9.13				

Table 4.36
Annual Average $PM_{2.5}$ Concentrations (µg/m^3)

Receiver ID	Project-only Predicted Impacts			
	Year 1	Year 4	Year 7	Year 10
Gloucester High School	0.01	0.04	0.06	0.05
Gloucester Hospital	0.01	0.03	0.05	0.04
Captain Cook Park	0.02	0.05	0.07	0.06
Source: Pacific Environment (2016a) – Table 9.14				

The predicted Project-only ground level concentrations for PM_{10} and $PM_{2.5}$ at sensitive locations within Gloucester township are well below the relevant impact assessment criteria. The addition of the Project-only ground level concentrations to existing background levels would not result in any additional exceedances of the relevant criteria.

4.4.9.9 Consideration of Privately-owned Land

Conditions of contemporary project approvals and development consents in relation to air quality have included a reference to impacts on vacant land in air quality criteria. Specifically, vacant land not owned by a resource company is considered to be adversely affected if greater than 25% of a property is predicted to exceed any of the impact assessment criteria and there is either a dwelling on the land or a dwelling could be built on the land under the relevant planning controls. Based on a review of the relevant air quality contours and land tenure information for the amended Project, no potential privately-owned land impacts have been identified for the amended Project, including land where a dwelling exists.

4.4.9.10 Consideration of a Modelling Scenario at 2.0 Million Tonnes of ROM Coal

The Applicant is seeking approval to mine up to 2.0Mt of ROM coal per year in the event that sufficient coal is exposed to enable the volume extracted to exceed that nominated in the production schedule identified at **Table 2.5**. An assessment of predicted dust concentrations / levels at this throughput was undertaken for Year 10 as opposed to the scheduled indicative quantity of 1.7Mt of ROM coal in that year.

Year 10 was chosen for assessment as the combined overburden (at 9.8Mbcm) and 2.0Mtpa production would amount to the highest quantity extracted in any one year. The assessment was undertaken for all residences in the vicinity of the Mine Area, however, a summary of predicted levels are displayed in **Table 4.37** for four of the closest residences in the vicinity of the Mine Area. For conservatism, the increased coal production was not offset with a corresponding reduction in overburden production.

Table 4.37
Predicted Dust Concentrations and Levels for Year 10 at 2.0 Mtpa of ROM Coal – Project Only

	Residence			
	6	**18**	**19A**	**36**
Annual Average TSP (µg/m^3)	3.08 (2.90)	14.33 (13.70)	8.99 (8.60)	2.95 (2.81)
Maximum 24hr Average PM_{10} (µg/m^3)	21.67 (21.03)	25.64 (24.91)	14.49 (14.01)	7.68 (7.42)
Annual Average PM_{10} (µg/m^3)	1.09 (1.05)	5.08 (4.95)	3.29 (3.20)	1.13 (1.10)
Maximum 24hr Average $PM_{2.5}$ (µg/m^3)	3.58 (3.48)	4.74 (4.61)	2.54 (2.47)	1.47 (1.41)
Annual Average $PM_{2.5}$ (µg/m^3)	0.19 (0.19)	0.85 (0.83)	0.56 (0.55)	0.21 (0.21)
Annual Average Dust Deposition (g/m^2/month)	0.08 (0.08)	0.24 (0.23)	0.16 (0.16)	0.05 (0.04)

Note: Values in brackets ( ) are for the scenario of 9.8Mbcm overburden and 1.7Mtpa coal.
Source: Pacific Environment (2016a) – Modified after Table 9.10

The modelling shows a small increase in dust concentrations/levels at the representative residences which is expected given that the additional ROM coal recovery, handling and processing. However, no privately-owned residences or receivers are predicted to receive dust levels that exceed the relevant criteria as a result of the Project-only emissions.

4.4.9.11 Spontaneous Combustion

Spontaneous combustion events have the potential to give rise to odour emissions. An assessment of the likelihood of a spontaneous combustion event occurring within the Mine Area has been conducted (LDO, 2012) and concluded that, based on historical information gathered from existing open cut operations in the Gloucester Basin and coal quality parameter analyses, the expected propensity for spontaneous combustion is low. Hence, with the implementation of the proposed management measures identified in Section 4.4.7.5, air quality impacts relating to spontaneous combustion would also be low.

4.4.9.12 Blast Fume

Introduction

Blasting activities have the potential to result in fugitive fume and particulate matter emissions. Particulate matter emissions from blasting are included in the dispersion modelling results presented in Sections 4.4.9.2 to 4.4.9.8 while this section addresses the potential impact from emissions of oxides of nitrogen (NO_x). NO_x comprises both nitric oxide (NO) and nitrogen dioxide (NO_2). With respect to potential health impacts, it is the concentration of NO_2 which is of greatest significance.

It is noted that the NSW Health – Hunter New England Local Health district specified the need for management and mitigation measures for SO_x production through blasting. As NO_x is the pollutant of significance for blast fume, SO_x has not been considered further.

Approach to Assessment

In ideal conditions, the only gaseous products from blasting activities are carbon dioxide, water and nitrogen. However, in reality, imperfect conditions (i.e. moisture in blast holes, mineral matter or other factors) lead to the formation of carbon monoxide and nitric oxide.

Consequently, the Approved Methods provide a number of approaches to calculating the NO_2 concentrations at representative residences or receivers. For this assessment, Pacific Environment (2016a) adopted the following methods.

- Emissions from ammonium nitrate/fuel oil (ANFO) assuming a mix of 94% ammonium nitrate and 6% diesel and a maximum blast size of 200m by 75m were calculated based on data presented in the Queensland Guidance Note for the management of oxides in open cut blasting (DEEDI, 2011) and assuming an initial NO_2 concentration in the plume of 70ppm, i.e. a Rating 4 Fume Category. It should be noted that a Rating 4 Fume Category would appear as an orange/red plume and any such occurrence would be reportable to the EPA and DPE. The outcomes from previous ACARP studies (Day et.al, 2013) recorded the frequency of Rating 4 Fume Category from 500 blasts as being less than approximately 0.2%. Therefore, the use of these initial NO_2 concentrations for all blasts is a highly conservative approach.
- The dispersion of the plume assuming a 10-minute release period every hour between 10:00am and 4:00pm every day for the year were modelled using the CALPUFF model for Years 4 and 7. Note that in reality, blasting would not occur on weekends or public holidays, and there would be a likely maximum of four blasts per week.
- Use of the Ozone Limiting Method to determine the NO_2 concentrations at the residences or receivers. This method assumes that at any given residence or receiver location, the amount of NO that is converted to NO_2 by this reaction is proportional to the ambient O_3 concentration.
- Results were calculated to include background NO_2 and O_3 concentrations determined from the Wallsend EPA monitoring station which, because of that site's location and proximity to major roads and industrial and commercial activities, are considered to be highly conservative estimates of the background concentrations in the Gloucester area.

Potential Emissions

Table 4.38 presents the predicted maximum and annual average NO_2 concentrations at each of four representative residence (6, 18, 19A and 23) due to blasting in Year 4 and Year 7 respectively.

Table 4.38
Maximum 1-hour and Annual Average NO_2 Concentrations Due to Blasting

Residence ID	Year 4		Year 7	
	Maximum 1-hr NO_2 concentration (µg/m^3)	Annual average NO_2 concentration (µg/m^3)	Maximum 1-hr NO_2 concentration (µg/m^3)	Annual average NO_2 concentration (µg/m^3)
	Impact Assessment Criteria (µg/m^3)			
	246	***62***	***246***	***62***
6	120	5	121	5
18	166	6	166	6
19A	139	5	139	5
23	116	5	117	5
Source: Pacific Environment (2016a) – Modified after Tables 11.1 and 11.2				

There are no residences at which an exceedance of the 1-hour NO_2 impact assessment criterion of 246µg/m^3 or the annual average impact assessment criterion of 62µg/m^3 is predicted to occur. The highest maximum predicted 1–hour NO_2 concentration of 166µg/m^3 and the highest annual average NO_2 concentration of 6µg/m^3 occur at Residence 18 in each of Years 4 and 7.

4.4.9.13 Diesel Fume

Introduction

In addition to assessment of blast fume, an assessment of diesel fume has been undertaken. The assessment focuses upon the predicted NO_2 and $PM_{2.5}$ concentrations as these are the main pollutants of concern from diesel combustion. Emissions of carbon monoxide (CO), and sulphur dioxide (SO_2) would also occur from diesel-powered equipment used on site, however these emissions are typically minor and too widely dispersed to give rise to significant off-site concentrations.

Approach to Assessment

It is noted that the emission factors used in the emission inventories (see Section 4.4.8.2) are considered to include particulate matter emissions from both mechanical processes and diesel combustion. In order to predict the contribution to $PM_{2.5}$ as a result of diesel combustion alone, the US-EPA Tier 2 $PM_{2.5}$ emissions standard of 0.66 kg/kL for non-road diesel was adopted.

For the NO_2 diesel assessment, Years 4 and 7 were chosen to be consistent with the blast fume assessment. Further, Year 7 is representative of operations at maximum overburden production, 80% coal production and a wide geographic spread of activities within the Mine Area. However, for conservatism, the diesel consumption for Year 10 (10.7ML) was applied to the modelling of Year 7 as this was the year of highest diesel consumption in any mining year.

Potential NO_2 Emissions

Table 4.39 presents the predicted maximum and annual average NO_2 concentrations at each of four representative residence (6, 18, 19A and 23) due to diesel combustion in Year 4 and Year 7 respectively.

Table 4.39
Maximum 1-hour and Annual Average NO_2 Concentrations Due to Diesel Combustion

	Year 4		Year 7	
	Maximum 1-hr NO_2 concentration (µg/m^3)	Annual average NO_2 concentration (µg/m^3)	Maximum 1-hr NO_2 concentration (µg/m^3)	Annual average NO_2 concentration (µg/m^3)
	Impact Assessment Criteria (µg/m^3)			
Residence ID	*246*	*62*	*246*	*62*
6	76	18	95	20
18	85	19	87	20
19A	90	18	93	19
23	76	18	91	19
Source: Pacific Environment (2016a) – Modified after Tables 12.1 and 12.2				

There are no residences at which an exceedance of the 1-hour NO_2 assessment criterion of 246µg/m^3 or the annual average impact assessment criterion of 62µg/m^3 is predicted to occur. The highest predicted 1-hour NO_2 concentration is 95µg/m^3 at R6 in Year 7 and the highest annual average NO_2 concentration is 20µg/m^3 at R6 and R18 predicted in Year 7.

Potential $PM_{2.5}$ Emissions – Diesel Only

A summary of the "Diesel-only" $PM_{2.5}$ concentrations predicted to occur at representative residences or receivers is provided in **Table 4.40**.

Table 4.40
Predicted $PM_{2.5}$ Concentrations – Diesel Only (µg/m^3)

Residence ID	Maximum 24-hour Average $PM_{2.5}$ Concentrations			
	Year 1	Year 4	Year 7	Year 10
6	0.26	0.60	1.77	1.03
18	0.55	0.62	0.79	1.55
19A	0.53	0.45	0.58	1.07
36	0.20	0.28	0.39	0.56
Annual Average $PM_{2.5}$ Concentrations				
6	0.02	0.07	0.15	0.08
18	0.13	0.15	0.20	0.37
19A	0.08	0.09	0.12	0.22
36	0.03	0.04	0.06	0.09
Source: Pacific Environment (2016a) – Modified after Tables 12.3 and 12.4				

A comparison of the results presented in **Table 4.40** with those presented in **Tables 4.30** and **4.31** indicates that diesel presents a minor contribution to the overall $PM_{2.5}$ concentrations received at the representative residences.

4.4.9.14 Cumulative NO_2 Emissions

A cumulative assessment of NO_2 impacts at residences due to blast fume, diesel fume and background concentrations has been completed. **Table 4.41** presents the maximum predicted 1-hour NO_2 concentrations at the four representative residences.

Table 4.41
Maximum 1-hour NO_2 Concentrations – Cumulative (Including Background)

Receiver ID	Year 4	Year 7
	Maximum NO_2 Concentrations (µg/m^3)	
Impact Assessment Criterion = 246 µg/m^3		
6	138	143
18	186	187
19A	160	160
23	138	139
Source: Pacific Environment (2016a) – Table 13.1		

There are no residences at which an exceedance of the 1-hour NO_2 criterion of 246µg/m^3 is predicted to occur. The highest maximum predicted cumulative NO_2 concentration is at a private residence is 187µg/m^3 at residence 18 in Year 7.

4.4.9.15 Domestic Tank Water Supplies

Pacific Environment (2016a) has undertaken a review of a number of studies undertaken which investigated the potential effects of deposited dust on domestic tank water supply. The review included reference to the following studies.

- A study prepared for Gloucester Shire Council (Parkinson and Stimson, 2010) which included laboratory testwork of rainwater tanks in Stratford village as well as from tanks in a number of other villages remote from coal mining areas. A statistical comparison of values between each village failed to indicate any significant difference in values of accumulated sediment in domestic water tanks between Stratford village and other villages tested.
- Recent research conducted at Hay Point in Queensland (in close proximity to the Dalrymple Bay Coal Terminal) which investigated the potential health risks as a result of elements contained in coal dust deposited on rooftops entering rainwater tanks systems used for potable supply (Lucas *et. al*., 2009). Tests indicated that negligible amounts of trace elements in coal dust were released in the rainwater, and all trace elements were below the Australian Drinking Water Guidelines (ADWG). The ADWG provide the threshold levels considered safe for human consumption.
- Research conducted by Associate Professor Barry Noller from the Centre for Mined Land Rehabilitation, University of Queensland in order to investigate the relationship between mining and levels of lead in the air and in rainwater tanks (Noller, 2009). The village of Camberwell and an outlying rural area of Muswellbrook were chosen for the study because of their close proximity to coal mining operations and local homes. A total of 36 houses were involved in the sampling study. The results of the study showed there was no demonstrated health risk from lead associated with coal mining in the Hunter Valley. The review also found that air and water lead levels were significantly below the relevant national standards.

The review of the studies found that the predicted deposited dust levels for the amended Project are an order of magnitude below the relevant criteria. Based on this, and the above studies, impacts on rainwater in tanks are expected to be minimal. Hence, it would not be necessary or appropriate for the Applicant to fund the cleaning of rainwater tanks within a 5km radius of the Site or provide bottled water as requested by the BGSPA.

4.4.9.16 Stock, Agricultural Productivity and Dairying

The potential effects of coal dust on agricultural production have been the subject of a study by Andrews and Skriskandarajah (1992) in Connell Hatch (2008). This study found that:

- cattle did not find feed unpalatable if coal mine dust was present at a dust deposition level of 4 000 milligrams per square metre per day (mg/m^2/day) (equivalent to a dust deposition level of approximately 120g/m^2/month);

- the presence of coal mine dust in feed did not affect the amount of feed that the cattle ate or the amount of milk that the cattle produced at a level equivalent to a dust deposition level of 4 000mg/m^2/day; and
- where cattle were able to choose between feed that was free of coal mine dust, feed that contained 4 000mg/m^2/day of coal mine dust and feed that contained 8 000mg/m^2/day of coal mine dust, cattle did not preferentially eat feed that did not contain coal mine dust.

Given that predicted amended Project dust deposition levels are far lower at nearby properties that those studied in Andrews and Skriskandarajah (1992) and Connell Hatch (2008), the effects of amended Project-related dust on agricultural production are expected to negligible.

4.4.9.17 Greenhouse Gases

Table 4.42 summaries the outcomes of the greenhouse gas emissions for the amended Project based on the indicative production schedule presented in **Table 2.5** and assuming the completion of mining, coal preparation activities and transportation in Year 17, with emissions in the subsequent years restricted to those from diesel during the final rehabilitation activities.

Average annual Scope 1 emissions from the amended Project (0.1 million tonnes [Mt] CO_2-e) would represent approximately 0.02% of Australia's commitment under the Kyoto Protocol (591.5Mt CO_2-e) and a very small portion of global greenhouse emissions, given that Australia contributed approximately 1.12% of global GHG emissions in 2012 (PBL Netherlands Environmental Assessment Agency, 2015).

The estimated GHG emissions intensity of the amended Project is approximately 0.09t CO_2-e per tonne of ROM coal (Scope 1 emissions only) which is similar to the majority of open cut coal mines in Australia (Scope 1 emission only) (Deslandes, 1999).

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's Direct Action Plan. The centrepiece of the plan is Emissions Reduction Fund which will provide incentives for emissions reduction activities across the Australian economy. The legislation to establish the Emissions Reduction Fund came into effect in December 2014. With the safeguard mechanism due to commence on 1 July 2016 this will require emitters to keep emissions within baseline levels.

4.4.10 Health Risk Assessment

4.4.10.1 Introduction

The following subsections summarise the outcomes of the Health Risk Assessment undertaken by Pacific Environment (2016b) which evaluates the possibility of impacts on human health from acute (i.e. short term) and chronic (i.e. long term) inhalation of particulate matter (all sources), particulate matter generated by diesel exhaust and nitrogen dioxide (all sources). The Health Risk Assessment has been peer reviewed by Associate Professor David McKenzie, Respiratory and Sleep Physician at the Prince of Wales Private Hospital and Medical Director of Medicine and Integrated Care at the Prince of Wales Hospital, Randwick, NSW.

Table 4.42
Summary of Estimated CO_2-e (tonnes) – All Scopes

	Scope 1 Emissions (t CO_2-e)				Scope 2 Emissions (t CO_2-e)	Scope 3 Emissions (t CO_2-e)				
Year	**Diesel**	**Fugitive Methane**	**Vegetation Stripping**	***Total***	**Electricity**	**Diesel**	**Electricity**	**Energy Production**	**Rail**	***Total***
1	11,652	10,800	706	*23,158*	30	598	4	339,782	381	*340,764*
2	12,736	27,000	706	*40,441*	68	653	10	849,452	952	*851,066*
3	12,736	27,000	706	*40,441*	68	653	10	849,452	952	*851,066*
4	18,968	59,400	706	*79,074*	18,549	973	2,650	1,868,791	2,094	*1,874,508*
5	27,910	75,600	706	*104,216*	18,581	1,431	2,654	2,378,464	2,665	*2,385,215*
6	27,910	75,600	706	*104,216*	18,581	1,431	2,654	2,378,464	2,665	*2,385,215*
7	27,910	75,600	706	*104,216*	18,581	1,431	2,654	2,378,464	2,665	*2,385,215*
8	28,723	86,400	706	*115,829*	18,609	1,473	2,658	2,718,243	3,046	*2,725,420*
9	28,723	86,400	706	*115,829*	18,609	1,473	2,658	2,718,243	3,046	*2,725,420*
10	28,994	91,800	706	*121,500*	18,609	1,487	2,658	2,990,068	3,350	*2,997,564*
11	27,368	97,200	706	*125,274*	18,623	1,403	2,660	3,159,959	3,541	*3,167,564*
12	27,097	97,200	706	*125,003*	18,623	1,390	2,660	3,159,959	3,541	*3,167,550*
13	27,097	97,200	706	*125,003*	18,623	1,390	2,660	3,159,959	3,541	*3,167,550*
14	27,097	97,200	-	*124,297*	18,623	1,390	2,660	3,159,959	3,541	*3,167,550*
15	15,987	59,400	-	*75,387*	18,535	820	2,648	1,698,903	1,904	*1,704,274*
16	17,342	75,600	-	*92,942*	18,582	889	2,655	2,378,464	2,665	*2,384,673*
17	19,510	-	-	*19,510*	0	1,001	0	0	0	*1,001*
18	19,510	-	-	*19,510*	0	1,001	0	0	0	*1,001*
19	10,839	-	-	*10,839*	0	556	0	0	0	*556*
Total	**418,110**	**1,139,400**	**9,175**	***1,566,685***	**241,891**	**21,442**	**34,556**	**36,186,627**	**40,546**	***36,283,171***

Note: Totals may differ to the sum of the columns due to rounding and significant figures.

Source: Pacific Environment (2016) – Table 18.1.

The methodology adopted in the conduct of the Health Risk Assessment is consistent with the protocols and guidelines recommended by the enHealth Council. These are detailed in the document "Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards" (enHealth, 2012a). The methodology includes:

1. a hazard assessment identifying hazards to health from pollutants (i.e. particulates and nitrogen dioxide);
2. an exposure assessment including identification of people who may be exposed and the potential exposure concentrations; and
3. risk characterisation providing a quantitative evaluation of potential health risk based upon the hazard and potential exposure.

It is noted that conservative safety margins are built into the risk assessment to ensure protection of the public.

4.4.10.2 Particulate Matter – All Sources

In recent years, a large amount of research has focussed on the health effects of particles. Effects have been found for both PM_{10} and $PM_{2.5}$. Most information comes from population-based epidemiological studies that find increases in daily mortality, as well as morbidity outcomes such as increases in hospital admissions and emergency room attendances, and exacerbation of asthma, to be associated with daily changes in ambient particle levels. There has also been an increasing focus on the link between exposure to particles and cardiovascular outcomes.

The approach used to calculate the risks to health has drawn upon internationally recognised estimates of the impact of particulate matter on health in relation to the known health indicators for NSW. It involves estimating the change in the incidence of a health outcome resulting from a given change in particulate matter concentrations. Baseline health incidence data was not available for the local areas, i.e. Gloucester and Faulkland State Suburbs. However, data was available for Tamworth, Newcastle and Sydney. The data from Tamworth has been used given that the local environment of Tamworth is more similar to the Gloucester area. **Table 4.43** summarises the baseline health statistics used in the risk calculations.

To provide a conservative approach, the 'average' $PM_{2.5}$ and PM_{10} concentrations that were used for the health risk assessment were the maximum average concentrations predicted at the representative residences (see **Tables 4.29** and **4.31**). These were extrapolated across the whole community. For the assessment of long-term mortality, the annual average concentrations were used in the calculations. For the short-term effects, the predicted maximum 24-hour average concentrations (see **Tables 4.27** and **4.30**) for the same locations were used and extrapolated across the relevant populations. These values were then used to calculate the daily mortality health endpoints. The predicted number of attributable health effects for $PM_{2.5}$ and PM_{10} arising from the amended Project are shown in **Table 4.43**.

Table 4.43
Health Incidence Rate per 100,000 – Baseline & Amended Project Related Risk Increase

Health Endpoint	Baseline (Tamworth – 2010)	Highest Predicted Increase in Number of Attributable Cases			
		Gloucester State Suburb (Residence 6)		Faulkland State Suburb (Residence 18)	
		Due to $PM_{2.5}$ Exposure	Due to PM_{10} Exposure	Due to $PM_{2.5}$ Exposure	Due to PM_{10} Exposure
MORTALITY					
Annual mortality all cause 30+ years	353	0.21	0.314	0.020	0.04
Cardiopulmonary disease 30+ years	164	0.22	NA	0.02	NA
Ischaemic Heart Disease 30+ years	66	0.15	NA	0.01	NA
Lung Cancer mortality 30+ years	16	0.02	NA	0.00	NA
Daily mortality all causes all ages	-	0.00	0.00	0.00	0.03
Daily mortality cardiovascular disease all ages	136	0.00	0.00	0.00	0.00
HOSPITAL ADMISSIONS					
Respiratory disease 65+ years	297	0.05	0.03	0.00	0.00
Cardiac disease 65+ years	542	0.11	0.09	0.01	0.01
Pneumonia and bronchitis 65+ years	96	0.02	0.01	0.00	0.00
Cardiovascular disease 65+ years	747	0.10	NA	0.01	NA
Respiratory disease 15-64 years	299	0.07	0.07	0.01	0.01
Emergency department visits (asthma) 1 - 14 years	258	0.01	0.01	0.00	0.00

Source: Pacific Environment (2016b) – Modified after Tables 5.6 to 5.10. NA = Not Assessed

The increased risk in the population (based on annual mortality rates, all causes) due to the worst case annual average increased long-term exposure to $PM_{2.5}$ and PM_{10} as a result of the amended Project would be less than 1 in 100,000 (the highest being 0.31 in 100,000). Therefore, in accordance with the *National Environmental Protection (Ambient Air Quality) Measure*, this increase is considered to be "sufficiently small and to be of no cause for concern".

Shorter term exposures to $PM_{2.5}$ and PM_{10} are also considered not to pose an unacceptable risk as the predicted number of attributable cases due to daily mortality (all cause all ages and cardiovascular disease all ages are less than 1 in 100,000 (the highest being 0.03 in 100,000) and orders of magnitude lower than the long-term exposure risk.

Therefore, based on the results of the health risk assessment for particulate matter, it is considered unlikely that an unacceptable risk due to particulate matter exposure would result from the amended Project.

4.4.10.3 Particulate Matter $PM_{2.5}$ – Diesel

Diesel exhaust particulate matter consists mainly of aggregates of spherical carbon particles coated with organic and inorganic substances, with the composition of the particles being predominantly organic and inorganic carbon. The organic fraction of diesel exhaust particulate matter contains compounds such as aldehydes, alkanes and alkenes, aliphatic hydrocarbons, polycyclic aromatic hydrocarbons and their derivatives. These substances are considered toxic air contaminants and some of them are genotoxic and carcinogenic. It has therefore has been considered appropriate to specifically review the cancer risk of particulate matter that would be generated from diesel exhaust arising from the amended Project.

Diesel exhaust particles from modern, optimal combustion engines are primarily $PM_{2.5}$ (WIMR-CAR, 2015). The predicted $PM_{2.5}$ arising from diesel combustion are outlined in Section 4.4.9.13 and **Table 4.40**. The carcinogenic inhalation risk due to $PM_{2.5}$ – diesel has subsequently been calculated by combining the project-only annual average $PM_{2.5}$ concentrations attributable to diesel with the cancer unit risk factor i.e. 0.000034µg/m^3, derived by the World Health Organisation (WHO) and an adjustment factor (0.25).

The highest annual average $PM_{2.5}$ concentration predicted at a private residence and attributable to diesel was 0.37µg/m^3 and has been applied across the whole population, i.e. Gloucester State Suburb and Faulkland State Suburb to provide a conservative estimate of the potential cancer risk. The adjustment factor assumes that residents in the adjacent communities will be at home for 20 hours per day for 365 days of the year for the life of the mine, i.e. 21 years. The adjustment factor was therefore calculated as follows: (20/24 hours x 21/70 years) = 0.25.

The results of these calculations show that cancer risk as a result of the highest annual average $PM_{2.5}$ concentration is ~0.31 in 100 000 / 3.1 in 1 000 000. This level is considered within the acceptable cancer risk range, i.e. 1 in 100 000 to 1 in 1 000 000 generally accepted by NSW, national and international authorities for airborne contaminants.

4.4.10.4 Nitrogen Dioxide - Blasting and Diesel

Blasting activities and diesel consumption within the Mine Area have the potential to result in emissions of oxides of nitrogen (NO_X). NO_X comprises both nitric oxide (NO) and nitrogen dioxide (NO_2). From the point of view of impacts on human health, NO_2 is of greatest concern. The main short-term health outcomes identified in epidemiology studies are increased respiratory disease and symptoms. The evidence for the long-term effects of long-term exposure to NO_2 is limited.

The cumulative predicted levels of NO_2 as a result of blasting are presented in Section 4.4.9.14 and **Table 4.41**. Notably, all predicted concentrations remain below the Australian *National Environmental Protection (Ambient Air Quality) Measure* criteria.

However, it is noted that NO_2 and PM_{10} potentially have additive effects (Streeton, 1997). As such, the health risk assessment was conducted to assess the combined effects of NO_2 and PM_{10}. In order to assess the potential health impacts, the predicted concentrations of NO_2 and

PM_{10} are compared to individual health-based ambient air quality criteria generated to protect public health. This comparison is performed by calculating a Hazard Quotient (HQ) which is the ratio of predicted concentrations to the ambient air quality criterion. A Hazard Index (HI) is the sum of the HQs for all pathways with similar toxic effects, assuming the health effects are additive", and is evaluated as follows.

1. HIs of less than or equal to one means that all the maximum predicted concentrations are below the health based air guideline value and there are no additive health impacts of concern.
2. HIs of greater than one but less than ten generally also do not represent cause for concern because of the inherent conservatism embedded in the exposure portions of a risk assessment. However, it is usual to examine the level of conservatism that has been assumed in the exposure assumptions.
3. HIs of greater than ten means that there is the potential for adverse health effects and should be evaluated.

The results of the calculated Health Indices for both short-term and long-term exposure are presented in **Table 4.44**.

Table 4.44
Short-term and long-term Health Indices for PM_{10} and NO_2 concentrations

	Receiver 6	Receiver 18	Receiver 19A	Receiver 23
Short-term				
Year 4	0.94	1.09	0.86	0.95
Year 7	1.29	1.25	0.95	1.22
Long-term				
Year 4	0.44	0.51	0.44	0.41
Year 7	0.48	0.58	0.49	0.45
Source: Pacific Environment (2016b) – Table 5.16.				

Four of the short-term Health Indices are either at or slightly above one. Comparatively, all of the long-term Health Indices are less than 1. This indicates that any potential short-term health effects could be appropriately mitigated by the use of known management measures and that long-term health effects are very unlikely.

As outlined in Section 4.4.9.12, the predicted NO_2 concentrations from blasting are based upon every blast having a Rating 4 Fume Category which would typically appear as an orange / red plume. However, the outcomes from previous ACARP studies (Day et.al, 2013) recorded the frequency of Rating 4 Fume Category from 500 blasts as being less than approximately 0.2%. This demonstrates that, with the implementation of appropriate management measures, the incidence of Rating 4 Fume Category blast plumes and resultant NO_2 concentrations should be very low.

Therefore, the short-term effects are expected to be mitigated by the use of measures known to minimise fume generation including blast design, product selection and quality, blast crew education, on bench practices, and blasting under wind conditions that favour dispersion of pollutants. Each of these measures would be identified in a Blast Fume Management Strategy (see Section 4.4.7.4) appended to the Blast Management Plan for the amended Project in order to prevent the 'worst case' modelled NO_2 concentrations occurring.

4.4.11 Monitoring

The Applicant proposes to continue to monitor PM_{10} and $PM_{2.5}$ concentrations continuously at selected locations which are representative of residences or receivers that may experience short-term elevated dust concentrations. A short-term average performance indicator would be set at a level that allows proactive dust management (in conjunction with the predictive meteorological monitoring) if dust levels are expected to approach the 24-hour PM_{10} impact assessment criteria in the upcoming 24 hours. Proactive dust management measures would be assessed, tailored and implemented at the time the performance indicator was reached. This is discussed in Section 4.4.7.

The existing monitoring network would be reviewed and augmented (if necessary) for the operation of the amended Project, with the review of the existing monitoring regime forming part of the AQGGMP. The proposed monitoring locations would include a suitable location in the vicinity of the Forbesdale Estate, as well as the existing monitoring locations to the north (adjacent to the Avon River Estate) and to the south of the Mine Area. The Applicant considers it is unnecessary to establish any monitoring locations within Gloucester township given the range and location of monitoring locations between the Site and the township and the modelling outcomes. All monitoring locations and the types of monitors and sampling regimes would be finalised within the AQGGMP. The Applicant would also consider monitoring at other locations in response to legitimate complaints.

Dust deposition monitoring would continue on a monthly basis at the locations described in Section 4.4.4.1. These locations would be reviewed and augmented, if necessary, for the operation of the amended Project, with the review of the existing monitoring regime forming part of the AQGGMP.

For air quality parameters involving an assessment of compliance on an annual basis (e.g. deposited dust), the results of the air quality monitoring program would be posted on the Applicant's website, generally on a monthly basis with a rolling annual average once 12 months of data is available.

4.4.12 Conclusion

The air quality modelling completed by Pacific Environment (2016a) predicts that there would be no exceedance of annual average TSP, PM_{10}, $PM_{2.5}$, or dust deposition criteria at any privately-owned residences or receivers, either from the amended Project alone or cumulatively. There would also be no exceedances of the 24-hour average PM_{10} or $PM_{2.5}$ criteria resulting from the amended Project alone.

Use of the statistical approach known as a Monte Carlo Simulation to determine the likelihood of cumulative exceedances of 24-hour PM_{10} indicated that there is a very low probability that cumulative 24-hour PM_{10} concentrations would result in any additional days over $50\mu g/m^3$ than would occur anyway due to background concentrations in the absence of the amended Project.

The Monte Carlo Simulation which was also used to determine the likelihood of cumulative exceedances of 24-hour $PM_{2.5}$ indicated that cumulative 24-hour $PM_{2.5}$ concentrations could result in two additional days per year of average 24-hour $PM_{2.5}$ concentrations over $25\mu g/m^3$ than would occur in the absence of the amended Project due to background concentrations.

The GHG assessment for the amended Project indicates that average annual direct emissions from the amended Project (0.1Mt CO_2-e) would represent approximately 0.02% of Australia's commitment under the Kyoto Protocol (591.5Mt CO_2-e) and a very small proportion of global greenhouse emissions.

The predictions presented in the air quality assessment incorporate a level of conservatism due to worst case assumptions and the nature of dispersion modelling. As a result, it is expected that actual ground level concentrations would be lower than those predicted during the operation of the amended Project.

Notwithstanding the predicted levels, it is proposed that the potential impacts would be managed on the day to day basis using predictive meteorological data and a network of real-time monitoring stations which would enable mine personnel to respond to elevated dust levels prior to reaching set trigger levels below relevant criteria, and modify activities, their location or increase controls as required to avoid exceedances.

Potential health issues arising from exposure to particulate matter, NO_2 and $PM_{2.5}$ generated from diesel combustion, the potential for short term or long-term effects have been assessed through consideration of susceptible / vulnerable groups within surrounding communities. Overall, it is concluded that air emissions from the amended Project would present little likelihood of causing adverse health effects to exposed individuals in the vicinity of the Site.

4.5 VISIBILITY

The visual impacts assessment of the amended Project was undertaken by Richard Lamb and Associates (RLA). The full assessment is presented in Volume 2 Part 3 of the Specialist Consultant Studies Compendium and is referenced throughout this document as RLA (2016a), with a summary of their assessment presented in the following subsections.

The approach to the identification of mitigation measures to minimise lighting impacts previously undertaken in conjunction with Wadco Lighting has been updated by R.W. Corkery & Co. Pty Limited. Their report is included as Appendix D of RLA (2016a).

4.5.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to visibility and their risk rankings after the adoption of standard mitigation measures are as follows.

- Change in content and composition of views from residences and public vantage points during construction of western and northern amenity barrier (high).
- Change in content and composition of views from residences and public vantage points during operations within the open cut pits and overburden emplacements (after the completion of the western and northern amenity barrier) (low).
- Visual intrusion or a reduction in scenic quality due to direct/indirect lighting or lighting glow of an evening (medium).
- Visibility of on-site traffic and maintenance activities (daytime and evening) (low).

In addition, the Director-General's Requirements issued by the then DP&I (now DPE) identified "Visibility" as one of the key issues requiring assessment. The principal assessment matters from DP&I relating to visibility include the following.

- Changing landforms on the Mine Area during the various stages of the Project.
- Potential visual impacts from the Project on private landowners in the surrounding area as well as key vantage points in the public domain (including the Kia Ora Lookout, Mograni Lookout and the walking track at The Bucketts Range, west of Gloucester township), including lighting impacts.

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the former Gloucester Shire Council, NSW Health – Hunter New England Local Health District, and the BGSPA. The additional matters identified in the additional correspondence are generally consistent with the DGRs, although the former Gloucester Shire Council requested that three-dimensional modelling be undertaken and the BGSPA requested that the impact of the scenic-heritage vistas should be assessed from a wide coverage of viewing points.

This section addresses visual impacts relating to the activities within the Mine Area, the private haul road and the relocated 132kV power line.

It is noted that visibility issues are also considered in the Historic Heritage Assessment (RLA, 2016b).

4.5.2 Existing Visual Amenity

4.5.2.1 Landscape Setting

The Site is located within the Gloucester Valley at the northern end of the Gloucester Basin, an area recognised for its moderate to high quality scenery. The key components of the amended Project are located within or on different landforms within the valley, the visibility of which are influenced by a range of factors including topography, land use, natural and cultural features, vegetation and the settlement pattern.

The Mine Area is located on the lower western slopes of the Mograni Range, a prominent range that forms part of the eastern edge of the Gloucester Basin. Elevations of land that would be disturbed within the Mine Area vary from approximately 100m AHD near Waukivory Creek to approximately 200m AHD on its eastern side. The private haul road is located on land which varies in elevation from approximately 110m AHD to 170m AHD, generally on the lower western slopes of the Mograni Range. RLA (2016a) records that given its location, the area proposed for the private haul road has a high visual absorption capacity[6].

RLA (2016a) records that the Site shares the character of many other areas of landscape in the Gloucester Valley and that the visual quality of the area in which the Site is located is considered moderate – high. Further, the Site does not have any particular distinguishing scenic features in itself and has a moderate to low visual absorption capacity.

[6] The higher the visual absorption capacity, the less obvious activities in that area would be.

4.5.2.2 Viewing Locations and Situations

The potential visibility of the Site, including the proposed private haul road, is limited by the topography, land use, natural and cultural vegetation and the settlement pattern of the locality. Viewing locations are either in the public or private domain as discussed as follows.

Views in the Public Domain

Intermittent views of the Site are possible from The Bucketts Way over a section of about 5.5km in length from near Jacks Road to Gloucester Tops Road, with other intermittent views also possible from some sections of local roads including Waukivory Road, Jacks Road, Grantham Road, Fairbairns Road and Maslens Lane.

No formal public lookout sites occur adjacent to The Bucketts Way that have views of the Mine Area. A number of other lookouts in the Gloucester Area are marked on tourist maps, such as the Mograni, Kia Ora, and The Bucketts walking track lookouts. It is noted that the Mograni Lookout is adjacent to The Bucketts Way east of Gloucester and does not have any view of the Site.

No formal parks or reserves in Gloucester township have views of the Site. Details of the views (and photographs) from representative locations in the public and private domain are provided in RLA (2016a). **Figure 4.27** displays the 59 locations that RLA (2016a) visited and assessed as part of the overall visual assessment.

Views in the Private Domain

A number of residences in the rural-residential areas experience views of various component areas within the Site, specifically those residences accessed off The Bucketts Way, Grantham Road, Fairbairns Road and Jacks Road. Those residences in the more elevated sections of the Avon River and Forbesdale Estates have direct visual access to all or components of the Mine Area, albeit restricted in places by vegetation and topography. Some rural residences adjacent to The Bucketts Way and Jacks Road also have views of components of the Mine Area.

There are isolated elevated areas within the Gloucester urban area that have restricted views of the Mine Area, albeit at distances in excess of 5km.

4.5.2.3 Viewing Situation Categories

In order to assess the extent of visual changes and the impacts of those changes attributable to the amended Project, RLA (2016a) identified four principal viewing situation category areas, each with somewhat different view compositions, i.e. focussing on the Mine Area. The four viewing situation categories are as follows.

Category 1: Distant, elevated view locations to the north and northwest (e.g. Kia Ora Lookout, The Bucketts walking track).

Category 2: Middle distance view locations to the northwest and north-northwest of the Mine Area (part of The Bucketts Way, rural residences adjacent to The Bucketts Way and rural residential estates accessed off Jacks Road).

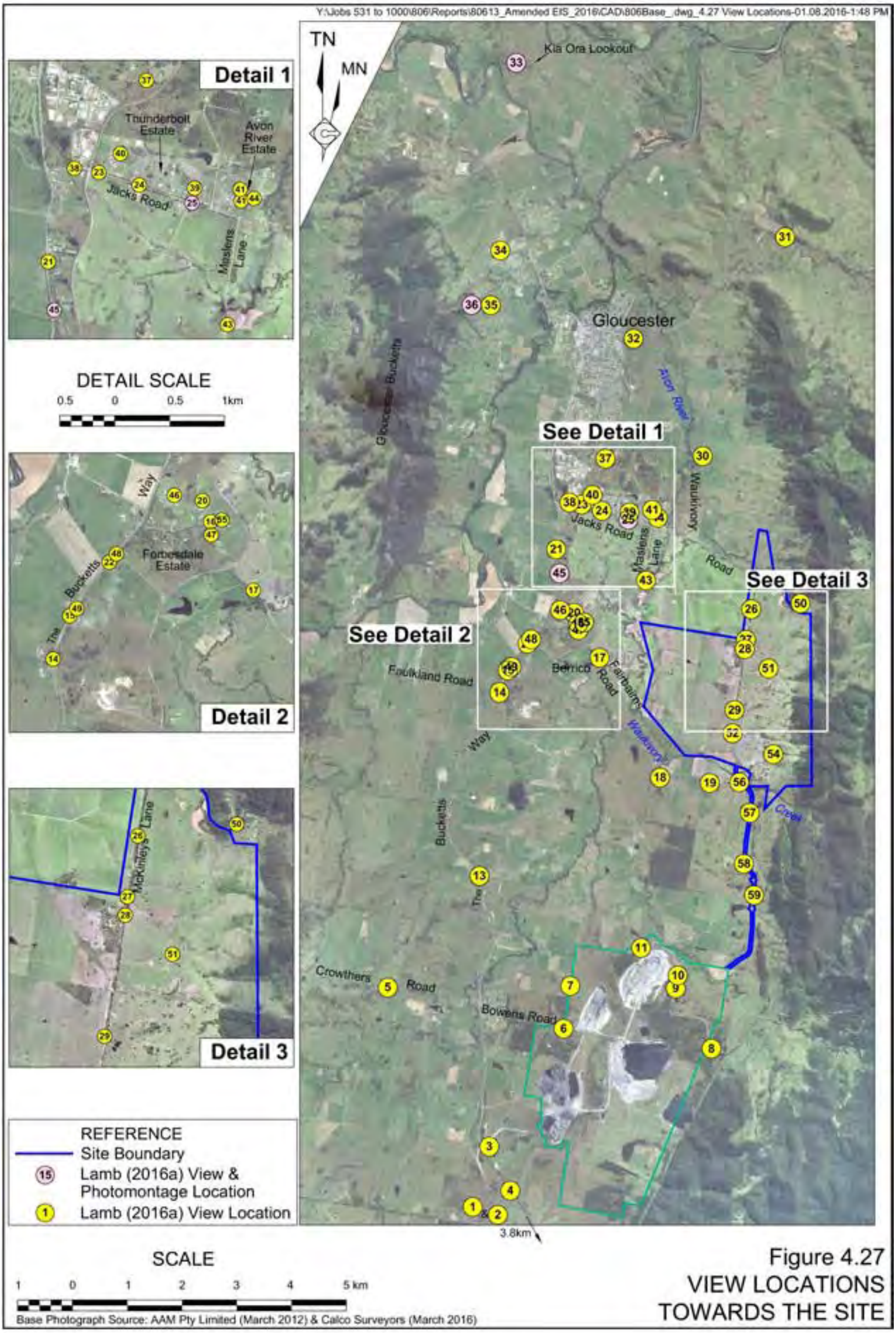


Figure 4.27
VIEW LOCATIONS TOWARDS THE SITE

Category 3: Middle distance view locations west of the Mine Area (The Bucketts Way and some of the rural residences in the Forbesdale Estate locality).

Category 4: Middle distance views from Fairbairns Road southwest and south of the Mine Area.

Figure 4.28 displays the locations of three of the four principal viewing situation category areas. It is noted that it is possible sections of the Mine Area may be visible from other areas in the vicinity of the Mine Area (or private haul road), although no significant visibility of the Mine Area is possible from the residential areas of Gloucester.

The factors contributing to the selection of the viewing situation categories were as follows.

Backdrop of Hills: The line and form of the wall of hills (Mograni Range) to the east of the Mine Area provide a background to all categories.

Open Cut Pit Orientation: The north-south orientation of the open cut pits would result in sub-parallel views when viewed from the north and northwest, e.g. Kia Ora Lookout, or perpendicular views when viewed from the west, e.g. Category 3 locations.

Elevation of Viewing Place: The Category 1 viewing situations are located at elevations of approximately 200m AHD and 350m AHD respectively and well above the land within the Mine Area. Category 2 and 4 viewing situations are located at elevations of between 100m AHD and 120m AHD, i.e. below or at approximately the elevation of the proposed ROM pad (and lower sections of the Mine Area). Category 3 viewing situations are typically at elevations between 125m AHD and 145m AHD, i.e. at elevations similar to those within the area of the proposed open cut pits.

Apart from the lookouts, the elevations of the viewing locations are such that, in the absence of mitigation measures, they would allow views of activities at and above natural ground level but not within the proposed open cut pits.

Viewing Distance: Apparent size is inversely proportional to the distance multiplied by the size of an object. Furthermore, the angle of view exponentially decreases with distance.

The Bucketts walking track and the Kia Ora Lookout (4.5-6.5km and 8.0-10.5km respectively from the Mine Area) are sufficiently distant not to allow a viewer to distinguish specific items. The angle of view of the 85m of elevation within the Mine Area between Waukivory Creek and the proposed clean water diversion channels when viewed from the Bucketts walking track and the Kia Ora Lookout would be approximately 0.6º and 0.4º respectively.

It is noted that there are no viewing locations with close range views of the Mine Area, i.e. <100m.

Line, Form Texture and Colours: Contrasts in the landscape reflecting combinations of line, form, texture and colours can be perceived at all distances.

The light to mid grey colour of the overburden (until satisfactorily revegetated) together with curvilinear forms created during the construction of the long-term and short-term amenity barriers would contribute to those components being noticeable from viewing locations.

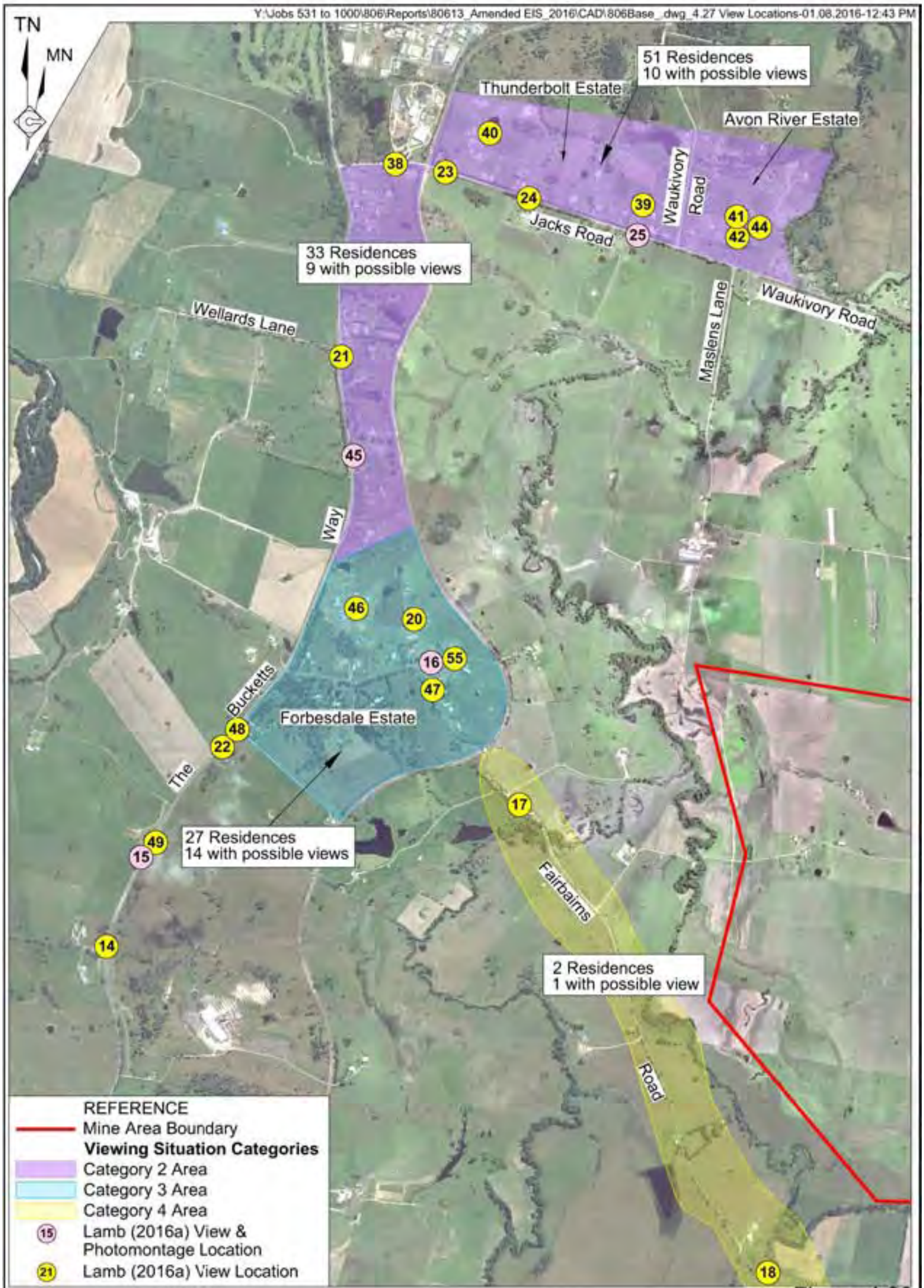


Figure 4.28
PRINCIPAL VIEWING SITUATION CATEGORIES

4.5.3 Potential Visual Impacts

The potential visual impacts are considered throughout the operational life of the amended Project and beyond, i.e. after all the disturbed land is rehabilitated.

4.5.3.1 Operational Daytime Impacts

During the daytime period, i.e. from 7:00am to 6:00pm – generally daylight hours, the following activities within and in the vicinity of the Site may be observed from some viewing locations.

Site Establishment and Construction Stage	Earthmoving and road construction equipment (bulldozers, off-road haul trucks, scrapers, graders, compactors and water carts) constructing the Mine Area access road and private haul road. Increase in trucks (some low loaders with oversize equipment) and light vehicle traffic on the public road network. Construction/assembly of site offices, amenities, workshop and ancillary facilities.
Years 1 to 16 Mining Operations	Earthmoving/mining equipment (drills, bulldozers, scrapers, off-road haul trucks, graders, excavators and water carts). Delivering and stockpiling of ROM coal and loading the rotary breaker. Transportation of sized ROM coal by truck from the sized coal bin to the Stratford Mining Complex. Periodic truck movements associated with delivery of consumables and light vehicle traffic on the public road network, i.e. principally via Jacks Road and Waukivory Road east of Jacks Road. All low loaders and oversize equipment would enter the Mine Area via the Stratford Mining Complex and the private haul road. The key component of the Mine Area that would be visible throughout part or all of the life of the amended Project would be the outer slopes of the western and northern amenity barrier (which would be progressively revegetated) and sections of the permanent overburden emplacement which would be visible for short periods during its formation, i.e. until it is revegetated.
Years 17 to 19 Main Pit Rehabilitation:	Earthmoving equipment (bulldozers, scrapers, off-road haul trucks, graders and excavators). This equipment would be retained on site after coal extraction ceases and progressively removed from site near and at the conclusion of the final landform reconstruction. Periodic truck movements associated with delivery of consumables and light vehicle traffic on the public road network, i.e. principally via Jacks Road and Waukivory Road, east of Jacks Road. The areas of activity during the final stage of on-site activities would be centred on the area of the interim overburden emplacement, the northern end of the Main Pit and the western and northern amenity barrier.

4.5.3.2 Operational Evening Impacts

From dusk to 10:00pm in Year 4 onwards, the number of haul trucks using their headlights and travelling on the internal haul roads would be similar or marginally less than those operating during the daytime, although real-time monitoring may result in a reduction in the number of haul trucks or changes to where they are operating within the evening period.

The extent of lighting impacts after dusk would depend upon:

- the type of lighting used, i.e. the amount of blue versus yellow light and its luminance level;
- whether the light is moving or stationary; and
- the presence of natural or man-made barriers either on or off site.

The lighting impacts would occur in one of three ways.

1. Direct Impacts – where light from a vehicle is travelling towards a viewer or a stationary light is directed towards a viewer.
2. Indirect Impacts – where the source of light is not directed at a viewer but the spread of light is observable.
3. Night Glow – where light from one or more sources is reflected in the atmosphere. The extent of night glow is a function of the presence or absence of fog, low cloud and/or airborne dust particles.

The lighting that would potentially be in use during this period would include:

- headlights from earthmoving equipment operating within the open cut pits, on internal roads and the out-of-pit overburden emplacements;
- headlights on light vehicles travelling within the Mine Area.
- headlights from light vehicles departing (and arriving) on site via the Mine Area access road;
- lighting towers within the open cut pits and on active overburden emplacement areas;
- safety and operational lighting within and around the ROM pad; and
- lighting within the administration area.

4.5.3.3 Long-term Impacts

Beyond the end of the rehabilitation stage of the amended Project, the final landform and its vegetation would remain as a permanent component of the landscape on the eastern side of the Gloucester Valley. Potential long-term impacts could arise in the event the landform does not blend into surrounding landform or its form, shape or profile is inconsistent with natural landform in that area of the valley.

4.5.4 Management, Mitigation and Contingency Measures

4.5.4.1 Introduction

The Applicant has already placed considerable weight upon the need to avoid and/or minimise the visual impacts of the amended Project. This subsection outlines the management measures taken largely during the design stage of the amended Project, together with the mitigation and contingency measures to be adopted throughout the life of the amended Project. During the Site establishment and construction stage, the Applicant would prepare a Visual Impacts Management Plan incorporating a separate Lighting Management Plan that would provide details of the specific measures introduced in this subsection.

4.5.4.2 Management Measures

The key management measures that the Applicant would adopt to minimise visual impacts both throughout the life of the amended Project and during the closure and decommissioning of the mine were established in conjunction with RLA during the early stage of the design of the amended Project.

The strategy developed by RLA (2016a) to underpin the approaches to identifying the key management measures to minimise visual impacts considered the following elements.

Effects on View Composition

The views from the nominated viewing locations would all have a similar composition reflecting the simple underlying physical landscape structure. The steep naturally vegetated hills of the Mograni Range form the backdrop, with steep dissected slopes that give way to gently undulating lower slopes. The areas of disturbance would run horizontally across the lower side slopes.

Changes to the Intrinsic Character of the Site

The need to place/store overburden beyond the areas of the open cut pits for the first 8 years of the amended Project necessitated this material be positioned at the most appropriate location(s) in the landscape that could accommodate or absorb that change. A key component of the strategy became the use of the appearance of the steeper mid slopes on the eastern side of the Mine Area, as placement of the overburden in this area would not break any views of the horizon and would only be visible until such times as the created landform is revegetated.

A further consideration of the landscape character on the mid slopes was the orientation of the secondary ridges. It became an important part of the strategy to create ridges within the final landform generally within the same location as existing ridges, albeit that they would be higher than in the same area of the existing landform. Adoption of this approach would also assist to manage upslope runoff from the elevated land to the east of the Mine Area on decommissioning the upslope diversion channels.

RLA (2016a) emphasises that the most important component of the strategy needs to be the objective to minimise the effect of the final landform on the scenic quality of the Mine Area. The secondary aim, while still important, would be to control the visibility of the mining and related activities throughout the operational life of the amended Project.

4.5.4.3 Daytime Mitigation Measures

The Applicant would adopt a range of mitigation measures to avoid and/or minimise the visibility of the on-site activities throughout the life of the amended Project. It is recognised that these mitigation measures need to relate to both design and operational features of the amended Project and are guided by the existing visual absorption capacity of the various locations where the mine-related components are located.

The visual absorption capacity establishes the extent to which the existing visual environment can reduce or eliminate the perception of the visibility of the amended Project or its effects. RLA (2016a) considers the Mine Area in its current form has an overall moderate to high visual absorption capacity when viewed from Category 1 and Category 4 viewing situations, a low to moderate visual absorption capacity from Category 2 viewing situations, and a low visual absorption capacity from Category 3 viewing situations.

Mine Area

The key design mitigation measure with respect to visibility would be the use of amenity barriers and the staging of activities to achieve the greatest effectiveness of those barriers. The Applicant proposes to construct one substantial long-term barrier and two short-term interim amenity barriers as displayed on **Figure 4.29**. Each of these barriers has been designed to visually shield different components on site. The design of the barriers in terms of their upper elevation and the preferred alignment has been established principally through the use of a series of cross-sections and analytical photomontages. Together, these methods have defined the optimum elevations along the length of each barrier to maximise the shielding of activities behind the barrier. However, it is acknowledged that whilst all efforts have been taken to fully shield on-site activities, there would be some locations during the first 8 years of the life of the amended Project where overburden haulage and placement would be visible in part, although for comparatively short periods, from some local properties – see Section 4.5.5.

Figure 4.30 displays the footprint and form of each of the barriers. It is noted that the western section of the western and northern amenity barrier has an irregular, non-linear footprint variations in slope and an undulating upper surface varying in elevation from approximately 120m to 160m AHD.

Figures 4.31 to **4.34** display a series of cross-sections from four representative vantage points identified on the layout on each figure. Each cross-section displays the presence of the western and northern amenity barrier, the interim amenity barriers, the vegetation adjacent to McKinleys Lane and the sight lines relevant to each, i.e. at Year 7. This year has been selected as it is able to display each of the visual controls fully developed and the effectiveness of each control. Beyond about Year 8, the bulk of the activities would be undertaken within the Main Pit and there would be very little change in the visual appearance of the Mine Area other than the progressive growth of vegetation. Details of the barriers are outlined below.

Other mitigation measures within the Mine Area relate mainly to vegetation, namely its retention where it provides good visual screening or its growth in areas to increase visual screening or softening of the views of the interim or final landforms.

Western and Northern Amenity Barrier

The western and northern amenity barrier would be a substantial structure covering an area of approximately 95ha and varying in height from approximately 10m to 40m above existing ground levels. The barrier would be required to limit both noise and visibility. RLA (2016a) assisted in the design of the barrier through recommending:

- the outer face of the barrier (covering approximately 75ha) have variable slopes, i.e. varying from 10° to 18° (see **Figure 4.29**).
- a variable upper surface varying in elevation from 140m AHD to 160m AHD; and
- an irregular pattern of vegetation covering approximately 34ha of the outer face of the barrier to achieve a natural rural appearance (see **Figure 4.29**).

These design features of the barrier have been recommended by RLA (2016a) to ensure that the barrier itself is not a source of further visual impact once it is constructed and vegetated.

The western and northern amenity barrier would comprise two sections, namely a western section and a northern section.

The Applicant proposes to complete the construction of the barrier by early in Year 3 of operations. The entire perimeter of the barrier would be constructed within the first 6 months to an elevation varying from approximately 115m AHD to 125m AHD. By the end of Year 1, the upper surface of the barrier would be between 130m AHD to 135m AHD. By the end of Year 2, much of the upper surface of the barrier would be completed to an elevation of 145m AHD to 156m AHD. The upper surface of the northern section of the barrier would be completed up to 160m AHD by early in Year 3. Whilst earthmoving equipment would be periodically visible on the active upper surface of the barrier, all efforts would be undertaken to minimise their duration in exposed areas.

An important component of the barrier construction would be the progressive completion of landform construction and revegetation of small (approximately 2ha) areas of the barrier's outer surface. These areas would typically be approximately 400m to 500m in length and 40m to 50m wide covering a vertical height of approximately 5m to 10m.

The western section of the western and northern amenity barrier would largely prevent visibility of the mining activities within the open cut pits and the haul trucks travelling on the internal roads when viewed from viewing locations within 3km to 5km of the Mine Area, i.e. principally from the west to the northwest. The northern section of the western and northern amenity barrier would largely prevent visibility of mining activities within the Mine Area from the Avon River and Thunderbolt Estates.

The western section of the western and northern amenity barrier would be in place for the duration of the amended Project and would only be removed following the cessation of coal extraction. At that time, its removal would be undertaken progressively from its eastern side to minimise the extent of exposure of the active earthmoving equipment.

The full extent of the northern section of the western and northern amenity barrier would be in place until about Year 14 after which the bulk of the barrier above approximately 130m AHD would be progressively removed from its southern side to allow coal to be extracted from the northern section of the Main Pit, leaving a small section of the former barrier with a reduced height of at least 10m to 15m above natural ground level.

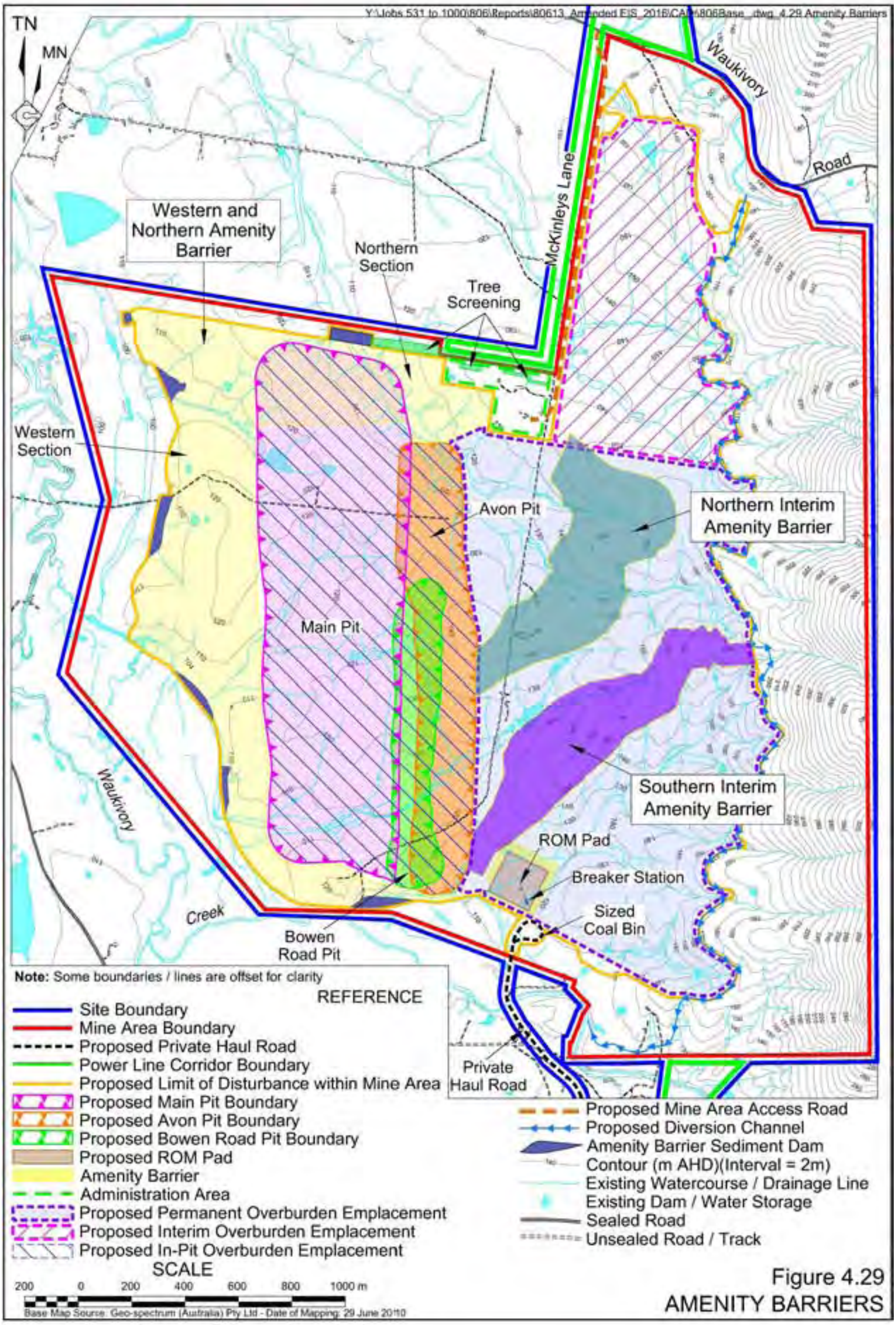


Figure 4.29
AMENITY BARRIERS

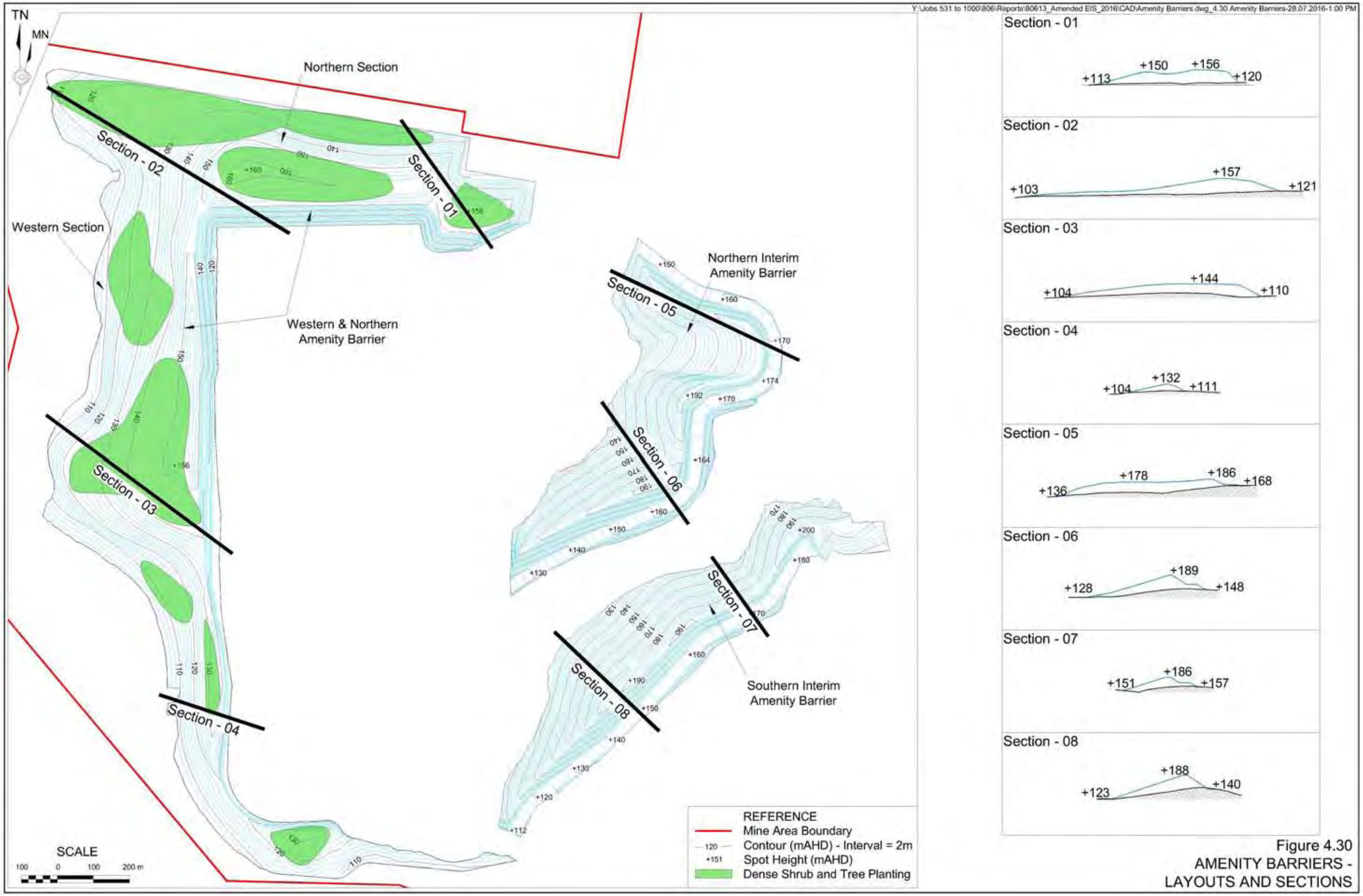


Figure 4.30
AMENITY BARRIERS - LAYOUTS AND SECTIONS

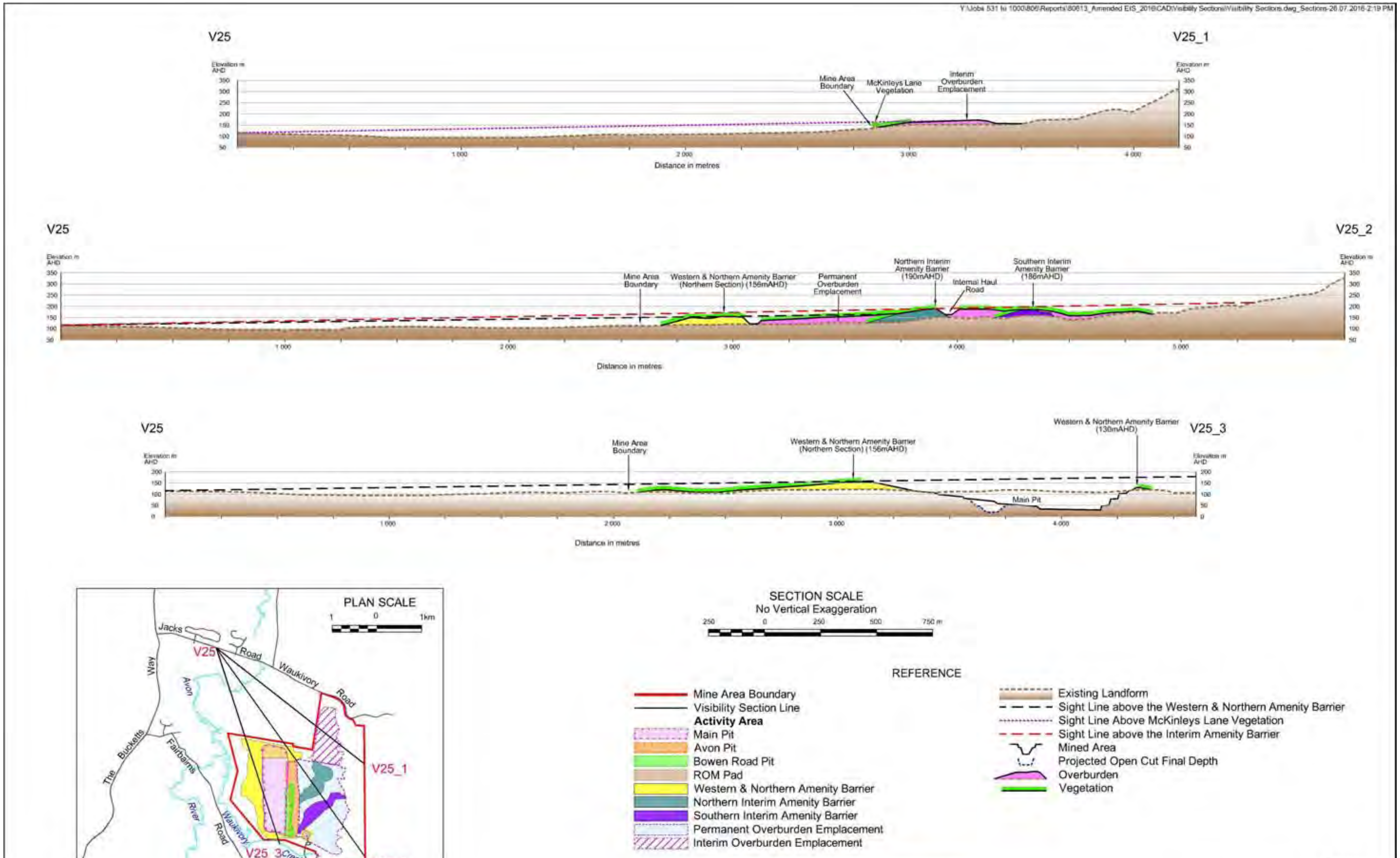


Figure 4.31
VISIBILITY SECTIONS FROM V25
ELEVATION 116m AHD - YEAR 7

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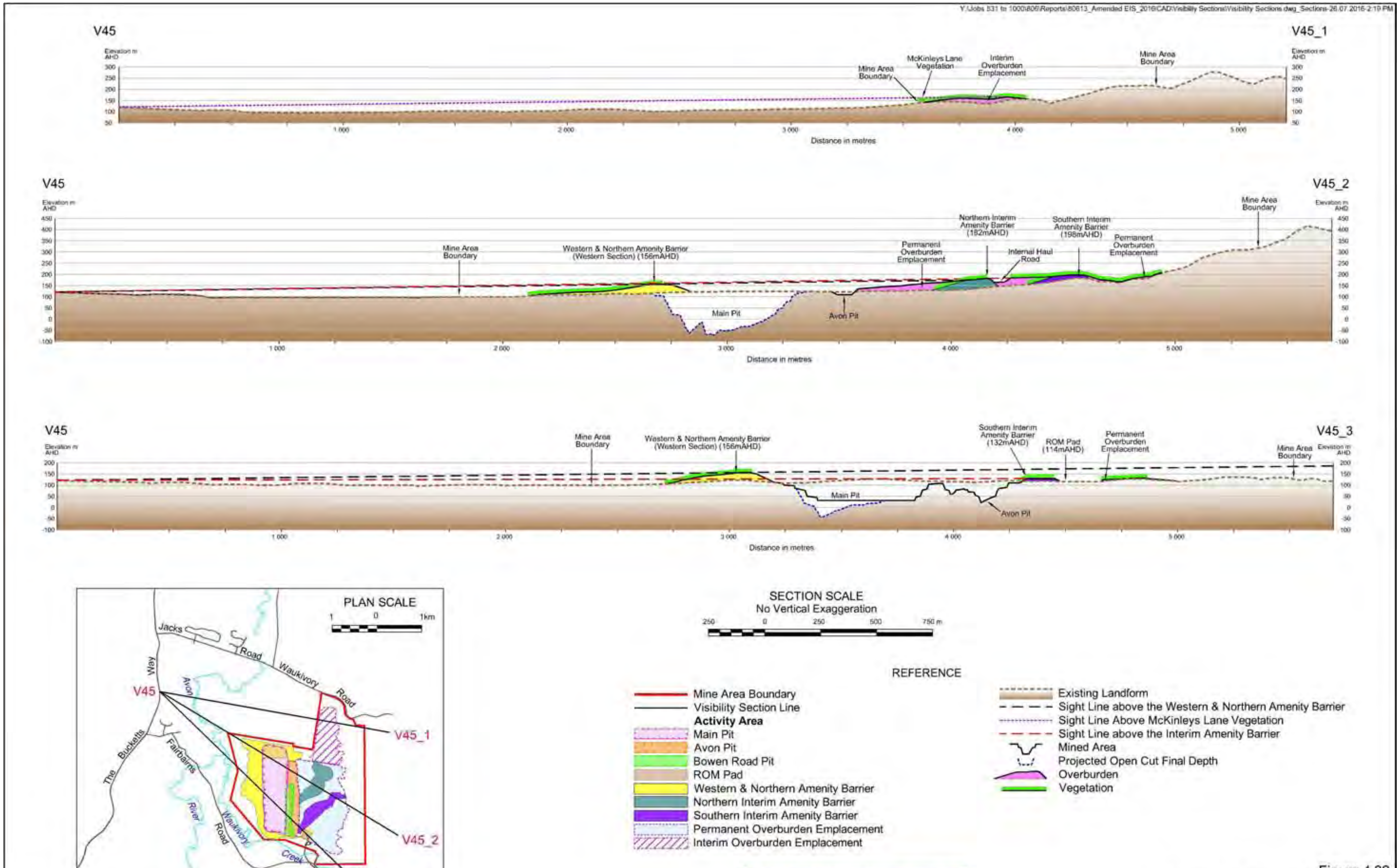

Figure 4.32
VISIBILITY SECTIONS FROM V45
ELEVATION 122m AHD - YEAR 7

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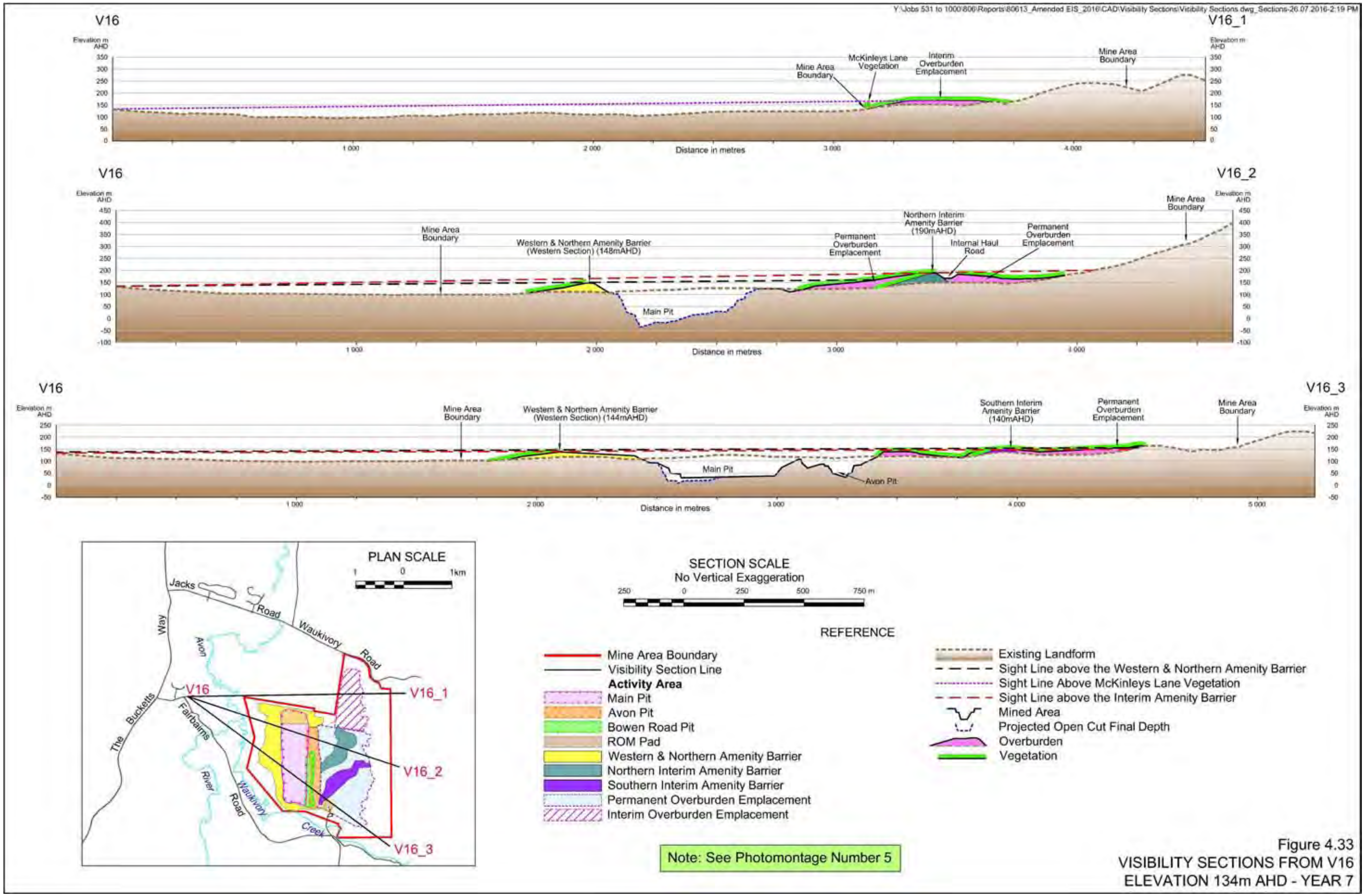

Figure 4.33
VISIBILITY SECTIONS FROM V16
ELEVATION 134m AHD - YEAR 7

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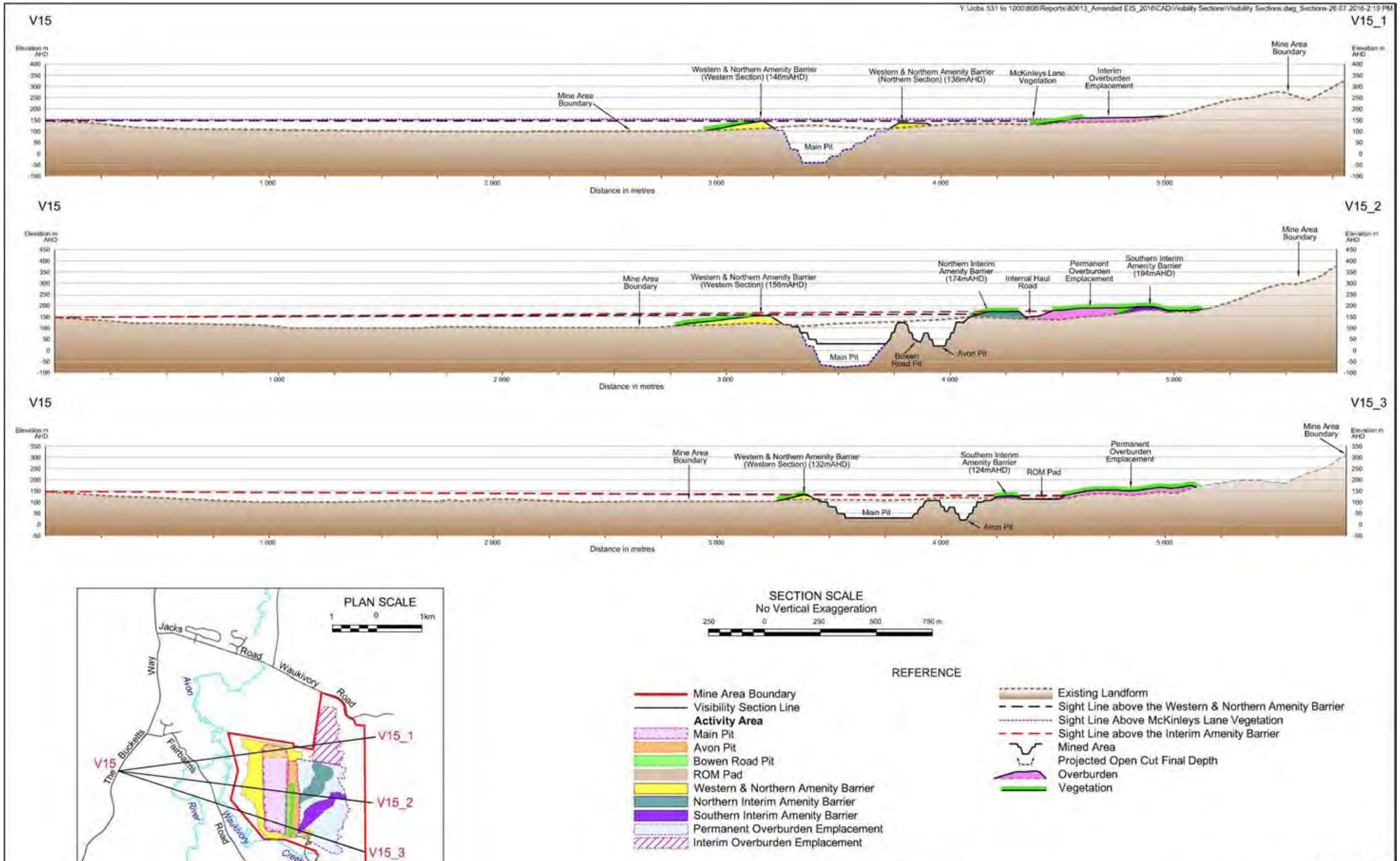

Figure 4.34
VISIBILITY SECTIONS FROM V15
ELEVATION 148m AHD - YEAR 7

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Interim Southern Amenity Barrier

The interim southern amenity barrier would be constructed during Year 2 to visually shield the subsequent construction of the more elevated southeastern sections of the out-of-pit overburden emplacement. The barrier would cover a footprint of approximately 28ha and vary in elevation along its southeastern side from approximately 112m AHD to 200m AHD. The northeast – southwest orientation of the barrier would maximise the screening of activities from the west and northwest. The northwestern face of the barrier would be shaped to approximately 18° to enable the surface to be easily revegetated with a pasture seed mix. The revegetation would be undertaken progressively once the required landform with sections of approximately 2ha are completed to the required contours. This barrier would be incorporated within the westerly advancing emplacement by about Year 6.

Interim Northern Amenity Barrier

The interim northern amenity barrier would be constructed in Year 4 to also visually shield the construction of the out-of-pit overburden emplacement as its construction advances northwards. The barrier would cover a footprint of approximately 30ha and vary in elevation on its southeastern side from approximately 130m AHD to 174m AHD. This barrier would also be constructed with a northeast-southeast orientation and an outer 18° slope and be revegetated with a pasture seed mix. This barrier would be incorporated within the westerly advancing emplacement by Year 8.

ROM Pad and Sized Coal Bin

The ROM Pad would be shielded on all sides by a barrier at least 10m high shielding the breaker station and the various activities within that area. The sized coal bin would be painted in a "Colorbond Wilderness" greyish-green hue similar in appearance to the canopy of the existing vegetation in the locality.

Private Haul Road

The design of the private haul road places considerable emphasis upon constructing the road as far east as possible from privately-owned residences and in an area that is shielded by topography and/or vegetation from viewing locations to the west. The road (**Figure 2.8**) is located on the eastern side of a small north-south ridge providing visual protection to the west for at least 1.8km of its length. The remaining 2.6km of the private haul road is largely shielded from the west by vegetation on the adjoining properties, or local topography.

Re-located 132kV Power Line

Given the re-located 132kV power line would be at the maximum distance from viewers in the various residential estates to the west of the Mine Area, and at the limit or beyond the distance range at which details of such items would be evident, the only specific measure would be for the power poles to be a comparable colour to the existing poles.

Maintenance and Planting of Vegetation

The Applicant would rely upon the existing vegetation adjacent to McKinleys Lane and in the vicinity of the administration area to shield the activities involved in the construction of the interim overburden placement to the east of McKinleys Lane. Further screen planting is proposed on the northern side of the Mine Area, immediately north of the administration area (**Figure 4.29**).

Reliance would be placed upon planted vegetation for two key reasons, namely to soften the visual appearance of the constructed landform and to shield activities behind the planted vegetation. The outer faces of all amenity barriers would initially be stabilised with a pasture seed mix suited to the planting season. In some cases, seeds of shrubs and trees may be planted with the pasture seed mix. Alternatively, the stabilised surface would be planted with either seed or tubestock of the preferred shrub and tree species. **Figure 4.30** displays the proposed areas of the planting on the northern and eastern amenity barrier, i.e. the areas in which it is proposed to incorporate taller and denser vegetation thereby achieving a mixture of plant heights and densities across the barrier. It is noted that the northern section of the barrier below approximately 130m AHD would be well vegetated with trees prior to the removal of the barrier above approximately 130m AHD in about Year 14 to accommodate the subsequent northern extension of the Main Pit.

4.5.4.4 Evening Mitigation Measures

The range of mitigation measures proposed to control visibility during the daytime would also assist to reduce the impacts of lighting during the evening, principally as they would shield light from both mobile and stationary light sources. It is noted that the period of evening lighting would effectively extend from dusk to 10:00pm, i.e. from about 5:00pm in winter to 8:00pm in summer (daylight saving time). Mining operations would not occur beyond 10:00pm until 7:00am on the following day, i.e. Monday to Saturday.

Mine Area

In order to further mitigate lighting impacts, the Applicant would adopt the following measures within the Mine Area. In all occupied areas of the Mine Area, external lighting would comply with AS 4282(INT) 1997 – Control of Obtrusive Effect of Lighting.

i) All stationary/fixed lights would be directed downwards with the height of the light source minimised. Where appropriate, full cut-off fittings would be provided to ensure only localised areas are illuminated.

ii) All stationary/fixed lighting would be positioned to direct light away from the northern to southwestern sector.

iii) All lighting towers within the open cut pits would be positioned in locations/elevations that would maximise the illumination of the operational area yet minimises the amount of reflected light and light directed in a northerly to southwesterly direction.

iv) Lighting would be selected to minimise the extent of bulbs generating blue/white light in favour of those generating yellow light. The selection would be guided largely by safety considerations.

v) Operational areas would be carefully planned to avoid working in areas that are in direct view of residents after dusk and/or by directing light away from these viewing locations.

The suppression of dust generated on the active haul roads used of an evening after dusk would assist to avoid or limit the generation of any glow above the Mine Area.

4.5.4.5 Long-term Mitigation Measures

The Applicant's acceptance of the recommendations of RLA (2016a) to create a final landform without a final void, and with a similar form, drainage features and micro-topography as the current landform, would be key measures to achieve an acceptable long-term landform that would avoid both long-term adverse impacts and provide a sustainable landform into the future.

4.5.4.6 Contingency Measures

The Applicant's internal monitoring and auditing programs would ensure that regular visits to surrounding vantage points are made by mine personnel to observe the effectiveness (or otherwise) of the visual controls, i.e. by day and after dusk. The Applicant's complaint management system would also alert site management to any concerns expressed by residents regarding deficiencies in the lighting and visual mitigation measures.

Reasonable and practical opportunities for improvements arising from the Applicant's own observations auditing and monitoring, together with the outcomes of discussions with neighbours, would be implemented as quickly as possible to eliminate/reduce the subject impacts.

The contingency measures would largely involve revision of site practices and procedures and/or construction of additional barriers or tree planting to eliminate/reduce any unexpected visual impacts.

4.5.5 Assessment of Impacts

4.5.5.1 Introduction

The visual impacts of the amended Project need to be considered in two time periods, namely, throughout its operational life and beyond its operational life, i.e. after all the previously disturbed land is rehabilitated.

The assessment of visual impacts of the operational components of the amended Project has been undertaken firstly by describing the effects of the changes to existing views that would occur throughout the life of the amended Project, and then in terms of visual compatibility, viewing places/viewer sensitivity, and after dusk lighting impacts. This assessment also incorporates a discussion of cumulative impacts. In order to better understand the changes to the views throughout the operational life of the amended Project, the Applicant has commissioned the preparation of a series of photomontages from six viewing locations, namely V15, V16, V25, V33, V36 and V45 as identified on **Figure 4.27**.

The photomontages comprise two types, namely:

a) analytical photomontages identifying the various parts of the Mine Area (through colour coding) that are subject to different management regimes; and

b) photorealistic photomontages that have been rendered and coloured to represent the appearance of the Mine Area from the respective viewing locations.

RLA (2016a) provides a detailed explanation of the development and use of both forms of photomontages.

The photomontages present the existing view and views at Year 0.5 and at the end of Years 1, 3, 7, 10 and 15 and the final view when all rehabilitation activities have been completed. All photomontages are presented in an enlarged form in Appendix B of RLA (2016a) with a companion set of the analytical photomontages identifying the components of the Mine Area that would be visible from the respective vantage point during each assessed year. The photorealistic photomontages that have been rendered with realistic colours and features such as vegetation, shadows, sun angle, haze effect and colour shift. A set of either four or two photomontages per A3 sheet are displayed as **Photomontages 1** to **6** on the following pages.

4.5.5.2 Visual Effects

RLA (2016a) undertook a visual effect analysis of the amended Project to review the effects on view composition and view loss focussing upon the changes within the Mine Area. Factors considered in the analysis of the effects on view composition include:

- viewing locations;
- the background of the Mograni Range;
- the orientation of the proposed open cut pits to the view line;
- the relative elevation of viewing places;
- viewing distance;
- line, form, texture and colours;
- landscape character and quality;
- evening lighting; and
- visual absorption capacity.

Each of the above factors are addressed in detail in RLA (2016a).

RLA (2016a) records that the visual effects for the Category 1 viewing situations arising from the amended Project would be:

- low from the Kia Ora Lookout; and
- low-moderate from The Bucketts walking track.

The extent of changes from the Kia Ora Lookout and the Bucketts walking track are displayed on **Photomontages 1** and **2** respectively. These effects would be visible during the daytime with the most visible components being the western and northern amenity barrier particularly those sections under construction or awaiting revegetation. The extent of change in the view from these viewing locations would be limited, particularly in the vertical dimension.

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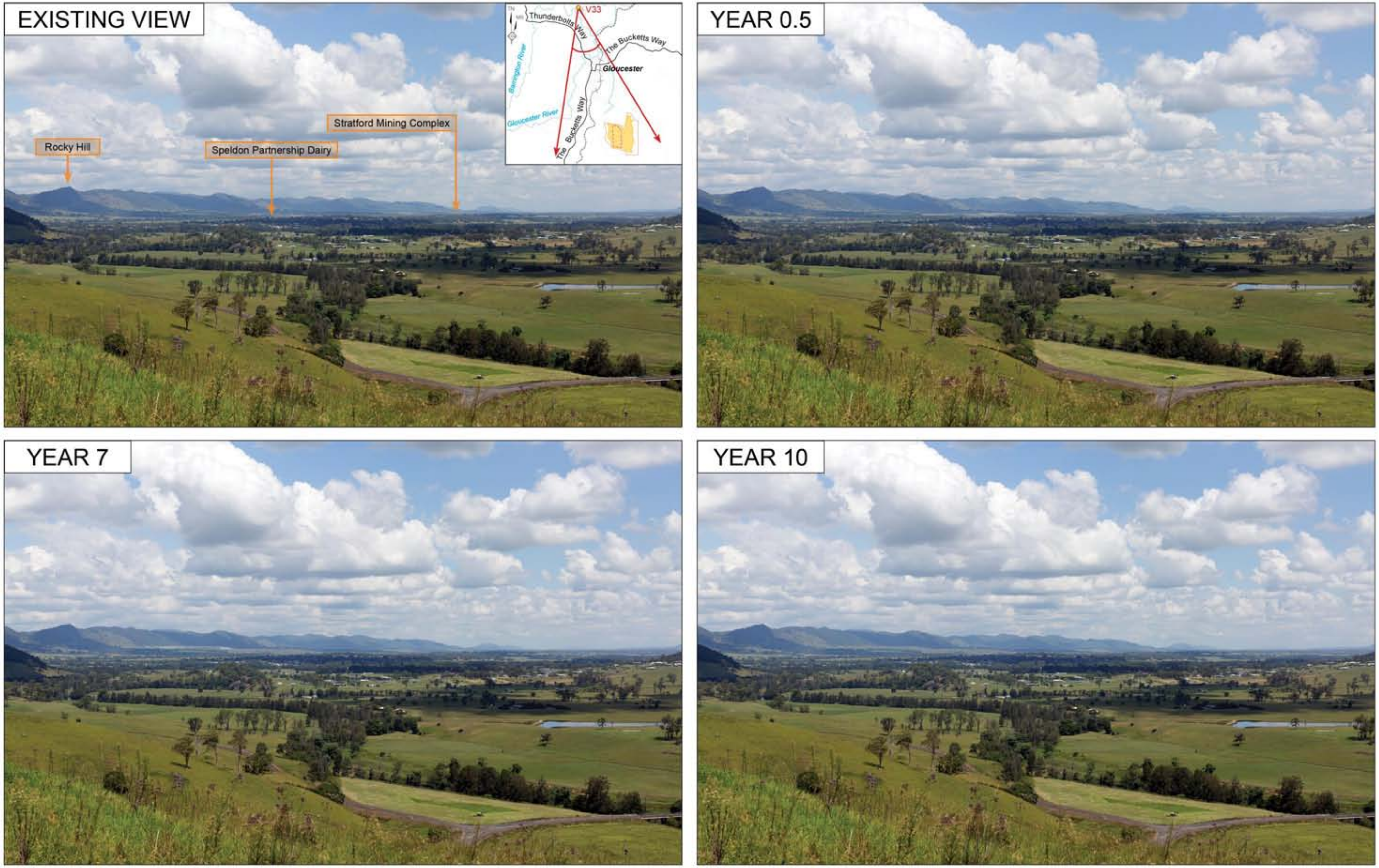
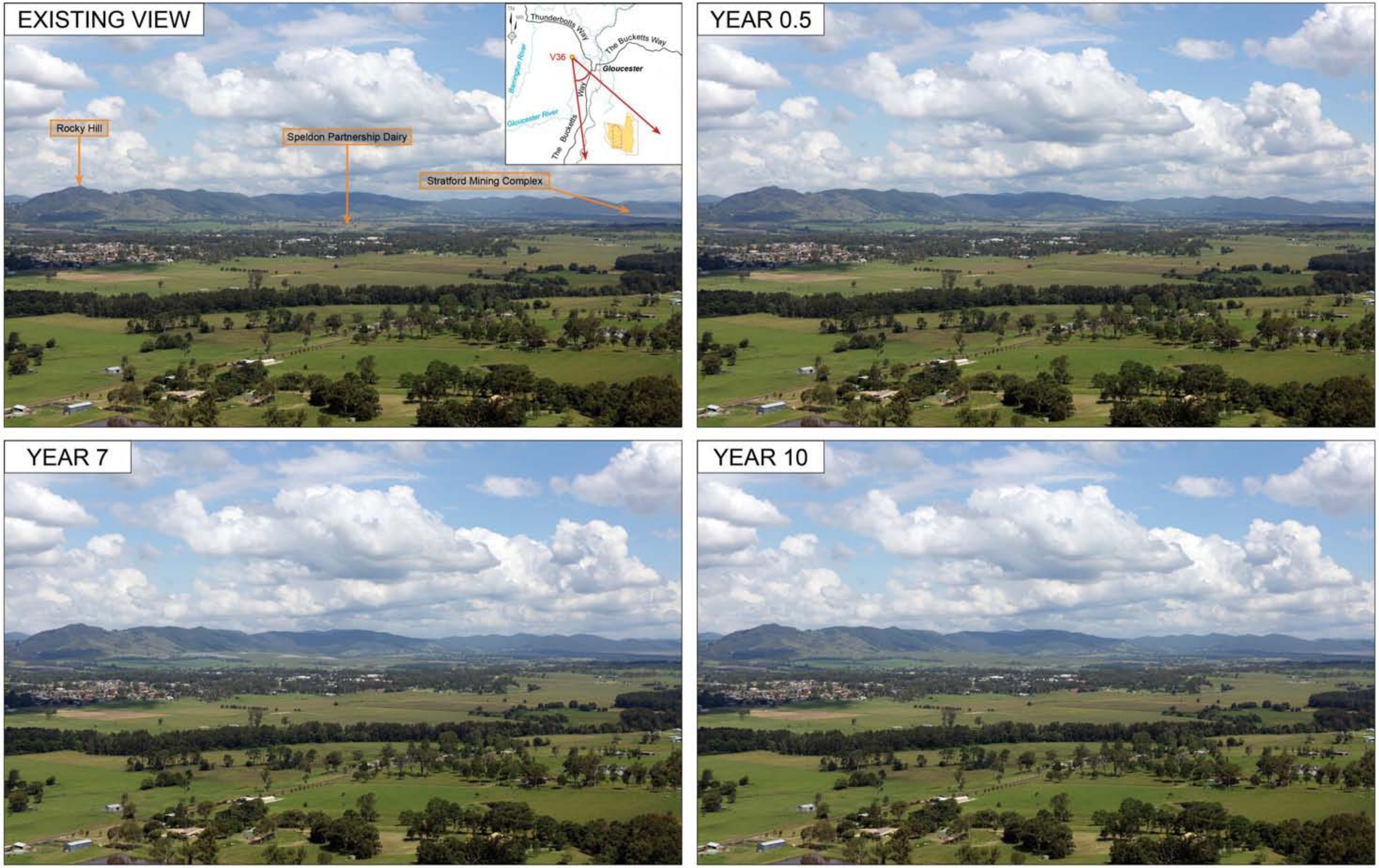


Photorealistic Photomontage 1 View from the Kia Ora Lookout – Viewing Location V33

Photorealistic Photomontage 1 View from the Kia Ora Lookout – Viewing Location V33

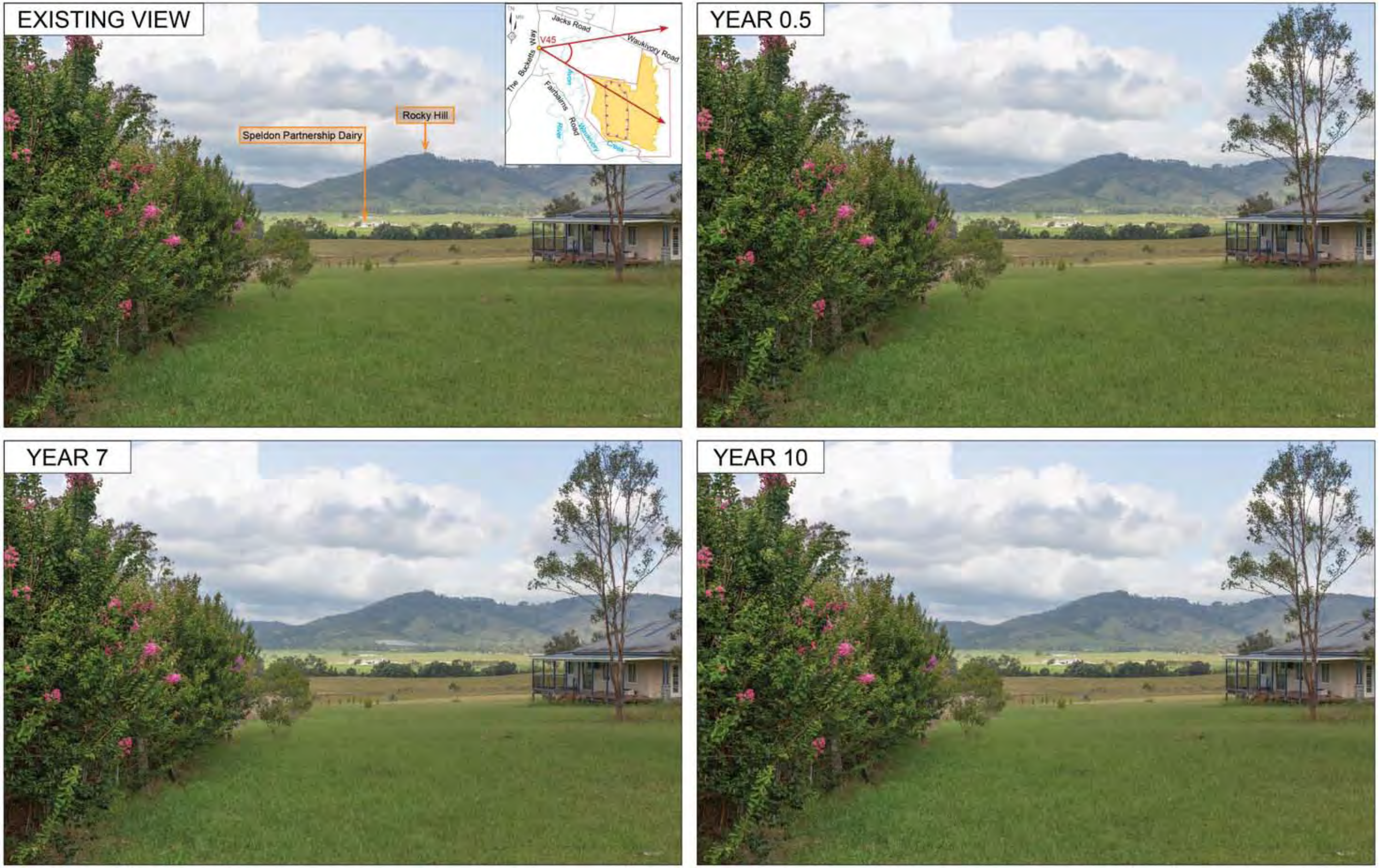


Photorealistic Photomontage 2 View from The Bucketts Walking Track – Viewing Location V36

Photorealistic Photomontage 2 View from The Bucketts Walking Track – Viewing Location V36

Photorealistic Photomontage 3 View from Jacks Road – Viewing Location V25

Photorealistic Photomontage 3 View from Jacks Road – Viewing Location V25



Photorealistic Photomontage 4 View from near 4434 The Bucketts Way – Viewing Location V45

Photorealistic Photomontage 4 View from near 4434 The Bucketts Way – Viewing Location V45

Photorealistic Photomontage 5 View from Grantham Road – Viewing Location V16

Photorealistic Photomontage 5 View from Grantham Road – Viewing Location V16

YEAR 7

YEAR 15

Photorealistic Photomontage 5 View from Grantham Road – Viewing Location V16

Photorealistic Photomontage 5 View from Grantham Road – Viewing Location V16

Photorealistic Photomontage 6 View from Opposite 4257 The Bucketts Way – Viewing Location V15

Photorealistic Photomontage 6 View from Opposite 4257 The Bucketts Way – Viewing Location V15

Photorealistic Photomontage 6 View from Opposite 4257 The Bucketts Way – Viewing Location V15

YEAR 10

FINAL

Photorealistic Photomontage 6 View from Opposite 4257 The Bucketts Way – Viewing Location V15

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RLA (2016a) undertook a review of the residences within the Category 2, 3 and 4 viewing situations to identify those residences with potential views towards the Mine Area. It was recognised that a number of residences have been constructed with their formal orientation towards the road with the most common orientation between the northwest and northeast, i.e. not towards the Mine Area. Local topography and vegetation was also recognised to restrict views from a number of residences towards the Mine Area. After taking into consideration formal orientation, topographic location and the blocking and screening effect of vegetation, RLA (2016a) concluded:

- six of the 31 residences within the Thunderbolt Estate would be likely to have possible views towards the Mine Area from their main living areas;
- four of the 20 residences within the Avon River Estate may have a view of some part of the Mine Area from main living areas;
- nine of the 33 residences on the eastern side of The Bucketts Way between Jacks Road and Forbesdale Estate appear to have potential for views of part of the Mine Area.
- 14 of the 27 residences within the Forbesdale Estate appear to possibly have views towards parts of the Mine Area.
- one of the two residences adjacent to Fairbairns Road appear likely or possibly to have a limited view towards the Mine Area.

RLA (2016a) qualified the number of residences with possible views given the assessment was determined through reference to high resolution aerial photographs, detailed topographic mapping and observations from the public road network. RLA (2016a) similarly acknowledged that some of the residences may have secondary orientations (other than from their main living area) which would provide viewing opportunities towards the Mine Area.

The visual effects when viewed from the Category 2 and 3 viewing situations relate mainly to the construction of the amenity barriers which, after they are constructed, would limit the visibility of the bulk of the overburden emplacement and on-site activities except when earthmoving equipment is operating at or near the surface of the overburden emplacements and are not effectively obscured by the barriers.

RLA (2016a) identifies that the relative elevation of the viewing locations would influence the view composition. As such, a number of the residences with possible views of the Mine Area (discussed above) are located at elevations above approximately 114m AHD. Clearly, the effectiveness of the western section of the western and northern amenity barrier with an upper elevation of 156m AHD would contribute substantially in limiting views of activities within the Mine Area from all residences, including those at higher elevations.

Overall, RLA (2016a) concludes there would be a range of visual effects created firstly by the construction of the western and northern amenity barrier during the first 2 to 3 years and the permanent overburden emplacement until about Year 7, albeit reduced by the considerable mitigation measures to be adopted. Beyond Year 8, there would be negligible activities visible from areas surrounding the Mine Area. In summary, RLA (2016a) concludes there would be:

- a low level of visual effects on Gloucester township;
- a low level of effect on the Kia Ora lookout;

- a low-moderate effect on the Bucketts walking track;
- a moderate level of initial visual effects for some view locations in the Thunderbolt and Avon River Estates i.e. for the first 2 to 3 years; and
- a moderate to high level of initial visual effects at some locations in the Forbesdale Estate with a high level of visual effects at some residences within Grantham Road, Forbesdale Close and Fairbairns Road between Grantham Road and the North Coast Railway Line crossing, particularly during the first 2 to 3 years.

The private haul road would be located at considerable distances from public viewing locations and for most of its length, the road (and trucks travelling on the road) would be hidden from view by topography and/or vegetation. RLA (2016a) notes that the private haul road corridor is located in an area with a high visual absorption capacity, the bulk of which would cause a low level of visual effects.

RLA (2016a) notes that excavated faces above parts of the southern and northern diversion channels may be visible from the rural-residential estates. However, given the variability of the topography they traverse and their higher elevation than most view locations, their visibility would also be variable. Over time, vegetation growth and the construction of the overburden emplacements would reduce the visibility of the channels.

The relocated 132kV power lines would be not be prominent on the western slopes of the Mograni Range, particularly give the considerable distance to viewing locations. Hence, their visual effects have been assessed by RLA (2016a) as moderate-low.

4.5.5.3 Visual Compatibility

The assessment of visual compatibility is intended to evaluate the extent to which changes to the visual landscape conform with, or acceptably fit into, the future visual character of the Site and its surroundings. Visual compatibility is not a measure of whether activities or components of the amended Project can be seen. Rather, it is an assessment considered over the total visual context.

Two issues relating to visual compatibility are relevant to the visual impacts assessment of the amended Project, namely physical and visual attributes, and cultural values.

Compatibility with Physical and Visual Attributes

RLA (2016a) considers that the location of the amended Project is compatible with retaining the physical and visual resources of the Gloucester Basin and the locality, and that the changes proposed are not of a significant scale when considered in comparison with either the physical and visual resources of the Basin or the locality. Objectively considered, the area to be disturbed in very small with respect to the area over which the same physical and visual attributes are distributed.

The amended Project would also be compatible with the scenic quality attributes of the setting, notwithstanding there would be some permanent changes to the landform and to the final appearance of the land use. The moderate to high scenic quality of the overall setting would not ultimately be significantly changed, although initial substantial short term localised changes to the horizontal field of some views would be evident, albeit that these would be progressively improved throughout the life of the amended Project. However, at the end of the operations, and after all areas of the final landform are revegetated, the Mine Area would be seen to be compatible with the overall physical and visual attributes of its setting.

With respect to Gloucester township, its predominant outlook is to the mountains to the west, north and east while its public domain open space is predominantly to the west and northwest. The Mine Area is not within this setting and the amended Project would not conflict with views from the township, particularly during the day.

Compatibility with Cultural Values

RLA (2016b) considers the more prominent scenic views within the cultural landscape as recognised by community groups such as BGSPA have all been appropriately considered in the assessment of impacts by acknowledging the scenic quality and sensitivity issue.

4.5.5.4 View Locations and Viewer Sensitivity

Sensitive view locations are public places that attract either large numbers of viewers for short periods, e.g. main roads or tourist routes, or any number of persons that experience views over a sustained period of viewing in places such as reserves, lookouts, walking tracks, etc. RLA (2016a) ranks the Category 1 viewing locations with a lower sensitivity than closer viewing locations principally because sensitivity decreases with viewing distance. The use of The Bucketts Way by motorists is assessed to have a high level of sensitivity, albeit that the duration of observation is likely to be short.

Viewer sensitivity from within private residences varies due to a wide range of factors. RLA (2016a) considers that moderate-high viewer sensitive locations are present within some private residences within the Forbesdale Estate.

4.5.5.5 After Dusk Impacts

With the adoption of the mitigation measures outlined in Section 4.5.4.4, the Applicant would effectively minimise the opportunity for direct lighting to be observed by residents in the vicinity of the Mine Area and motorists travelling along The Bucketts Way during the period from dusk to 10:00pm. Headlights of vehicles travelling on the public road network from the Mine Area would also be visible (as is currently the case, albeit at a lower intensity) and while travelling on the Mine Area access road, albeit screened by the retained vegetation along McKinleys Lane.

It is possible that under low cloud conditions, a night glow would be visible above the active open cut pit(s) arising from the use of mobile lighting towers and mobile equipment headlights.

It is also possible that the catchment in which the Mine Area is visible would be extended slightly during the evening during cloudy periods when a night glow is present above the operational area. However, the lighting within the Gloucester urban and industrial area would itself limit visibility of night glow from Gloucester and cause a similar glow to be visible under low cloud conditions from those residences in the rural-residential estates south of the Gloucester urban area.

4.5.5.6 Long-term Impacts

Emphasis needs to be placed upon the rehabilitated Mine Area given its long-term presence, i.e. far longer than the mine's operational life. The Applicant has placed considerable emphasis upon achieving an appearance for the final landform that relates closely to the underlying structures, drainage pattern and micro-topography of the existing landscape. The final land use and land cover is also intended to respond to the existing and typical adjacent patterns, albeit there is proposed to be a higher presence of rehabilitated land with an open woodland character than at present. This would be in line with natural regeneration that can be observed to be occurring along the side slopes in other analogous locations.

Those with a close familiarity with the Mine Area would recognise that the final landform would be different in overall levels and in micro-topography. However, this is a residual impact that would not be evident to the majority of viewers and would decrease with time. The landform comparison shown on **Figure 2.21** shows the similarity of the existing topography and the proposed final landform. Such an outcome would be an achievement consistent with best practice in the Australian coal mining industry.

4.5.5.7 Cumulative Impacts

In a cumulative sense, the amended Project would impact on a wider area than the Site as there would be short-term off-site road and bridge construction activities and increased light and heavy vehicle traffic levels on local roads. These activities, while noticeable, would not have any adverse impacts as they are activities already visible in the local area from time to time and the proposed levels would not be excessive. In any event, the activities would also be beneficial for the motorists using these roads.

The proposed re-located 132kV power line and new 11kV power line and the associated substation would be of a scale that is unlikely to contribute to any noticeable cumulative impacts.

The Stratford Mining Complex, located approximately 5km south of the Mine Area, lies within some common view catchments to the amended Project, i.e. from the Category 1 lookouts and a few locations along The Bucketts Way. However, for most of the viewing locations to the northwest and west of the Mine Area, the two mines would not be in the same view. Both mining operations would cause changes to topography and generate colour changes.

The amended Project would share the coal handling and processing plant and rail load-out facility at the Stratford Mining Complex and there would be no significant visual impacts arising from the transportation of coal product via the private haul road. No significant changes are proposed in these facilities in the approved Stratford Extension. The new pits in the Stratford Extension are predominantly of low external visibility and the overburden emplacements required are neither extensive nor in high sensitivity locations.

RLA (2016a) concludes that, on balance, while minor cumulative impacts would occur, given the comparatively short life span of the amended Project and that of the Stratford Extension Project, the cumulative impacts would not be significantly increased as a result of the combined presence of the Stratford Mining Complex and the Applicant's amended Project.

4.5.6 Conclusion

The visual impacts of the amended Project need to be considered in two time periods, namely throughout its operational life and beyond its life after all the disturbed land is rehabilitated.

The key strategy throughout the operational life of the amended Project for using landforms on the Mine Area to control visibility and to quickly and efficiently work towards achieving the final landform has been a central consideration of its design. Considerable emphasis has been placed upon designing the western and northern visibility barrier with variable slopes, elevations and vegetation densities and heights to assist in achieving a natural appearance to the barrier.

The northern and southern interim amenity barriers, present only in the first 8 years of the life of the operation, would also be visible to variable extents but largely screened by the western and northern amenity barrier. The interim overburden emplacement east of McKinleys Lane would be predominantly screened by vegetation within the road reserve which is up to 25m in height.

From an operational perspective, RLA (2016a) concludes the amended Project would have short term impacts on the existing character of the Mine Area particularly from some locations within the Forbesdale Estate (Viewing Situation Category 3 Area) during the construction of the western and northern amenity barrier. However, once the barrier is constructed and vegetated, there would be no significant visibility of the mining operations. Nor would the barrier itself contribute to adverse visual impacts principally because of its design features outlined in Section 4.5.4.3.

There would be no significant impacts arising from the transportation of sized ROM coal by the private haul road to the Stratford Mining Complex at any time throughout the life of the amended Project.

The final rehabilitated landform of the Mine Area would begin to be visible from approximately Year 3 to the southeast of the Main Pit above the southern interim amenity barrier. The visibility of the remainder of the operations would rapidly decline in all views by Year 8, with only minor changes visible thereafter until Year 16. The Mine Area would be progressively returned to agricultural use.

At the end of the mining operations, over a period of approximately 3 years, there would be occasional periods when earthmoving equipment would be visible while filling and re-contouring the remaining void within the former Main Pit, using material from the interim overburden emplacement and the western and northern amenity barrier. All buildings and other site infrastructure not required for post-mining land uses would be removed from site.

Given its permanent nature, RLA (2016a) places considerable weight on the long-term landform and concludes that the final landform is considered to be a satisfactory outcome of the use of the area for mining purposes, given the practical constraints that apply and the extensive resources of landscape of similar character in the Gloucester Basin generally. The final landform would be essentially indistinguishable from the surrounding landscape for other than those that are familiar with it, and would be compatible with its landform, land use and character. The comparatively small scale and short life span of the amended Project are also relevant considerations. The amended Project would not have a significant detrimental long-term impact on the overall resources of moderate-high quality scenery in the region.

4.6 GROUNDWATER

The groundwater assessment of the amended Project was undertaken by Australasian Groundwater & Environmental Consultants Pty Ltd (AGE). The full assessment is presented in Volume 3 Part 4 of the Specialist Consultant Studies Compendium and is referenced throughout this section as AGE (2016), with a summary of their assessment presented in the following subsections.

4.6.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to groundwater beneath and in the vicinity of the Mine Area and their risk rankings after the adoption of standard mitigation measures are as follows.

- Reduction in baseflow in the Avon River and Waukivory Creek and inflows between pits and alluvium and vice versa impacting on stream flow (medium).
- Discharge of poor quality groundwater from the post closure landform (low).
- Reduced water quantities within groundwater systems irrespective of saline quality (high).
- Impacts on groundwater (alluvial) biota (low).
- Reduced water quality within groundwater systems (low).
- Noticeable reductions in base flow regimes in the Avon River and Waukivory Creek, with impacts on downstream aquatic ecology and other users (low).

In addition, the Director-General's Requirements issued by the then DP&I (now DPE) identified "Groundwater" as one of the key issues requiring assessment. The principal requirements relating to groundwater included:

- detailed modelling of potential groundwater impacts, including any potential impacts on the alluvial aquifers of the Avon River and Waukivory Creek and confirmation of the physical extent of the associated alluvium;
- impacts on affected licensed water users and basic landholder rights;
- assessment of impacts of salinity from mining operations, including disposal and management of coal rejects and modified hydrogeology. A salinity budget and the evaluation of salt migration to surface and groundwater sources;
- identification of any licensing requirements or other approvals under the *Water Act* 1912 and/or *Water Management Act 2000;*
- demonstration that water required for the construction and operation of the Project can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);
- a description of the measures proposed to ensure the Project can operate in accordance with the requirements of the relevant WSP or water source embargo; and

- a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate groundwater impacts.

Additional matters relating to groundwater for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA, the former NSW Office of Water (NOW) now DPI-Water, the former Gloucester Shire Council, Division of Resources and Energy (DRE), NSW Health – Hunter New England Local Health District, Mid-Coast Water, Hunter-Central Rivers NSW Catchment Management Authority and the BGSPA. The additional matters identified in the additional correspondence are generally consistent with the DGRs.

It is noted that a number of the above requirements equally apply to the surface water assessment presented in Section 4.7.

4.6.2 Regional Groundwater Regime

Groundwater within the Gloucester area principally occurs within the Permian sedimentary rocks of the Gloucester Basin and the surrounding Carboniferous sedimentary rocks and volcanics of the New England Fold Belt. The two geological provinces display different hydrogeological characteristics with little interaction between the two. Groundwater also occurs within Quaternary alluvial sediments and colluvial deposits within both provinces.

4.6.3 Site Groundwater Regime

4.6.3.1 Introduction

Considerable data has been assembled by the Applicant, AGL and Gloucester Coal Ltd (now Yancoal Australia Limited) on the occurrence of groundwater in the northern section of the Gloucester Basin in the vicinity of the Mine Area. Some data is also publicly available from the NSW government registered groundwater bore network.

The network of groundwater monitoring bores within and in the vicinity of the Mine Area installed by the Applicant in 2011 and 2012 comprises 15 monitoring bores, each of which is fitted with a continuous water level recorder. The network has been designed to enable the collection of groundwater data from each lithology type within the Mine Area, namely the Permian coal seams and interburden, shallow weathered bedrock and associated colluvium, and shallow alluvium.

4.6.3.2 Groundwater Systems

Three distinct groundwater systems are present within and in the vicinity of the Mine Area, namely:

- Permian coal seams and interburden;
- shallow weathered bedrock (regolith) with associated colluvial deposits; and
- shallow alluvium associated with the floodplains of the Avon River and Waukivory Creek and their minor tributaries.

The systems are invariably related to the local geological setting as displayed in **Figure 4.35**.

Coal Seams and Overburden / Interburden

The coal seams are the main continuous water-bearing formations throughout the Gloucester Basin. The Permian strata are further categorised into the following two hydrogeological units.

- Hydrogeologically “tight” and hence very low yielding sandstone and lesser siltstone that comprise the majority of the Permian overburden/interburden.
- Low to moderately permeable coal seams which are the prime water-bearing formations within the Permian coal measures.

Within the Mine Area, the coal seams are recharged by direct rainfall in subcrop areas or via leakage from the regolith or overlying colluvial deposits. The pristine water table surface is a subdued reflection of the topography. Groundwater levels in higher elevated parts of the Mine Area vary from between approximately 5m and 10m below the surface, while closer to Waukivory Creek, groundwater levels in the coal seams can be less than 5m below the surface. Groundwater flow is to the west-southwest with potential for discharge to the alluvial system along the Avon River/Waukivory Creek system via the overburden.

The hydraulic parameters of the coal seams can vary over a number of orders of magnitude depending on the depth of burial of the seam and degree of jointing and cleat density. The hydraulic conductivity of the coal seams (and the interburden) decreases with depth principally due to the closure of permeable fractures and increasing lithostatic pressure at depth.

Measured hydraulic conductivity values for the coal seams near the surface vary from 0.002m/day to 0.15m/day with an average of 0.055m/day. These values gradually decrease with depth. Hydraulic conductivity values of 0.04m/day to 0.2m/day were measured in the overburden / interburden with an average value of 0.12m/day. The horizontal hydraulic conductivity of the interburden between the coal seams ranges from 5×10^{-3}m/day to 1×10^{-7}m/day which is typically an order of magnitude higher than the vertical hydraulic conductivity. Yields from the coal seams and interburden are typically <0.6L/s.

Regolith and Colluvium

Groundwater occurs in the weathered zone (regolith) and colluvial deposits in the Mine Area. These angular colluvial deposits typically occur at the base of the steep slopes on the eastern side of the Mine Area along the margin of the Gloucester Basin and also inter-finger with alluvial sediments near the southern side of the Mine Area.

The colluvial deposits, which are more permeable than the underlying coal seams, are recharged by rainfall and by runoff from the steep slopes and have been interpreted as an important recharge source of the underlying coal seams.

Groundwater flow within the regolith and colluvium is from the margins of the basin towards its centre, i.e. towards the Avon River and Waukivory Creek.

The one measured hydraulic conductivity value in colluvium was 0.08m/day.

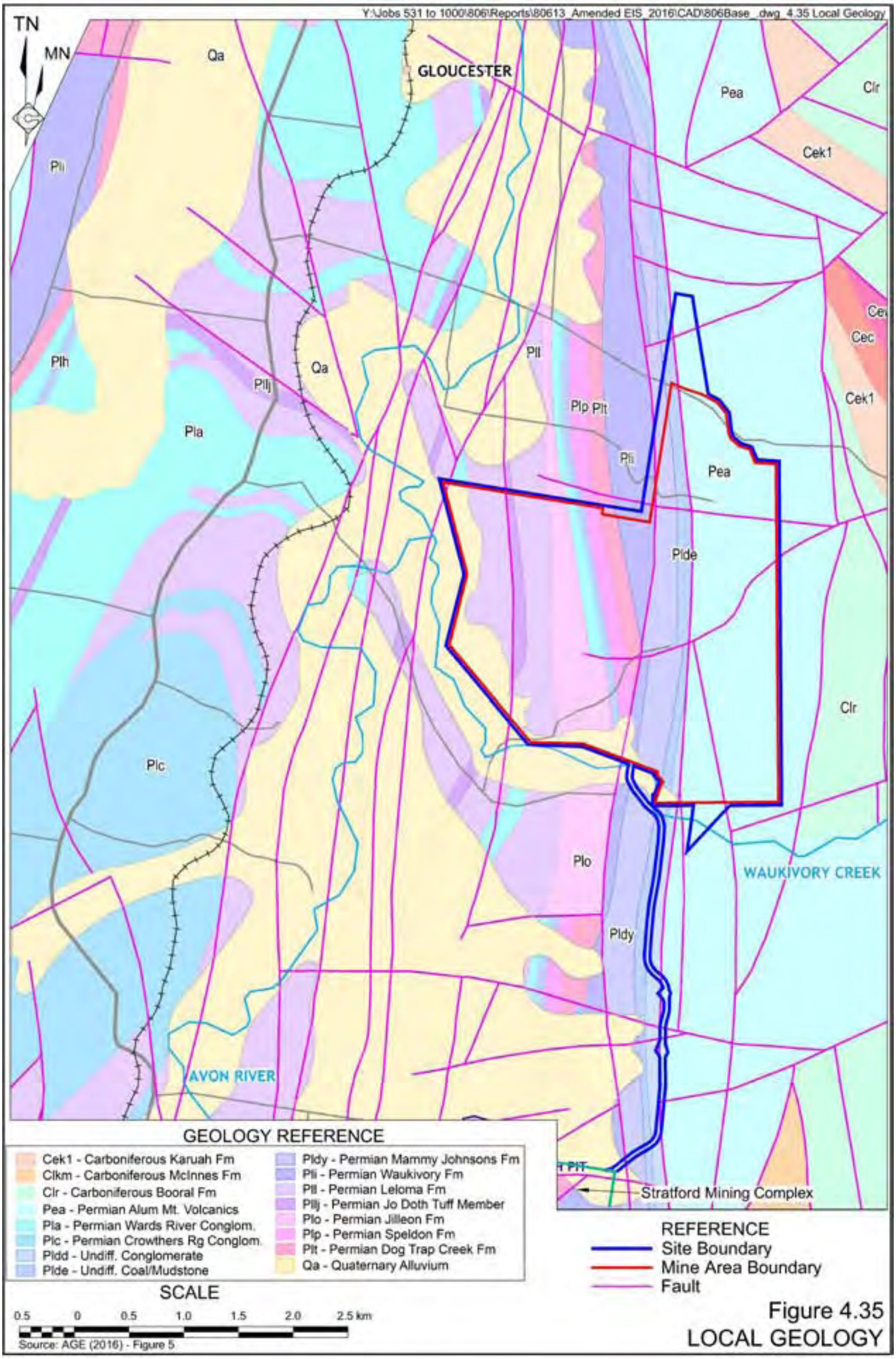


Figure 4.35
LOCAL GEOLOGY

Alluvium

An unconfined shallow groundwater system is associated with the alluvial floodplain deposits of the Avon River and Waukivory Creek and their minor tributaries (see **Figure 4.35**). The alluvial boundary is invariably delineated by changes in slope, with the boundary most evident adjacent to convex slopes and less evident adjacent to concave slopes (GSSE, 2011). The alluvial deposits comprise a sequence up to 12m of silty sands, gravelly sands and clays invariably sitting on a siltstone (Permian) basement. Adjacent to the Mine Area, the alluvium comprises 4.0m to 6.5m of mixed gravels overlain by 2m to 5m of clay and up to 1m of topsoil.

The majority of recharge to the shallow alluvial groundwater system occurring within and adjacent to the Mine Area is expected to be from direct infiltration of rainfall.

Groundwater within the alluvium is typically 0.5m to 4m below ground level i.e. a level generally consistent with the surface water level in the nearby watercourses. Locally, during normal to wet periods, groundwater in the alluvium discharges gradually into the Avon River and Waukivory Creek, however, this is reversed in dry periods when stream flow is likely to be a source of recharge to the shallow alluvial groundwater system.

The hydraulic conductivity of the alluvial sediments is comparatively high and varies from 27m/day to 392m/day adjacent to the Mine Area. The variations reflect the differing proportions of clay, silt, sand and gravel present. Yields of between 2L/s to 4L/s are typical.

The groundwater within the alluvium also receives a component of sub-surface recharge or flow from the Permian sediments as evidenced by saline groundwater at its margins and near the base of the alluvium (see Section 4.6.3.4).

4.6.3.3 Groundwater Levels and Gradient

Table 4.45 presents the groundwater level and hydraulic conductivity data recorded within the Mine Area and **Figure 4.36** displays both the indicative existing groundwater contours and the depth of the groundwater below natural ground level. The groundwater contours, and hence groundwater gradients, are effectively a subdued reflection of the natural topography. The existing groundwater table displays a general gradient to the west-southwest across the Mine Area with the depth to groundwater invariably less than 15m and often less than 5m.

4.6.3.4 Groundwater Quality

A total of 15 monitoring bores have been installed and screened in alluvium, interburden or coal seams within and in the vicinity of the Mine Area to allow collection of groundwater samples from the key hydrogeological units (see **Figure 4.37**). Up to 63 water samples have been collected from each bore and analysed on a minimum monthly basis since March 2011 for:

- pH and electrical conductivity (EC);
- Major ions (Ca, Mg, Na, K, Cl, SO_4, alkalinity, Si, F);
- Nutrients (NO_2, NO_3, Total P); and
- Trace elements (As, Cd, Cr, Cu, Pb, Mn, Zn, Fe).

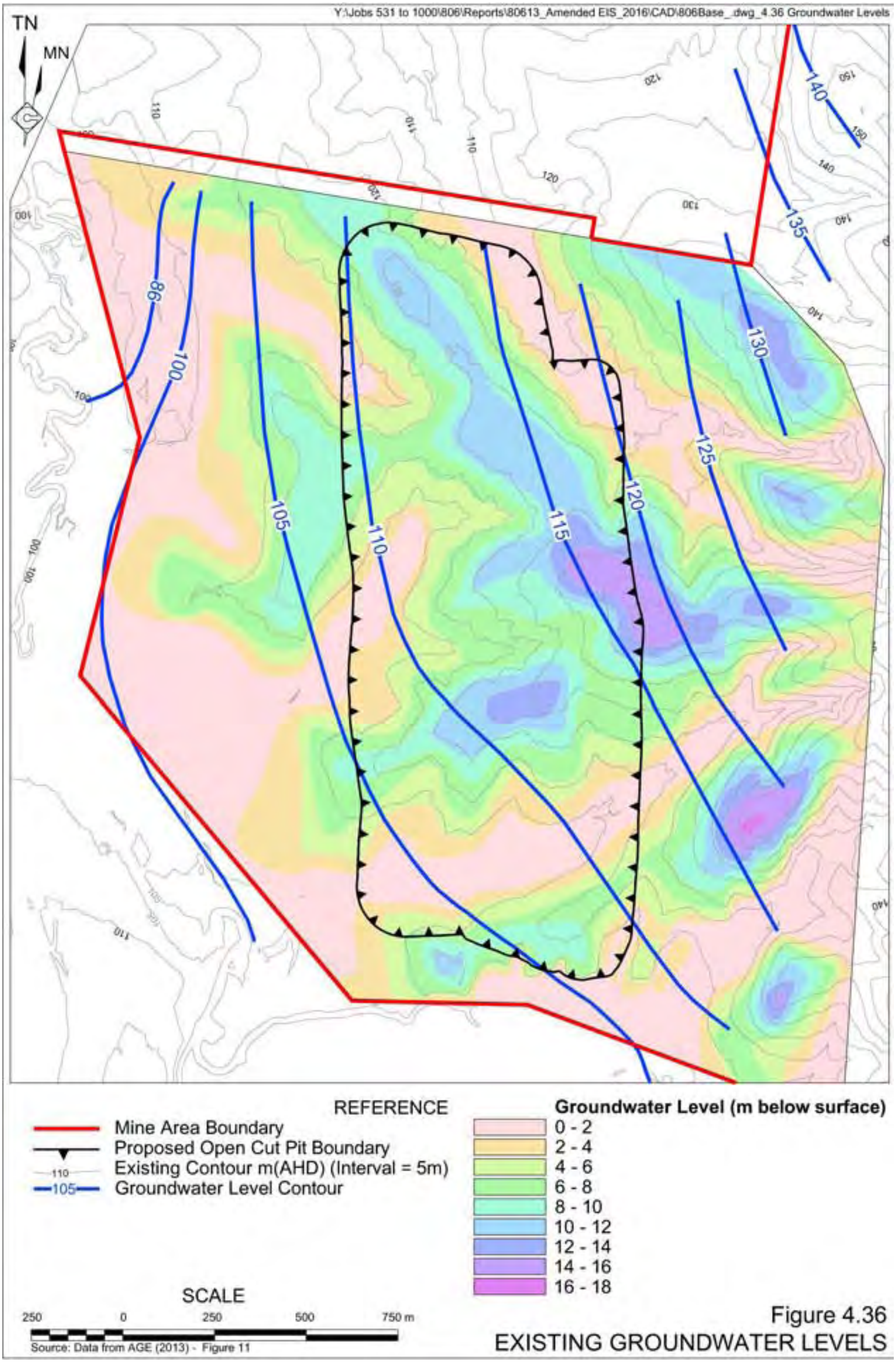


Figure 4.36
EXISTING GROUNDWATER LEVELS

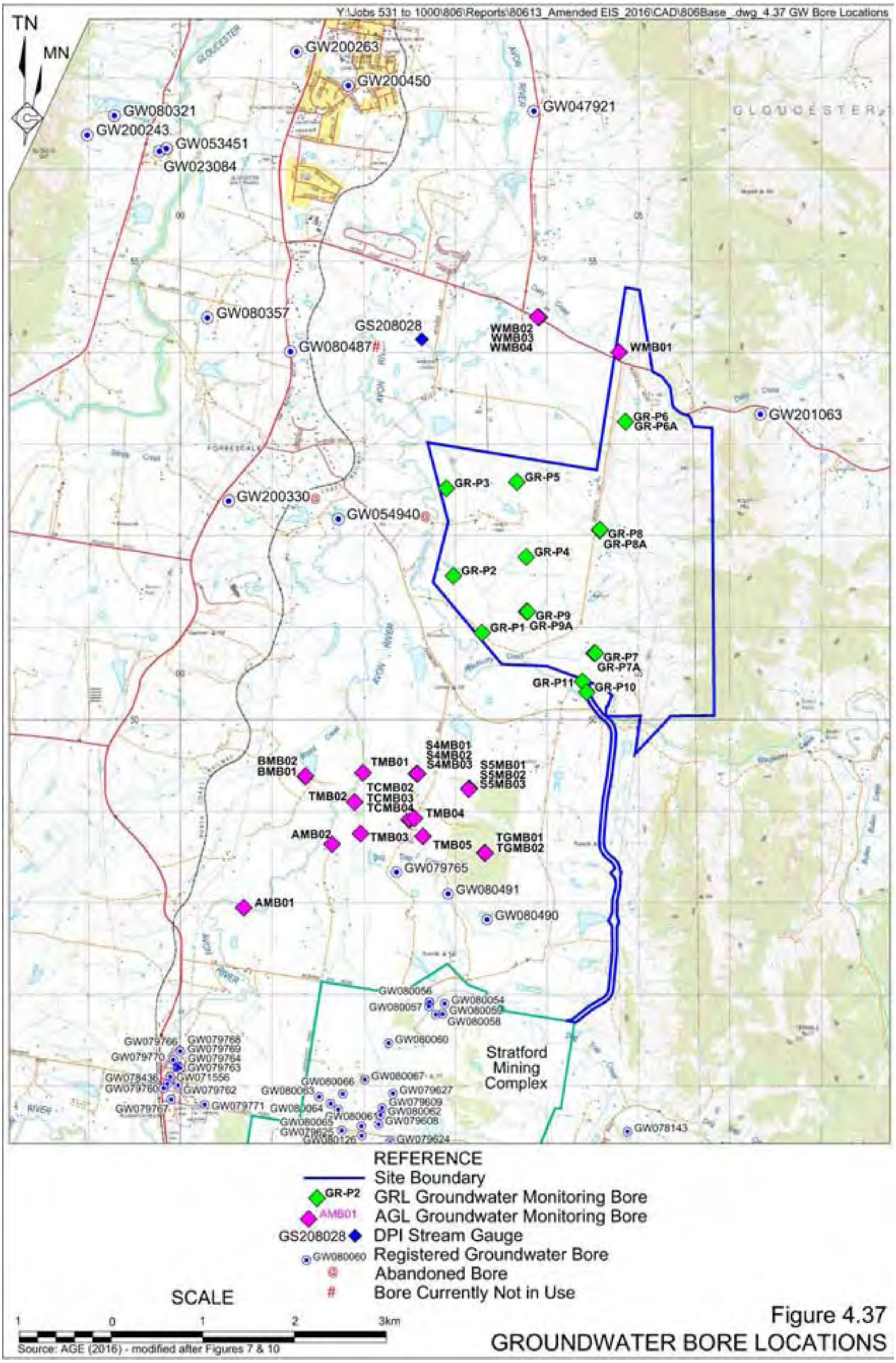


Figure 4.37
GROUNDWATER BORE LOCATIONS

Table 4.45
GRL Monitoring Bores – Groundwater Levels and Hydraulic Conductivity 2011 to 2016

Bore ID#	Elevation (mAHD)	Total Depth (mbGL)	Screen Interval (mbGL)	SWL 2011 (mbGL)	SWL 2011 (mAHD)	Hydraulic Conductivity (m/day)	Screened Lithology
GR-P1	104.37	10.2	5.5-8.5	4.40	100.55	50-150	Quaternary Alluvium
GR-P2	101.86	10	4-9	2.24	100.39	50-150	Quaternary Alluvium
GR-P3	99.57	11.2	5-9	2.95	97.32	50-150	Quaternary Alluvium
GR-P4	118.37	37	32.5-35.5	6.68	112.32	0.2	Interburden
GR-P5	126.39	30	24-30	14.44	112.64	0.05	Interburden
GR-P6	145.30	24	17-23	3.81	142.22	0.04	Interburden above Weismantel Seam
GR-P6A	145.33	97	89-95	10.43	135.58	0.06	Weismantel Seam
GR-P7	115.69	7.6	4-7	2.47	113.83	0.08	Colluvium
GR-P7A	115.52	72	59-71	1.41	114.72	0.002	Avon Seam
GR-P8	133.50	42	29-41	8.66	125.48	0.015	Weathered interburden above Avon Seam
GR-P8A	133.36	72	62-70	6.73	127.31	0.01	Avon Seam
GR-P9	117.19	34	24-33	10.44	107.42	0.2	Interburden above Cloverdale Seam
GR-P9A	116.97	66	59-65	9.71	107.98	0.15	Cloverdale Seam
GR-P10	109.88	10.2	5.5-8.5	4.8*	105.73*	126-392	Quaternary Alluvium
GR-P11	109.97	10.3	6.3-9.3	4.58*	105.96*	27-108	Quaternary Alluvium

Notes: mbGL – metres below ground level # - See **Figure 4.37** * - SWL when constructed in 2012
Source: AGE (2016) – Table 8

The results of the analyses for each monitoring bore are summarised in **Table 4.46**. The groundwater monitoring network and the data collected to date is considered by AGE to be adequate and suitable to enable a description of the existing groundwater environment.

Table 4.46
GRL Monitoring Bores - Groundwater Quality 2011 to 2016

Bore ID	Elevation (mAHD)	Total Depth (mbGL)	EC (µS/cm)	pH	Redox (mV)	DO (mg/L)	Screened Lithology
GR-P1	104.37	10.2	4320-6450	5.81-7.53	-144-+210	0.46-6.29	Quaternary Alluvium
GR-P2	101.86	10	704-1885	5.57-7.57	-97-+213	0.40-4.9	Quaternary Alluvium
GR-P3	99.57	11.2	3110-4640	5.35-7.14	-112-+212	0.37-6.7	Quaternary Alluvium
GR-P4	118.37	37	3830-7480	4.37-6.93	-93-+114	0.22-5.4	Interburden
GR-P5	126.39	30	2380-4400	4.8-6.97	-155-+124	0.56-6.4	Interburden
GR-P6	145.3	24	2470-3340	5.06-7.79	-139-+389	0.33-7.0	Interburden above Weismantel Seam+
GR-P6A	145.33	97	2800-5230	6.79-11.88	-212-+143	0.34-6.1	Weismantel Seam+
GR-P7	115.69	7.6	994-1357	6.05-7.93	-124-+142	0.37-7.0	Colluvium
GR-P7A	115.52	72	2740-3900	6.2-7.32	-211-+144	0.47-6.6	Avon Seam
GR-P8	133.5	42	2840-5700	4.0-7.77	-150-+854	0.38-7.4	Regolith above Avon Seam
GR-P8A	133.36	72	4270-6550	6.02-7.66	-151-+913	0.43-141	Avon Seam
GR-P9	117.19	34	4170-6840	5.32-7.69	-218-+174	0.35-204	Interburden above Cloverdale Seam
GR-P9A	116.97	66	2900-6400	5.42-7.65	-297-+134	0.41-6.29	Cloverdale Seam
GR-P10	109.88	10.2	330-990	6.19-8.02	-161-+786	0.4-7.0	Quaternary Alluvium
GR-P11	109.97	10.3	1140-1882	6.20-7.85	-116-+592	1.21-6.2	Quaternary Alluvium

Notes: mbGL – metres below ground level DO – Dissolved Oxygen + - No longer to be extracted
Source: AGE (2016) – Table 9

Coal Seams and Overburden / Interburden

Groundwater within both the coal seams and overburden / interburden within and in the vicinity of the Mine Area is invariably brackish with electrical conductivity values varying from 2 470 to 6 550µS/cm and 2 450 to 7 480µS/cm respectively.

The pH values in the groundwater within the Permian strata typically vary between 5.0 and 7.8. The groundwater in the Permian strata is classified as a sodium chloride type.

Regolith and Colluvium

Groundwater in the regolith is a sodium/chloride-bicarbonate water type with pH values between approximately 4.0 and 7.8 and electrical conductivity levels of between 2 840 and 5 700µS/cm reflecting the fact the groundwater in the regolith also receives upward leakage of much higher salinity groundwater from the Permian strata.

Groundwater in colluvium is a sodium chloride water type with pH values between and approximately 6.0 and 8.0 and electrical conductivity levels of less than 1 500µS/cm reflecting its recharge by direct rainfall infiltration.

Alluvium

Groundwater quality in the alluvium is variable from fresh to moderately saline, with electrical conductivity values ranging from 330 to 6 450µS/cm. This substantial range indicates that the alluvium receives recharge not only from direct rainfall but also from higher salinity sub-surface groundwater inflows from the nearby and/or underlying Permian strata. Profiling of the water column has identified higher salinity levels near the base of the alluvium indicating the Permian groundwater has infiltrated the alluvium near its base.

The pH values in the groundwater within the alluvium vary from 5.35 to 8.02. The groundwater in the alluvium is classified as a sodium chloride type.

4.6.3.5 Registered Bores and Groundwater Usage

A search of the NSW Natural Resource Atlas indicates that nine registered private groundwater bores are located within 3km of the Mine Area boundary, all of which are <80m in depth and with standing water levels of 14m and 17m of the ground surface recorded in two of the bores. **Figure 4.37** displays the locations of the registered bores and **Table 4.47** provides a summary of available data relating to the nine closest bores. The closest private bore (GW201063) is located approximately 0.6km to the east of the Mine Area but approximately 2.2km from the closest proposed mining. The next closest bore to the Mine Area is GW054940 which is approximately 1km west of the Mine Area boundary and approximately 1.8km from the closest proposed mining. The NSW Natural Resource Atlas reports that bores GW054940 and GW200330 have been abandoned and destroyed. Bore GW080487, located approximately 2.5km northwest of the closest proposed mining, though usable, is not currently in use.

Table 4.47
Registered Private Groundwater Bores within 3km of the Mine Area Boundary*

Work No.	Easting (m)	Northing (m)	Type	Status	Date Drilled	Total Depth (mbgl)	SWL (mbgl)	Salinity (ppm)	Yield (L/s)
GW047921	403861	6456639	Bore	Collapsed Bore	Dec 1980	65	-	501-1000	-
GW054940	401727	6452184	Excavation	Abandoned & Destroyed	Feb 1981	4	-	-	-
GW079765	402361	6448334	Well	Private bore monitored by Stratford Mine	Oct 1998	-	-	-	-
GW080357	400296	6454380	Bore	Active	Mar 2002	40.5	14	820	0.25
GW080487	401204	6454014	Bore	Active	May 2004	60	17	-	0.1
GW080490	403349	6447816	Bore	Unknown	Oct 2003	-	-	-	-
GW080491	402924	6448098	Bore	Unknown	Oct 2003	-	-	-	-
GW200330	400528	6452381	Bore	Abandoned & Destroyed	Dec 2006	50	-	-	-
GW201063	406373	6453263	Bore	Active	Apr 2004	78	-	3500	0.05

Note: Coordinates are in MGA94, Zone 56
mbgl – metres below ground level
SWL – standing water level
Units for salinity and yield are assumed
*excludes monitoring bores within the Mine Area.

Source: AGE (2016) – Extract from Table 6

4.6.3.6 Groundwater Dependent Ecosystems

The Commonwealth Government's Bioregional Assessment Program (Commonwealth Government, May 2014) assessed the Gloucester Basin as the Gloucester Subregion. An assessment of potential groundwater dependent ecosystems, undertaken in conjunction with OEH, concluded that no groundwater dependent ecosystems are located in the Gloucester Subregion.

Notwithstanding the broad nature of the bioregional assessment, two ecosystems are considered dependent upon groundwater within and in the vicinity of the Mine Area, based upon site specific studies undertaken by Biosis (2016) (Terrestrial Ecology) and Cardno Ecology Lab (Aquatic Ecology). These two studies have identified the presence of riparian vegetation adjacent to the Avon River and Waukivory Creek, and stygofauna within the alluvial groundwater system.

The riparian vegetation comprises mainly a River Oak/Cabbage Gum/Broad-leaved Apple Riparian Forest, the details of which are provided in Section 4.12.3.2.

Stygofauna, i.e. specialised macroinvertebrates that have adapted to living in groundwater habitats, are present in small numbers in some of the groundwater bores located in the alluvium, the details of which are provided in Section 4.13.3.8.

4.6.4 Potential Groundwater Impacts

Potential groundwater impacts arising from the amended Project relate to the following.

i) The inflow of groundwater from the alluvium into the open cut pits, thereby reducing the available groundwater recharge to, and baseflow within the Avon River and Waukivory Creek.

ii) The inflow of saline groundwater from the Permian coal seams and interburden into the open cut pits as a result of extraction below the regional groundwater table, and its subsequent management.

iii) The drawdown of the existing groundwater table causing a reduction in availability of groundwater for holders of existing registered groundwater bores in the vicinity of the Mine Area.

iv) The period for the groundwater table to recover to its post-mining stable level after the cessation of coal extraction.

v) The long-term inflow of saline water to the groundwater in the alluvium from the re-established regional groundwater table.

vi) The reduction in groundwater salinity as a result of the removal of an average of 2 520 tonnes of solid salt per year.

vii) Irrigation of treated sewage that does not meet nominated quality standards.

Each of the potential impacts in i) to v) above has been addressed through the use of the predictive modelling conducted by AGE (2016) – see Section 4.6.5.

4.6.5 Groundwater Modelling

AGE (2016) developed a finite difference numerical model from the conceptualisation of the groundwater flow regime using the MODHMS software package. The model consisted of 10 layers, the upper layer representing the alluvium, colluvium and weathered bedrock (regolith) and the bottom (base of model layer), representing the underlying Alum Mountain Volcanics (see **Figure 2.3**). The intermediate layers represent the Permian coal measures, these being the major coal seams separated by interburden. The hydraulic conductivity of the coal seams was reduced continuously with depth to account for the effect of increasing confining stress and the model was calibrated by adjusting the hydraulic conductivity to reflect the geological / hydrogeological variables relevant to the Mine Area.

The modelling software allowed for the coupled groundwater and surface water interaction to be developed and calibrated. The transient calibration provided a reliable match between observed and modelled data which, in turn, provided confidence in the predictive capacity of the model.

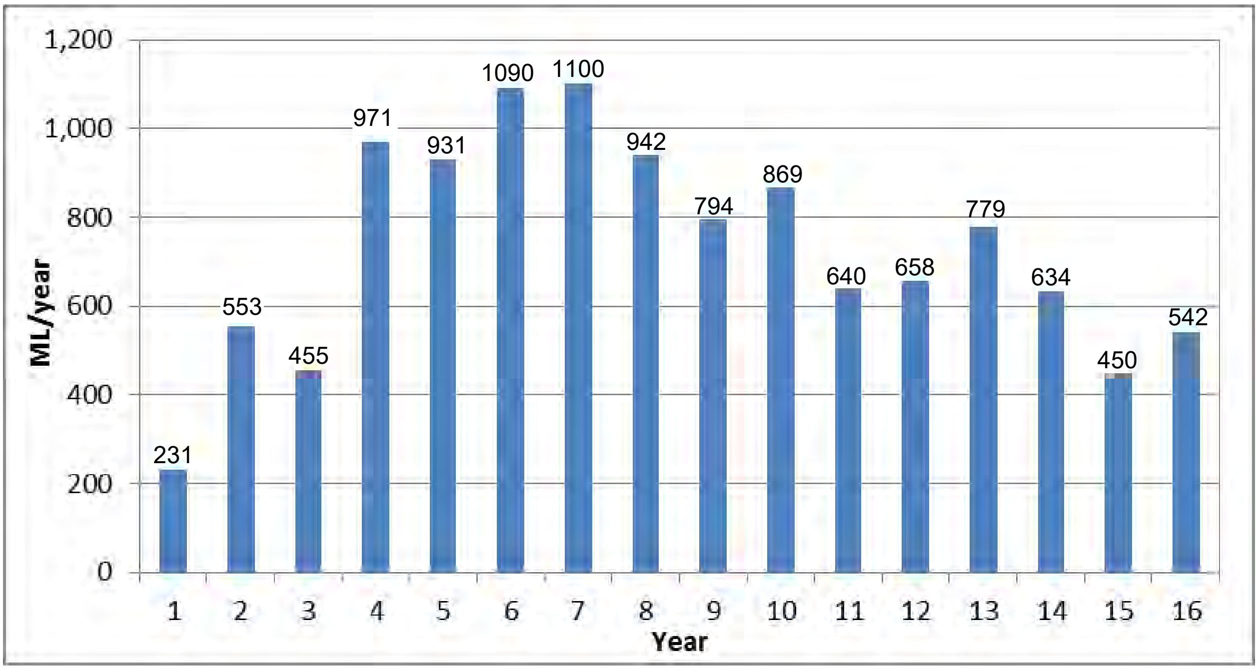
In order to assess the potential cumulative impacts within the northern section of the Gloucester Basin, the numerical model also included the areas of mining operations at the Stratford Mining Complex that commenced in 1995, as well as the proposed extended and new pits approved as part of the Stratford Extension Project in the predictive simulations.

AGE (2016) conducted both a sensitivity analysis and transient calibration on the model to confirm that the model inputs and assumptions were appropriate and that the model was robust. The conceptual model, numerical model and the inputs/assumptions adopted for the amended Project were peer reviewed by Dr Frans Kalf, an experienced hydrogeological and numerical modelling specialist.

The groundwater data collected between 2011 and 2016 and summarised in Sections 4.6.3.3 and 4.6.3.4 is considered by AGE to be adequate and suitable for the assessment and description of the existing environment and for the required impact assessment. This conclusion is also supported by Dr Kalf in his peer review of the groundwater assessment. The data has enabled the numerical model to be calibrated to a transient dataset that is representative of baseline conditions. This transient calibration took into account the various recharge conditions that occur to the groundwater and surface water systems and allowed for surface water and groundwater interactions to be simulated.

The groundwater model predicted the following impacts to the groundwater systems arising from the amended Project. It is noteworthy, however, that given the use of quarterly increments into the model throughout the life of the amended Project, the actual rate of inflow would not be expected to peak at the values predicted by the model simulation.

i) During the scheduled 16 year mining period, the cumulative rate of inflow to the three contiguous open cut pit voids would be on average 727ML/yr. This would vary throughout the mining period with a predicted peak of 1 100ML/yr in about Year 7. **Figure 4.38** graphically displays the simulated annual inflow volumes for each of the mining years.



Source: AGE (2016) – Figure 58

Figure 4.38
Simulated Annual Inflows

A proportion of groundwater that seeps into the open cut pits would be either evaporated from the active faces within the coal and/or interburden / overburden (likely to be up to 10% of total inflow), or removed as moisture with the coal and interburden / overburden during mining (reported to be 5-7% moisture content for ROM coal or approximately 11% of total inflow). As the coal seams within the Mine Area dip steeply, there will be a larger surface area of coal in the pit exposed to more direct sunlight compared with mines in the Hunter Valley. This larger surface area is likely to result in greater evaporation of water not only from the exposed coal faces but also from the interburden and overburden material in the open pits. It is considered that the predicted inflows to the mine, and water to be managed within each pit, is likely to reduce by up to 20% after taking these factors into account. This factor has been incorporated into the overall water balance for the amended Project.

ii) The zone of groundwater drawdown in the coal seams attributable to the amended Project would expand to the south, north and west of the open cut pits, but would be restricted to the east by outcropping coal measures and the edge of the Gloucester Basin.

iii) The model predicts that once mining commences, there would be a net reduction in flow from the Permian strata to the alluvium of 0.02ML/day to a maximum of 0.53ML/day. The peak loss would occur for a short period in Year 11 of operations which would then reduce to 0.26ML/day by Year 16. This reduction in flow would arise due to changes in vertical gradients between the alluvium and Permian strata. The drawdown in groundwater levels within the open cut pits would effectively cause the existing flow (of saline groundwater) from the Permian strata to the alluvium to slow down with a flow reversal (from the alluvium to the open cut pits) adjacent to the open cut pits during Years 8 to 13. It is noted, the majority of the net reduction in flow from the Permian strata would not flow directly to the open cut pits, but simply remain in the underlying Permian bedrock and therefore not be lost from the regional groundwater system. As such, there would be little impact on base flows within the Avon River. AGE (2016) calculated that the average daily reduction in groundwater flow to the alluvium would amount to less than 2.6% for the median base flow component of the Avon River. When coal extraction ceases, the Permian strata would gradually re-pressurise and the flow rates from the Permian strata to the overlying alluvium would increase and return to the pre-mining rates over time.

iv) Groundwater levels would recover to within 95% of the pre-mine groundwater levels within 5 years of the cessation of coal extraction. The remaining recovery is predicted to take a further 5 years to stabilise, i.e. 10 years after coal extraction ceases.

The predicted post closure groundwater levels are predicted to be slightly lower than the existing groundwater levels. This lower post closure water table results from the higher hydraulic conductivity applied to the overburden emplacement areas.

The process of mining and progressively backfilling the pits with overburden and minor quantities of breaker rejects is likely to result in the re-establishment of groundwater flow conditions similar to those observed pre-mining.

The recovering groundwater would mix with the replaced overburden and breaker rejects and result in the partial dissolving of mineral matter within the backfilled pits. This solute, mobilised by the infiltration of enhanced recharge in the backfilled overburden, would result in leachate within the backfilled open cut pits. Kinetic testing undertaken by RGS (2016) demonstrates that this leachate is likely to comprise a mix of relatively fresh groundwater (<300µS/cm from the overburden / interburden samples) and possibly brackish groundwater from the breaker rejects). However, given the proportion of breaker rejects is less than 1% of the backfilled overburden emplaced in the pits, it is likely that the electrical conductivity of this leachate will be more representative of the kinetic test results of the overburden / interburden samples (i.e. 300µS/cm) and is likely to have a lower electrical conductivity level compared with the baseline groundwater in the Permian strata.

4.6.6 Management, Mitigation and Contingency Measures

4.6.6.1 Management Measures

The key measures the Applicant would adopt in the management of the groundwater resources within the Mine Area would focus upon the collection of data recording the status of groundwater levels and chemistry, and the quantity and quality of inflows to the open cut pits. This information would assist in planning the storage/placement of saline water within the saline water zone within the Mine Area (see Section 4.7.4.4) and its management.

The bulk of this information would be gained from the groundwater monitoring program discussed in Section 4.6.9, together with records of volumes of water pumped from the sumps within the active open cut pits and related water data.

It is currently predicted that the Applicant's entitlement to extract groundwater from the alluvium and surface water from the Avon River and Waukivory Creek under the water access licences (for 267ML) it holds exceeds the likely maximum inflow (see Section 4.6.5). The Applicant would review the monitoring data once operations are well underway and consider the transfer/sale of surplus entitlements to other parties. The decision to proceed with a transfer/sale would depend upon the need for water for the ongoing and expanded agricultural activities on the Applicant's landholdings.

Section 3.2.3.3 presents details of the Water Sharing Plan (WSP) for the North Coast Fractured and Porous Rock Groundwater Sources which came into effect on 1 July 2016. Water access licences and entitlements will be required under the *Water Management Act 2000* to account for the inflows of water from the Permian strata into the open cut pits.

Based upon the contents of the WSP and the report card for the Gloucester Basin Groundwater Resource (DPI-Water, 2016), there is no unassigned water that could be licenced. Rather, the Applicant would need to acquire (through purchase or trade) water access licences from those licence holders who have had their water access licences under the *Water Act 1912* converted to licences under the *Water Management Act 2000*.

The Applicant has investigated the availability of water access licences to purchase or trade to account for the predicted inflows into the Mine Area. In doing so, the Applicant has established that both AGL and Yancoal hold licence entitlements in excess of their requirements (see Section 4.6.8). Hence, the Applicant proposes to acquire the required licences progressively:

- in line with the predicted inflows outlined in **Figure 4.38**; or
- reflecting the actual inflows and groundwater levels determined through monitoring and, if warranted, refinement of the groundwater model.

This latter provision is nominated given the recognition that the groundwater inflows predicted by AGE (2016) are conservative and that the opportunity would exist to monitor inflows and groundwater levels so that the number of units for the water access licences acquired match the actual inflows.

4.6.6.2 Mitigation Measures

Few measures are available to the Applicant to mitigate the inflow of groundwater into the open cut pits. AGE (2016) explains that there would be little benefit in constructing a grout curtain between the alluvium and the southern ends of the Avon, Bowen Road or Main Pits as these structures would reduce inflows by the order of only 0.1ML/day. This 0.1ML/day reduction inflow from the alluvium is considered insignificant when compared to the long-term base flow component of the Avon River (10.2ML/day) and represents less than 1% of base flow in the downstream surface water system.

The Applicant would ensure that the sewage management system installed adjacent to the site offices is appropriately designed, operated and monitored to enable the required treated water standard to be achieved, and thereby not contaminate the groundwater resource beneath the Mine Area.

4.6.6.3 Contingency Measures

The need for contingency measures would be assessed in the event the monitoring data determines that either inflows or groundwater chemistry deviates substantially from the conservative modelled predictions. Relevant groundwater level and chemistry trigger values would be documented in the Water Management Plan prepared prior to the commencement of mining. Any observed exceedance of those trigger values would be investigated and a formal response developed if results from three consecutive sampling events show a consistent exceedance of the trigger levels.

Annual assessments would be carried out to identify monitoring data trends and/or departures, all of which would indicate the need for more intensive monitoring or to invoke impact re-assessment and/or mitigation measures.

4.6.7 Assessment of Impacts

4.6.7.1 Streamflow

The change in flows within the Avon River and Waukivory Creek would not be measurable as the groundwater base flow to surface water systems in the Gloucester Basin is a very small percentage of the contribution to the regional water balance. Hence, the potential impacts are assessed as acceptable.

4.6.7.2 Water Quality Impacts

The increased recharge component to the backfilled overburden would yield better quality water due to the increased component of fresh (low salinity) rainfall mixing with the predicted solute concentrations determined from the kinetic leach testing. As a result of these processes, the post-mining groundwater quality that discharges from the Permian strata to the Quaternary alluvium is likely to be slightly improved.

AGE (2016) also considered the potential for the breaker reject co-disposed with the overburden in either the out-of-pit overburden emplacements or as backfill in the open cut pits to contribute to a variation in groundwater quality. Given that the quantity of breaker rejects would amount to approximately 0.7% by weight of the quantity of overburden, AGE (2016) concludes the breaker rejects would not impact upon groundwater quality, i.e. result in changes to salinity.

4.6.7.3 Groundwater Users

The numerical modelling predicts that there is unlikely to be any measurable drawdown in the surrounding groundwater bores as a result of the amended Project. No private groundwater users are expected to be impacted by the mining operations.

4.6.7.4 Groundwater Dependent Ecosystems

A groundwater dependent ecosystem comprising River Oaks, Cabbage Gum and Broad-leaved Apple has been identified along the riparian zone of the Avon River and Waukivory Creek. The groundwater modelling indicates that groundwater level drawdown in the Quaternary alluvium is unlikely. As a result, it is not expected that there would be any reduced availability to the shallow groundwater system or impact to any groundwater dependent ecosystem adjacent to these watercourses.

CEL (2016) has assessed that the amended Project would result in negligible impacts to stygofauna (see Section 4.13.6.4).

4.6.7.5 Cumulative Impacts

AGE (2016) reviewed the predicted groundwater drawdown levels for the proposed Stratford Extension Project and established that there would be no cumulative groundwater impact between the Stratford Extension Project and the amended Rocky Hill Coal Project. The predicted drawdown from both sites would not overlap.

4.6.7.6 Compliance with the NSW Aquifer Interference Policy

The Aquifer Interference Policy nominates that for highly and less productive groundwater sources, the maximum permissible drawdown in bores of existing users should be 2m. The Policy also refers to changes in water table and pressure head declines as a result aquifer interference activities. AGE (2016) concludes that the amended Project adequately addresses these minimal impact considerations outlined in the Policy and provides sufficient hydrogeological information for the amended Project to be assessed against these criteria.

Details of how the groundwater assessment complies with the Aquifer Interference Policy is provided in Table 3 in Section 4.4.4 of AGE (2016) and referred sections. The manner in which the amended Project satisfies the three key components of the Policy's minimal impact considerations for aquifer interference activities (i.e. water table, water pressure and water quality) is as follows. The bulk of the groundwater to be intersected lies within less productive groundwater sources nominated in the Policy as "Porous and Fractured Rock Water Sources" and therefore the amended Project has been assessed against the minimal impact considerations for this groundwater source. In addition, the amended Project will have some interactions with the Quaternary Alluvium and it has therefore also been assessed against the minimal impact considerations for "highly productive – alluvial groundwater sources".

Water Table

AGE (2016) concludes that the groundwater modelling established "there will unlikely be drawdown in the Quaternary Alluvium", thereby not reducing the availability of water to the shallow groundwater system on which the riparian vegetation adjacent to Waukivory Creek is periodically reliant.

There are no high quality culturally significant sites within or nearby the proposed area of disturbance (ASR, 2016).

Throughout the life of the amended Project, groundwater levels would be lowered by varying amounts although AGE (2016) predicts the groundwater level would almost recover to pre-mine levels within 10 years, i.e. to levels marginally lower than pre-mining levels. Importantly, the predicted groundwater level drawdown would not cause any reduction >2m in the nine registered groundwater bores within 3km of the Mine Area. AGE (2016) predicts there would be no drawdown or impact at any of these bores as a result of the amended Project.

Water Pressure

As stated above, it is predicted that there would be no drawdown or impact at any registered groundwater bore as a result of the amended Project. Hence, it is not expected that groundwater levels at any water supply work would be adversely affected.

Water Quality

The detailed study by AGE (2016) has established that groundwater quality, particularly that which is likely to ultimately discharge (in small quantities) to the Quaternary Alluvium, would be comparable or slightly improved, i.e. exhibit slightly lower than existing salinity levels.

A small section of the Main Pit will encroach within 200m of the high bank of Waukivory Creek, however, the water level and quality change as a result of this are assessed to be minimal with no adverse impact predicted.

4.6.7.7 Compliance with Groundwater Quality Protection Policy

The assessment undertaken by AGE (2016) has established that each of the management principles within the Groundwater Quality Protection Policy are appropriately satisfied by the amended Project. The manner in which the amended Project satisfies the objectives of the Policy is presented in Sections 11 and 13 of AGE (2016).

4.6.8 Legislative Issues and Licensing

The Applicant's interception of groundwater occurrences within the Mine Area would require licensing under the *Water Management* (WM) *Act 2000*.

Water Management Act 2000

The WM Act requires that all extraction of surface water required for the amended Project from the Avon River or Waukivory Creek and alluvial groundwater inadvertently taken must be properly accounted for under the rules of the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources*. The Applicant already holds water access licences under the WM Act for 267ML, an amount in excess of the predicted average inflows of 100ML/yr or maximum inflow of 193ML/yr (in Year 11), i.e. the reduction in the quantity of Permian groundwater that would enter the alluvial aquifer when mining proceeds. Hence, no further licences are required under this WSP.

The *Water Sharing Plan* (WSP) *for the North Coast Fractured and Porous Rock Groundwater Sources* came into effect on 1 July 2016. As a consequence, the Applicant will need to acquire sufficient water access licences to account for the predicted take of groundwater from the Permian water source.

The need to acquire the water access licences through trading/purchase arises from the report card for the Gloucester Basin Groundwater Source (DPI – Water, 2016). The report card identifies that the long-term average annual extraction limit of 2 030ML/yr[1] for the entire Gloucester Basin Groundwater Source is already fully allocated with the following volumes nominated for the rights and licences currently held under the *Water Act 1912*.

- Basic landholder rights
  - Domestic and stock 106ML/yr.
  - Native title – 0ML/yr.
- Extraction under access licences
  - Domestic and stock – 0ML/yr.
  - Local water utility – 50ML/yr.
  - Aquifer access licences – 1 871 unit shares (max 1ML/yr/share).
- Unassigned water – 0ML/yr.

These allocated quantities were established through the licences held under the *Water Act 1912* which have now been transferred for administration under the WM Act.

[1] The long-term average annual extraction limit of 2030ML/year is also nominated in Part 6 (25)(7) of the WSP.

The Applicant has established that the bulk of the 1 871 unit shares referred to above are held by two resource companies, namely, AGL Upstream Investments Pty Ltd (AGL) and subsidiaries of Yancoal Australia Limited (Yancoal). Given that AGL will no longer require water entitlements in the Gloucester water source for exploration or production activities, and that the entitlements held by subsidiary companies of Yancoal exceed the operational requirements at the Stratford Mining Complex, the Applicant is confident of being able to obtain sufficient licences to cover the predicted take of groundwater from the Permian water source.

Table 4.48 prepared by AGE lists the relevant rules of the for *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources*, together with the respective requirements and the Applicant's approach to each requirement. Upon receipt of the requested licences, the Applicant would abide by the rules within Part B, Clause 38 of the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources*.

Table 4.48
Checklist against *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009*

Page 1 of 3

Item no.	Rule no.	Rule requirement	Applicant's Response
How much water is available?			
1	30(a)	The available share component of unregulated river access licences in the Avon River Water Source is 1985 unit shares.	GRL currently holds 267 units of unregulated river access licences in the Avon River Water Source. In addition, the proposed surface water management dams will either be: a) located on minor watercourses and be solely for the capture, containment or recirculation of drainage. The dams will therefore be 'excluded works' under the *Water Management (General) Regulation 2011*. The taking of water from these dams is therefore exempt from the requirement for a water access licence (*Water Management (General) Regulation 2011* cl 18 and Item 12 Schedule 5); or b) be of a size which is within the harvestable rights capacity for GRL's landholding and therefore the taking of water from the dam is exempt from the requirement for a water access licence (s 52 Water Management Act 2000). In combination with the above exemptions and the 267 units of unregulated river access licences, GRL considers that it is able to pump surface water from the Avon River Water Source in accordance with the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009* and the *Water Management Act* 2000.
2	32(a)	The available share component of aquifer access licences in the Avon River Water Source is 20 unit shares.	Adequate aquifer access licences will need to be obtained (through converting existing unregulated river access licenses) for any take of water as a result of the Project. Under clause 71 of the Water Sharing Plan, conversion of an access licence from an unregulated river access licence to an aquifer access licence is permitted.

Table 4.48 (Cont'd)
Checklist against *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009*

Page 2 of 3

Item no.	Rule no.	Rule requirement	Applicant's Response
Available water determinations			
3	52 & 54	The available water determination for both unregulated river access licences and aquifer access licences in the Avon River Water Source should be equal to 1 megalitre per unit share of access licence share component.	GRL considers that they hold sufficient annual allocations to licence any take of surface water or drawdown on the Avon River Water Source in any particular year of the amended Project.
Work approval requirements			
4	39	A water supply work approval will not be granted where the work is within: a) 200 metres of another water supply work approval taking water from the alluvial sediments; b) 200 metres of another water supply work approval taking water from the alluvial sediments for basic landholder rights; c) 300 metres of the property boundary; d) 100 metres of another water supply work approval taking water from the alluvial sediments by a water utility; or e) 400 metres of a departmental observation bore.	None of these restrictions apply because: a) the Project is a State significant development and in accordance with section 89J of the *Environmental Planning and Assessment Act 1979* a works approval under the *Water Management Act 2000* is not required; and b) there are no works within the specified distances of the Site.
Management of groundwater connectivity			
5	67	There are restrictions on the management of groundwater connectivity which apply to the Avon River Water Source whereby aquifer access licences are subject to the same 'cease to pump requirements' as unregulated river access licences. In effect this means that pumping from alluvial bores must cease where: a) if the licence replaced a 1912 Act licence which contained a cease to pump limit, in accordance with that cease to pump limit; or b) where there is no visible flow in the water source in the immediate downstream vicinity of the nominated water supply work, or if that work is taking water from a pool, when there is no visible inflow and outflow to and from that pool. For an aquifer licence this is taken to mean a visible flow in the river immediately adjacent to the water supply work nominated by the licence.	These restrictions are noted.
Restrictions on dealings			
6	69(2)(b)	An assignment of access rights, an assignment of water allocation or the nomination of a different water supply work is prohibited if the licence is an aquifer licence in the Avon River Water Source and is required or is being moved to a water source requiring a temporary water restriction order to be in place.	Despite GRL holding sufficient licences for the amended Project, there is a sufficient depth of market in available licences in the Avon River Water Source which can be moved to the location of the amended Project in compliance with the restrictions on dealings rules to allow it to cover any impacts of the amended Project. GRL believes that the minimal drawdown in the aquifers of the alluvial groundwater system will not require a temporary water restriction order to be made.

Table 4.48 (Cont'd)
Checklist against *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009*

Page 3 of 3

Item no.	Rule no.	Rule requirement	Applicant's Response
Restrictions on dealings (Cont'd)			
7	69(2)(c)	An assignment of access rights or an assignment of water allocation from an aquifer access licence is prohibited if it nominates a water supply work located within 40 metres from the top of the bank of a river.	The amended Project does not require the extraction of water from any bores that would be located within 40 metres of a river and therefore this restriction on dealings does not apply.
8	70(2) & (6)	Trading into the Avon River Water Source is prohibited if the dealing involves a change from one extraction management unit to another extraction management unit. Dealings that involve a change to the water source to which an access licence applies from the Lower Manning River, Lower Barrington/Gloucester Rivers and the Manning Estuary Tributaries Water Sources into the Avon River Water Source are not prohibited (provided that the dealing causes the sum of all access licence share components in the water source to exceed the sum of all access licences share components in the respective water source at the commencement of the Water Sharing Plan).	Despite GRL holding sufficient licences for the amended Project, they consider that there are sufficient water licences currently available in the Avon River Water Source to licence the impacts of the Project without the need to transfer any licences into the water source.
9	71(2)(a)	It is permitted to convert an unregulated river access licence to an aquifer access licence in the Avon River Water Source.	GRL may apply to convert unregulated river access licences to aquifer licences if there is insufficient available water licences for each category to licence the impacts of the Project. This conversion is permissible.
10	75(2)(d)	Mandatory conditions – carry over provisions of *Water Act 1912* (NSW) licences do not apply unless specifically stated on the licence.	GRL will review the specific conditions applying to any licence prior to that licence being used for the Project.
11	81, 82 and 83	Mandatory conditions	GRL has noted these mandatory conditions and considers that its licensing strategy can meet all of these conditions.

4.6.9 Monitoring

The existing groundwater monitoring network within and in the vicinity of the Mine Area would be used:

- for the ongoing assessment of impact of the amended Project;
- as a pro-active indicator of any adverse impacts on the groundwater regime; and
- as a baseline data set with which to validate the numerical groundwater model predictions throughout the life of the amended Project.

The expanded baseline data accumulated over time would also provide a substantial data set with which to develop a series of trigger values for both groundwater levels and quality.

Five of the 15 existing monitoring bores would be retained long term while the remaining ten bores would be progressively removed and replaced as mining advances. A total of eight new monitoring bores would be installed i.e. four paired bores. **Figure 4.39** displays the locations of existing bores to be retained, those to be progressively removed and indicative locations for the proposed new monitoring bores. The nominal depths of the new bores are recorded on **Figure 4.39**. The combined bore network would monitor water levels in all three groundwater systems.

It is noted that the Applicant has recently assumed responsibility for and has extended its monitoring program for two bores previously established and monitored by AGL, namely WBM01 and WBM03 (see **Figure 4.39**).

All groundwater monitoring locations would be documented in the Operational Water Management Plan which would be updated annually.

It is proposed that the groundwater levels would continue to be monitored every 6 hours using dedicated data-loggers in each monitoring bore.

Groundwater quality sampling would be undertaken on either a quarterly or monthly basis. The details of the analytes and frequency of monitoring would be set out in the Water Management Plan although initially, it is proposed to monitor the following.

- pH and electrical conductivity (EC);
- Major ions (Ca, Mg, Na, K, Cl, SO_4, alkalinity, Si, F);
- Nutrients (NO_2, NO_3, Total P); and
- Trace elements (As, Cd, Cr, Cu, Pb, Mn, Zn, Fe).

The analytes and frequency of sampling would be reviewed at least every 2 years to ensure only meaningful data is being collected.

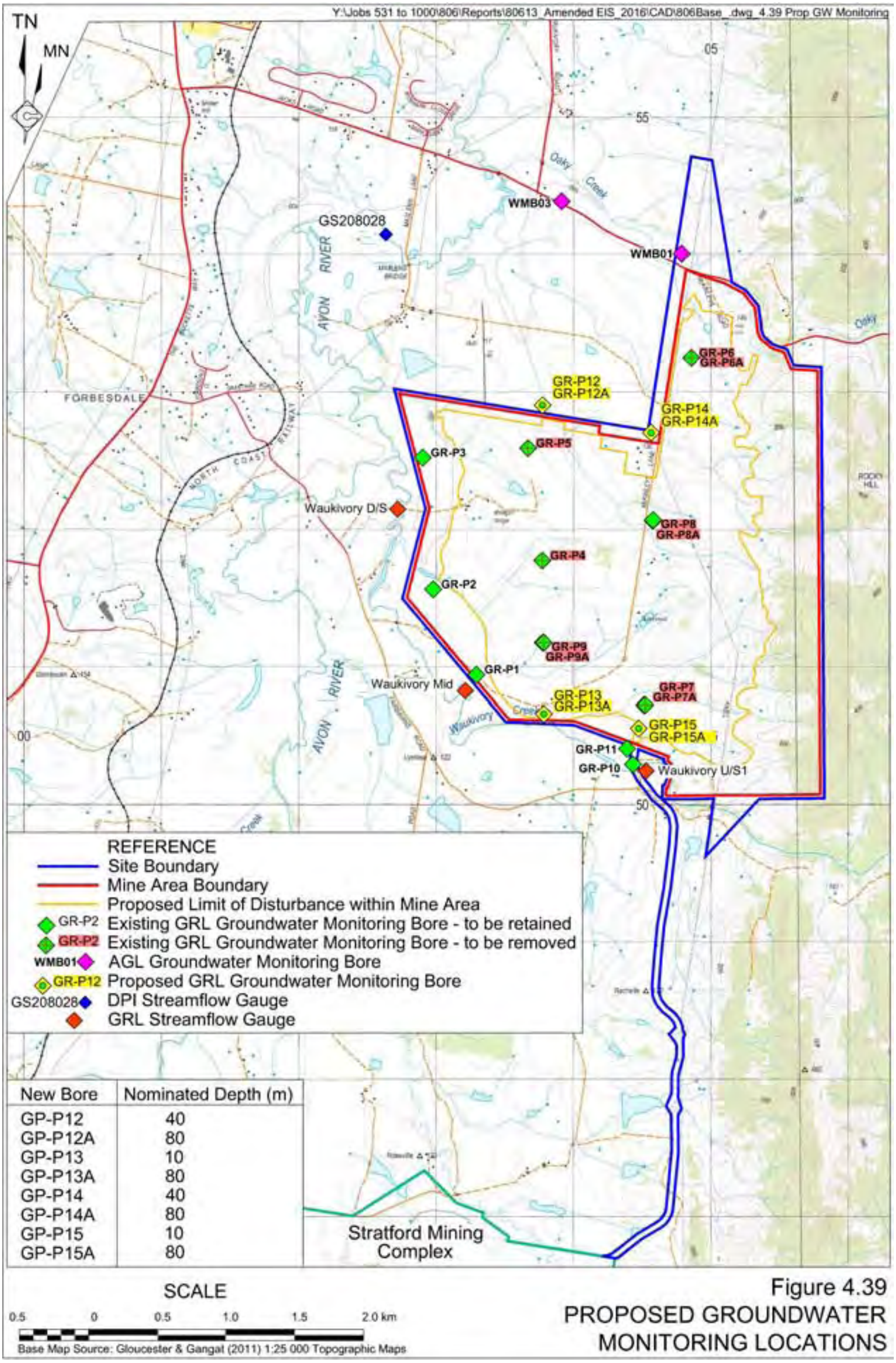
The Water Management Plan would incorporate a series of trigger levels that would set the threshold values at which some further investigation should be carried out. The following approach to setting trigger values would be undertaken based upon recommendations provided by AGE (2016).

- Salinity – individual trigger values would be calculated for each monitoring bore using values for EC, TDS, and cations/anions.
- Metals – as the primary use of the water in the area is for irrigation and stock water, the ANZECC (2000) trigger levels for Livestock Drinking Water are proposed.
- Pesticides and Hydrocarbons – no triggers are proposed.

It is noted that the trigger levels are not pass or fail compliance criteria. Rather, they represent a threshold value above which some further investigation should be carried out, typically when three successive exceedances occur.

All monitoring results would be reviewed upon receipt to ensure trigger levels have not been exceeded. All results would be assembled on a quarterly or monthly basis and presented in each Annual Review for the amended Project.

AGE (2016) also recommends that the validity of the groundwater predictions should be re-assessed every 5 years based upon the monitoring data assembled. This recommendation was also supported by Kalf and Associates who undertook the peer review of the groundwater assessment.



New Bore	Nominated Depth (m)
GP-P12	40
GP-P12A	80
GP-P13	10
GP-P13A	80
GP-P14	40
GP-P14A	80
GP-P15	10
GP-P15A	80

Figure 4.39
PROPOSED GROUNDWATER MONITORING LOCATIONS

4.6.10 Conclusion

The groundwater data collected between 2011 and 2016 is considered by AGE (2016) and Dr Frans Kalf of Kalf and Associates to be adequate and suitable to describe the existing environment and as a basis to predict the impact of the proposed mining on the existing groundwater environment. The data has enabled a numerical model to be calibrated to a transient dataset that is representative of baseline conditions. This transient calibration takes into account the various recharge conditions that occur to the groundwater and surface water systems and allows for surface and groundwater interactions to be simulated. This model has then been used to predict impacts to the groundwater systems that would occur as a result of the amended Project.

The modelling conservatively predicts that inflow rates to the open cut pits are likely to average 727ML/yr with a maximum inflow of 1 100ML/yr (3ML/day). An estimated 20% of this inflow would be lost to evaporation and retention in the ROM coal and interburden/overburden. Inflows would stabilise to an average rate of 1ML/day to 2ML/day throughout the life of the amended Project.

The overall reduction in flow of water from the Permian strata to the Quaternary Alluvium would typically vary from 0.1ML to 0.4ML/day with a maximum reduction of 0.53ML/day.

The drawdown attributable to the amended Project is likely to expand to the north and south of the open cut pits with limited drawdown occurring to the east. The drawdown would be limited to the Permian coal seams and typically follow the strike of the Permian strata, i.e. to the north and south of the Mine Area.

The model predicts that no existing groundwater users would be impacted by the amended Project, and there would not be any reduced availability of groundwater to the shallow groundwater system and no impact to any groundwater dependent ecosystems. The impact of the amended Project on flows within the Avon River and Waukivory Creek is not expected to be measurable as groundwater base flow to surface water systems in the Gloucester Basin is a very small percentage of the contribution to the regional water balance.

4.7 SURFACE WATER

The surface water assessment of the amended Project was undertaken by WRM Water and Environment Pty Ltd. The full assessment is presented in Volume 3 Part 5 of the Specialist Consultant Studies Compendium and is referenced throughout this section as WRM (2016), with a summary of the assessment presented in the following subsections.

4.7.1 Introduction

Based on the risk assessment undertaken for the amended Project (Section 3.3.1 and **Appendix 6**), the potential impacts relating to surface water and their risk rankings after the adoption of standard mitigation measures are as follows.

- Discharge of sediment-laden water into the Avon River and Waukivory and Oaky Creeks impacting upon the riverine ecology and downstream users (medium).
- Pollution of alluvial water and potentially the Avon River and Waukivory and Oaky Creeks (medium).

- Rapid discharge of saline / sediment-laden water into the Avon River and Waukivory and Oaky Creeks leading to loss of life and damage to infrastructure (low).
- Retention of excess poor quality water due to above average rainfall (medium).
- Chemical contamination of surface water impacting on surface water or groundwater biota in the Avon River and Waukivory and Oaky Creek surface water catchments and alluvial groundwater systems (low).
- Diversion channel erosion / instability leading to increased sediment loads in the Waukivory Creek/Oaky Creek surface water catchments (medium).
- Erosion of Waukivory and/or Oaky Creek channels leading to increased sediment loads (low).
- Loss of flood storage and increased adjacent flood levels due to earthworks on margin of a floodplain impacting infrastructure and cropping on the Avon River and Waukivory Creek floodplains (low).
- Long term impact to salinity levels in regional surface and groundwater due to mining impacts to floodplains (low).

In addition, the Director-General's Requirements issued by the then DP&I (now DPE) identified "Surface Water" as one of the key issues requiring assessment. The principal assessment matters from DP&I relating to surface water included the following.

- A detailed assessment of potential impacts on the quality and quantity of existing surface water resources, including:
  - impacts on affected licenced water users and basic landholder rights; and
  - impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows.
- A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures.
- An assessment of proposed water discharge quantity and quality/ies against receiver water quality and flow objectives, including water diverted by the construction and operation of the proposed mine.
- Assessment of impacts and salinity from mining operations, including disposal and management of coal rejects and modified hydrogeology, a salinity budget and the evaluation of salt migration to surface and groundwater sources.
- Identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000.
- Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP).

- A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo.
- A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts.
- A detailed flood impact assessment, which identifies impacts on local flood regimes, including:
  - an assessment of the potential for flooding to occur in the open-cut pits; and
  - any measures proposed to mitigate potential flood impacts.

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA, the former NSW Office of Water (NOW) now DPI – Water, the former Gloucester Shire Council, DRE, NSW Health – Hunter New England Local Health District, Mid-Coast Water, Hunter-Central Rivers NSW Catchment Management Authority, NSW – Fisheries and BGSPA. The additional matters identified in the additional correspondence are generally consistent with the DGRs.

Emphasis is placed in this section upon the surface water management within and in the vicinity of the Mine Area, given it is this area that would experience the greatest level of disturbance over the life of the amended Project. Whilst road construction works are proposed for the private haul road, the potential impacts would be very localised and confined within a comparatively short period. As a consequence, the description and evaluation of surface water in the vicinity of the road is comparatively brief.

4.7.2 Existing Surface Water Environment

4.7.2.1 Catchment Setting

The Mine Area is located within the Avon River catchment, with parts being within its tributary catchments, i.e. Waukivory and Oaky Creeks. The private haul road also lies within the catchment of the Avon River with parts located within the tributary catchments of Waukivory Creek and Dog Trap Creek. The Avon River is a tributary of the Gloucester River, which joins the Barrington River further downstream, before eventually feeding into the Manning River which flows eastward to the coast. **Figure 4.40** displays the catchments of Waukivory, Oaky and Dog Trap Creeks and the Avon River.

The catchment area of the Avon River to the Gloucester River confluence, approximately 5km downstream (north) of the Mine Area, is approximately 290km^2 whilst the total catchment of the Manning River is approximately 8 190km^2 (see **Figure 4.40**).

The local catchments within the Mine Area are relatively small, and the flow in the local watercourses is ephemeral. A number of small farm dams are constructed across these watercourses collecting flows before they enter the Avon River and Waukivory Creek (see **Figure 4.41**).

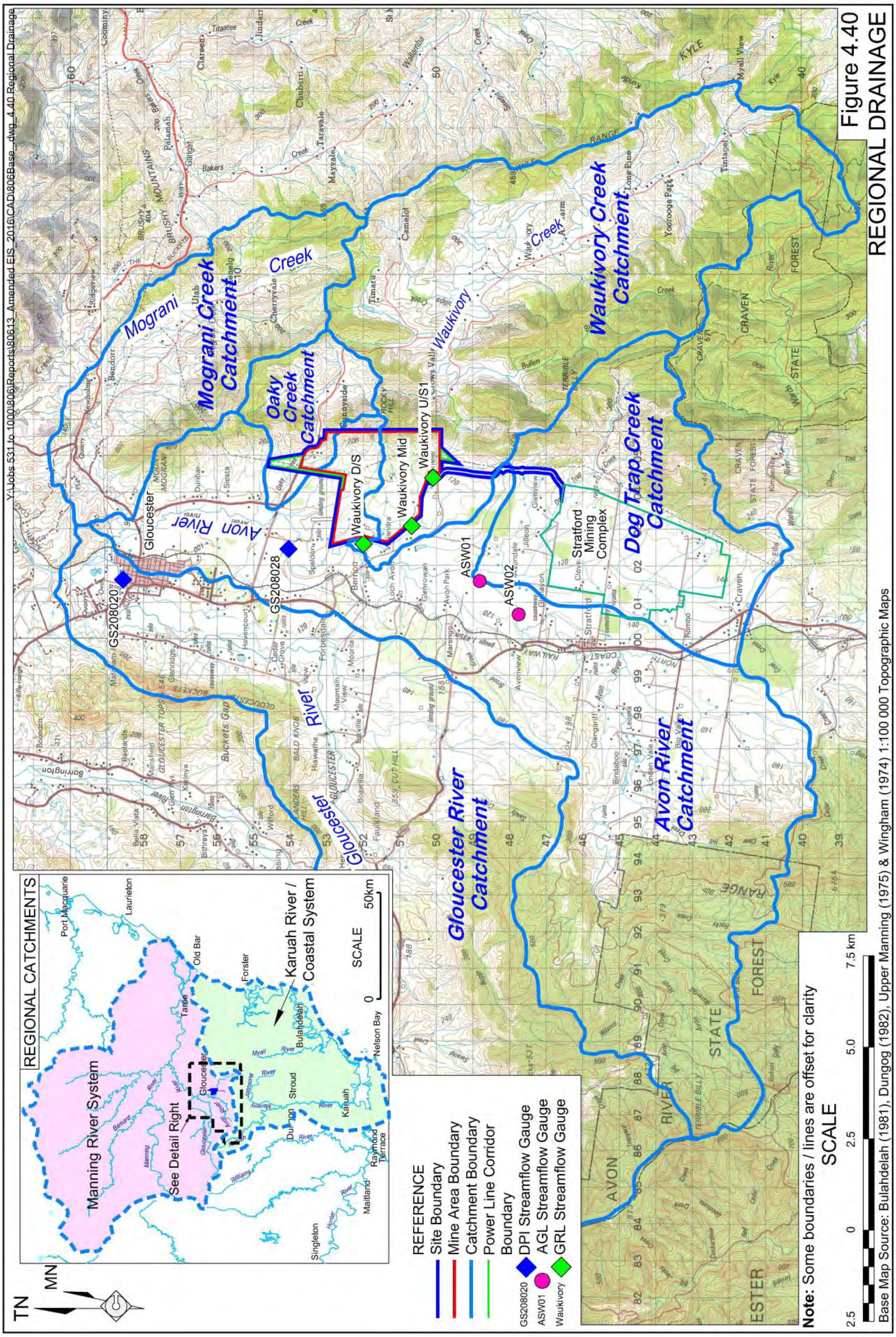


Figure 4.40
REGIONAL DRAINAGE
REGIONAL CATCHMENTS
Manning River System
Karuah River / Coastal System
See Detail Right
SCALE
0
50km
REFERENCE
Site Boundary
Mine Area Boundary
Catchment Boundary
Power Line Corridor Boundary
GS208020 DPI Streamflow Gauge
ASW01 AGL Streamflow Gauge
Waukivory GRL Streamflow Gauge
Mograni Creek Catchment
Oaky Creek Catchment
Waukivory Creek Catchment
Dog Trap Creek Catchment
Gloucester River Catchment
Avon River Catchment
Stratford Mining Complex
Waukivory D/S
Waukivory Mid
Waukivory U/S1
GS208028
GS208020
ASW01
ASW02
Gloucester
Avon River
Gloucester River
Mograni Creek
Waukivory Creek
Note: Some boundaries / lines are offset for clarity
SCALE
2.5
0
2.5
5.0
7.5 km
Base Map Source: Bulahdelah (1981), Dungog (1982), Upper Manning (1975) & Wingham (1974) 1:100 000 Topographic Maps

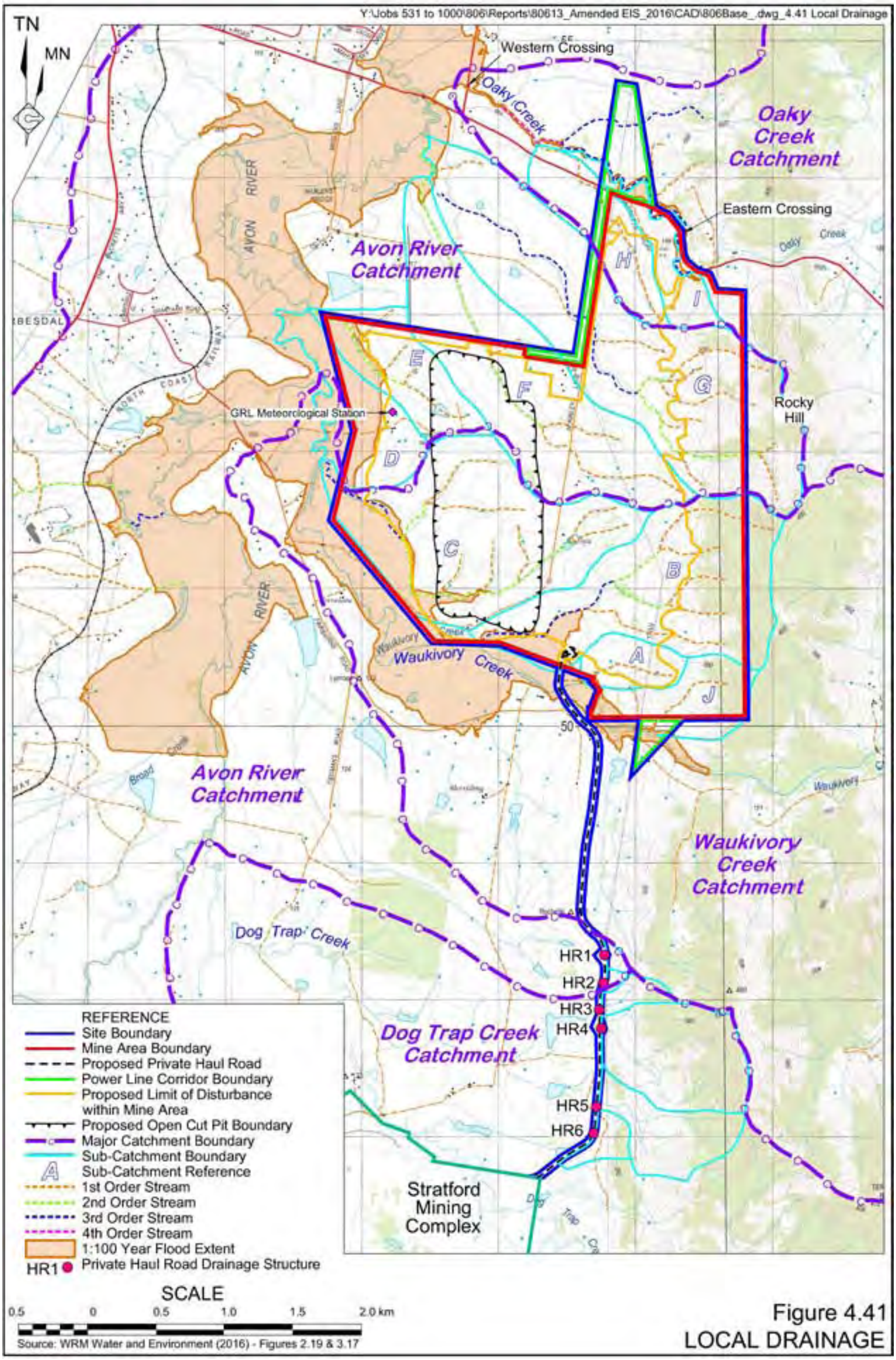


Figure 4.41
LOCAL DRAINAGE

4.7.2.2 Stream Geomorphology

The stream geomorphology of the Avon River, Waukivory Creek, Oaky Creek and Dog Trap Creek and the Mine Area watercourses are summarised as follows.

Avon River

In the vicinity of the Mine Area, the Avon River is a 5th order stream (under the Strahler classification system), and has a longitudinal slope of approximately 0.1%. The channel is approximately 35m wide and 5m deep. The floodplain is approximately 500m wide. A number of watercourses that traverse the Mine Area and one watercourse that traverses the private haul road flow directly into the Avon River.

Waukivory Creek

Waukivory Creek is a 5th order stream. It drops approximately 9m in elevation adjacent to the Mine Area over a distance of approximately 5km, providing a longitudinal slope of approximately 0.2%. Cross-sections of Waukivory Creek at the three water level gauges adjacent to the Mine Area (see **Figure 4.40**) show the creek channel to be approximately 20m wide and 5m deep. Local variations in stream slope occur as the extent of incision varies. Stream bed control is largely cobble based with extended pools often greater than 2m deep. The section of Waukivory Creek into which clean water would be directed throughout the mine life comprises a cobble bedload and some small boulders.

The Waukivory Creek floodplain varies in width from approximately 300m in the upstream section to more than 500m near the confluence with the Avon River. It is noted that parts of the Waukivory Creek (and the Avon River) channels are perched up to several metres above the neighbouring floodplain areas.

Oaky Creek

Oaky Creek is a 3rd order stream for the 3.2km length from the Mine Area to its confluence with the Avon River. The channel is relatively steep, with an essentially uniform slope (apart from local variations) of approximately 1.1%.

In its upper reaches (defined as occurring above the Waukivory Road eastern crossing but below the steep gully associated with its headwaters located east of the Mine Area), the Oaky Creek channel is shallow (approximately 0.5m to 1.0m deep), narrow (up to 15m wide) and meanders across a narrow floodplain up to approximately 50m wide. Within the channel, the stream bed is primarily armoured by large cobbles and small boulders with some cobbles and boulders also present on the surrounding overbank areas. Large casuarina trees also line the channel, creating a stable watercourse that is likely to be resistant to future hydrological changes.

In its lower reaches (defined as occurring downstream of the Waukivory Road eastern crossing – see **Figure 4.41**), the channel becomes straighter and deeper (up to 4m) as it incises into the underlying bedrock, with the floodplain becoming wider (up to 300m). Throughout the lower reaches, the stream either flows directly on eroded bedrock, or comprises a bedload consisting primarily of cobbles with some boulders also present. Large trees occur along the banks below the Waukivory Road eastern crossing, providing erosional protection, but as the channel flows further away from the Mine Area towards the Waukivory Road western crossing and the Avon River, the woody vegetation becomes sparse with bank erosion more pronounced.

Dog Trap Creek

Dog Trap Creek is an ephemeral watercourse which discharges into the Avon River about 2.1km downstream of Wenham Cox Road (upstream of the Mine Area). In the vicinity of the proposed private haul road, it is a 4th order stream. The Dog Trap Creek channel is relatively steep in the upper catchment area which is also heavily forested. In the vicinity of the private haul road and the Stratford Mining Complex (SMC), the Dog Trap Creek channel flattens considerably as it meanders through cleared farming land. Although the channel is generally well vegetated, there are sections which are poorly defined with the channel hard to distinguish against the surrounding landscape.

Mine Area Watercourses

The watercourses that traverse the Mine Area are located in local catchments where the flow is ephemeral. **Figure 4.41** displays the various minor sub-catchments across the Mine Area. The watercourses on the eastern side of the Mine Area are often very steep with rocky floors and thick remnant vegetation cover. Further to the west, the watercourses are less steep and invariably well grassed, with the exception of a few watercourses where erosion is evident. In most cases, the watercourses do not display well-defined channels.

Private Haul Road

The northern section of the private haul road would cross Waukivory Creek approximately 300m south of the proposed ROM pad with a prefabricated metal bridge. It would then generally traverse the eastern side of a north-south ridgeline in a southerly direction toward the Stratford Mining Complex. Runoff from this section of the private haul road would drain to an ephemeral watercourse which flows northwards to Waukivory Creek. This watercourse flows into a farm dam upstream of the proposed Fairbairns Road haul road crossing immediately before entering Waukivory Creek.

The southern section of the private haul road drains to the west via tributaries of the Avon River and Dog Trap Creek. The watercourses upslope of the private haul road are comparatively steep given their close proximity to the crest of the nearby Mograni Range. The private haul road would cross Dog Trap Creek within the Stratford Mining Complex. An assessment of the Dog Trap Creek crossing is being undertaken by Stratford Coal Pty Ltd.

Within the Site, the private haul road crosses four first order, one second and one third order watercourse along the proposed alignment.

4.7.2.3 Streamflow Characteristics

The nearest streamflow gauge is located on the Avon River (GS208028) adjacent to the Mine Area, downstream of the Waukivory Creek confluence (see **Figure 4.40**). The catchment upstream of this gauge is approximately 225km^2. This gauge, which is currently managed by the DPI-Water has been operational since September 2004. The flow records at this location indicate that baseflow tends to persist over long periods. Median daily flow in the Avon River at the gauge is 10.2ML. During drier periods, flows throughout the Avon River catchment are likely to be predominantly groundwater inflows from the alluvial groundwater systems adjacent to the Avon River and its tributaries as evidenced by the higher ECs within the catchment during these periods.

Water levels within both the Avon River and Waukivory Creek are also monitored continuously at three locations established by the Applicant (within Waukivory Creek) and two locations established by AGL (within the Avon River). This data provides a good basis upon which to correlate water quality data and streamflow/water levels during flood events.

4.7.2.4 Flooding

Detailed hydrological and hydraulic flood models have been prepared of the floodplains adjacent to the Mine Area. Whilst no records of flood heights are available on or adjacent to the Mine Area for the large historical floods in 1894, 1929, 1956, 1957, 1963, 1976, 1978 and 2011, data has been collected during recent floods at nearby water level gauges within the Avon River and Waukivory Creek (see **Figure 4.40**). The flood models have been calibrated using this data, along with surveyed peak water levels across the adjacent floodplains. It is noted there are no existing floodplain risk management plans relevant to the Mine Area.

Figure 4.41 displays the modelled 1 in 100 annual exceedance probability (AEP) flood level for both the Avon River and Waukivory Creek. It is noted that the western boundary of the western and northern amenity barrier is generally coincident with the 1 in 100 Annual Exceedance Probability (AEP) Waukivory Creek flood level. Flooding in excess of a 1 in 100 AEP event would, without the protection afforded by the western and northern amenity barrier and/or the levee formed by the end wall of the proposed pits, result in floodwaters entering the two watercourses on the southern side of the Mine Area, and potentially entering both the Avon and Main Pits.

4.7.2.5 Avon River Catchment Water Usage

The Avon River catchment defines the Avon River Water Source, which is part of the Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources. Water use from the entire Avon River Water Source makes up 2.2% of the total Manning Extraction Management Unit Entitlement.

The DPI-Water provided WRM with details of water access licences issued in accordance with the *Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources* and held by landholders in the vicinity of the Mine Area for irrigation and farming purposes. The approximate locations of the water extractions authorised under the associated Works Approvals are shown in Figure 2.24 in WRM (2016). Five water extractions are located on Waukivory Creek (total entitlement share, 195 units), of which two are located upstream of the Mine Area and the other three (totalling 151 units) are held by GRL. Downstream of the Waukivory Creek confluence, water is currently extracted from the Avon River under six licences (total entitlement share, 168 units), one of which is held by GRL (26 units). GRL also holds a water access licence with an associated Works Approval located on the Avon River well upstream of the Waukivory Creek confluence (entitlement share 90 units).

At the time of commencement of the Lower North Coast Unregulated and Alluvial Water Sources Water Sharing Plan, NOW estimated local water utility access licences to account for extractions totalling 15 666ML/yr. The Gloucester township's water supply is drawn from the Barrington River. A number of towns within the region are supplied from the Manning River via MidCoast Water's Manning Scheme. When water quality permits, water is pumped from the Manning River to Bootawa Dam, near Wingham, for storage and supply to Taree, Wingham, Forster, Tuncurry, Pacific Palms, Nabiac, Dyers Crossing, Harrington, Coopernook, Hallidays Point and Lansdowne. The intake for the scheme is more than 50km downstream of the Mine Area.

4.7.2.6 Water Quality

Regular surface water monitoring has been undertaken at 13 sites within and in the vicinity of the Site since July 2010 to fully understand the existing water quality in the various watercourses and dams. Sampling has been undertaken under a range of flow conditions on either a monthly or quarterly basis (with some opportunistic samplings) at the locations shown in **Figure 4.42**. All samples were analysed at a NATA-accredited laboratory for the following parameters.

- pH, EC, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, Sodium Absorption Ratio (SAR).
- Major ions (Cl, SO_4, Ca, Mg, Na, K, Si, F).
- Heavy Metals (Ag, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, Fe).
- Nutrients (NO_2, NO_3, Total N, Total P) and Alkalinity.
- Oil and Grease, C Fractions, TPH(u)/BTEX Surrogates, E. coli, Coliforms.

Continuous salinity data is also collected by AGL at the Site ASW01 (see **Figure 4.40**).

The results of the analyses for the key analytes of interest are summarised in **Table 4.49**, with the NSW Water Quality Objectives (WQOs) for aquatic ecosystems protection in upland rivers of the Manning River catchment or other relevant water quality objectives also shown for comparison.

Table 4.49
Surface Water Quality Summary

Sample Location (see Figure 4.42)	Median Results					
	pH	**EC**	**TSS**	**TN**	**TP**	**SO_4**
Water Quality Objective	*6.5-8.0*	*30-350*	*<5-29*	*0.25*	*0.02*	*-*
Avon River						
Avon Upstream	7.3	387.0	7.0	0.900	0.080	11.0
Avon Downstream	7.3	436.5	8.5	0.800	0.080	12.0
Waukivory Creek						
Waukivory Upstream 1	7.7	442.0	5.0	0.600	0.060	11.0
Waukivory Upstream 2	7.7	416.0	6.0	0.600	0.060	12.0
Waukivory Downstream	7.3	432.0	8.0	0.800	0.085	9.0
Oaky Creek						
Oaky Upstream	7.3	401.0	7.0	0.600	0.030	18.0
Mine Areas, Watercourses and Dams						
B1	7.4	612.5	28.5	1.650	0.180	28.0
C1	6.7	470.0	8.0	1.100	0.080	37.0
E1	7.3	212.0	40.5	3.000	0.210	4.0
G1	7.6	988.0	12.5	0.750	0.075	47.5
H1	7.0	1370.0	19.0	2.400	0.330	78.0

EC = Electrical Conductivity TSS = Total Suspended Solids TN = Total Nitrogen TP = Total Phosphorous SO_4 = Sulphate

Source: WRM (2016) – Modified after Tables 2.5 to 2.8

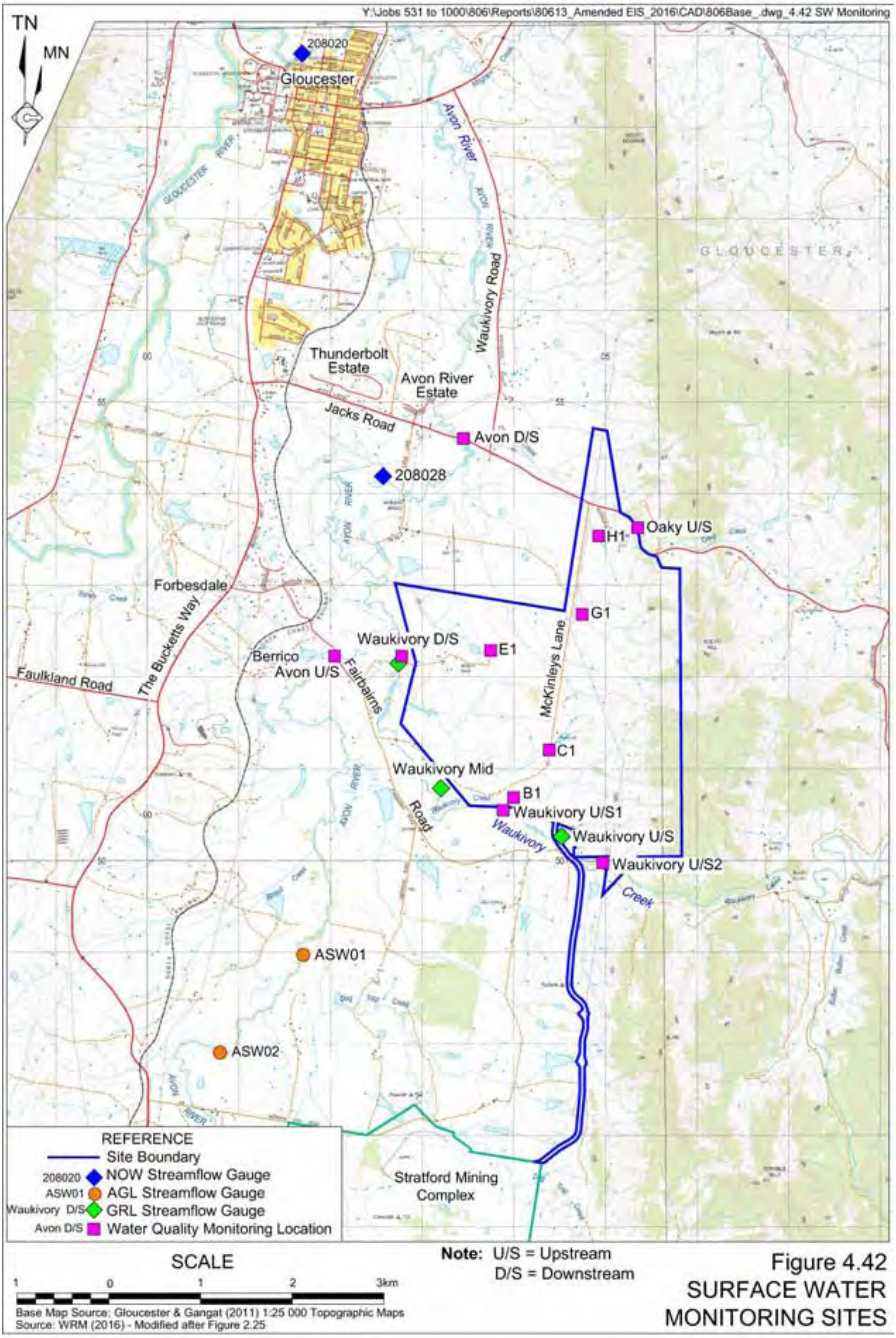


Figure 4.42
SURFACE WATER MONITORING SITES

An overview of the results is provided as follows.

Avon River:	pH is generally neutral (median value of 7.3) with median electrical conductivity levels of 387µS/cm (upstream) and 437µS/cm (downstream) and median TSS values of 7mg/L (upstream) and 8.5mg/L (downstream).
Waukivory Creek:	pH is neutral to slightly alkaline (median values of 7.3 to 7.7) with median electrical conductivity levels of 416 to 442µS/cm and median TSS values of 5 to 8mg/L.
Oaky Creek:	pH is generally neutral (median of 7.3) with median electrical conductivity values comparable with the Avon River and median TSS values of 7mg/L.
Mine Area Watercourse and Dams:	pH is near neutral (median values vary from 6.7 to 7.6) with variable median electrical conductivity levels of 212µS/cm to 1 370µS/cm) and median TSS values from 8 to 41mg/L (with the higher values in dams, as would be expected).

WRM (2016) notes that the water quality objectives for electrical conductivity, suspended solids and turbidity were all exceeded at most sampling locations from time to time and that a number of samples in receiving waters (the Avon River and Waukivory Creek) exceeded the metalloid trigger levels for the 95% protection of freshwater species for cadmium, copper, chromium, lead and zinc.

The median results for total nitrogen and total phosphorus across all sampling sites were above the water quality objectives for the 95% protection of freshwater species.

4.7.3 Potential Surface Water Impacts

The development and operation of the amended Project could have a range of potential surface water-related impacts which have previously been identified in the risks presented in Section 4.7.1. Each of the potential impacts outlined below has been studied in detail by WRM (2016) in conjunction with the Applicant to ensure appropriate design and operational safeguards would be implemented to avoid or minimise adverse environmental impacts (see Section 4.7.4).

- Pollution and/or contamination of existing surface water sources within the Avon River and/or Waukivory Creek either through discharge and/or dam failure.
- Chemical contamination of existing surface water sources causing adverse impacts on aquatic biota.
- A reduction in flows in either the Avon River or Waukivory Creek causing less water to be available for environmental benefits or licenced water users and landowners with landowner's rights.
- Adverse impacts of flood flows including increased flood levels upstream, loss of flood storage and/or flood inflows to the open cut pit(s).
- Erosion of Waukivory Creek and Oaky Creek, including at the points of entry from the eastern (upslope) clean water diversion channels.

- Erosion during the construction and use of the private haul road.
- The availability of water throughout all stages of the amended Project to satisfy operational water requirements, including during periods when any "cease to pump" requirements are invoked.

4.7.4 Management, Mitigation and Contingency Measures

4.7.4.1 Introduction

In order to avoid or minimise the adverse impacts throughout the development and operation of the amended Rocky Hill Coal Project, the management of surface water requires a coordinated and systematic approach that collectively addresses all potential surface water impacts. This subsection outlines how the Applicant would manage the quantity and quality of surface water encountered during the site establishment and construction stage and throughout the life of the mining operation to the completion of the final rehabilitation program.

Surface water would be managed on site according to quality, namely:

i) clean water, i.e. runoff (typically upslope) that is not affected by any disturbed areas or mine-related activity(ies) and including rehabilitated areas that are no longer a source of significant sediment;

ii) dirty or sediment-laden runoff containing only sediment and originating from soil stockpiles and disturbed or bare areas within the Mine Area; or

iii) saline groundwater inflows and surface runoff accumulating within the open cut pits which would have an increased risk of containing elevated levels of dissolved metals and hydrocarbons.

This subsection concludes with an overview of the site water balance which outlines how the Applicant would prioritise the use of water within the Mine Area and ensure sufficient water is available for dust suppression.

The management of surface water within the Mine Area would be a continually evolving component of the overall management of the mine. A detailed Water Management Plan would be prepared prior to the commencement of any disturbance on site, setting out the design features and the operational and monitoring procedures for all structures. The Plan would be updated annually with emphasis placed upon the subsequent year's activities.

The consideration of the management and mitigation measures, and the subsequent assessment of environmental impacts throughout the life of the amended Project, was undertaken for representative mine Years 0.5, 2, 4, 8 and 15.

4.7.4.2 Clean Water Management

The clean water management system would ensure the volume of sediment-laden or saline water to be managed is minimised by diverting upslope runoff away from potential contamination sources.

Mine Area

The clean water system within the Mine Area would primarily comprise clean water diversion channels and flood levees.

Clean Water Channels

The Applicant would progressively construct two channels on the eastern side of the Mine Area immediately upslope of the out-of-pit overburden emplacement. **Figure 4.43** displays the locations and features of the channels. The southern channel, covering a length of approximately 2.0km, would direct upslope runoff southwards towards Waukivory Creek and the northern channel covering a length of approximately 2.9km, would direct upslope runoff northwards towards Oaky Creek. Both channels would largely follow the natural contours on the hill slopes and generally exhibit a gentle gradient with a grass-lined (unless bedrock is present), trapezoidal cross-section.

The channels would have base widths varying along their lengths to limit flow velocities to less than 1.5m/s and incorporate a series of detention structures to assist in reducing flow velocities. The channels would typically have a base width of approximately 1m to 15m and incorporate rock-lined chutes with energy dissipators at their downstream ends as they enter either Waukivory Creek or Oaky Creek. The energy dissipators would likely comprise stepped drop structures within the chutes themselves.

Flood Levees

The western and northern amenity barrier and open cut pit walls on the southern side of the open cut pits would prevent any floodwaters from entering the pits. If required, protection involving rock armouring or rock gabions would be installed at the toe of the western section of the western and northern amenity barrier where it slightly encroaches into the Avon River and Waukivory Creek floodplains. All flood controls would be in place to protect both human health and the Applicant's assets.

4.7.4.3 Sediment-laden Water Management

Mine Area

Runoff from stockpiled subsoil, topsoil and most overburden emplacements would be directed to a series of sediment dams constructed within the Mine Area. Sediment-laden runoff would also be generated from the outer western and northern faces of the western and northern amenity barrier prior to the establishment of a stable vegetation cover and would be collected in a series of sediment dams strategically placed along the toe of the barrier.

Figure 4.44 displays the locations of the proposed sediment dams within the Mine Area. All sediment dams would be sized and operated in accordance with the "Blue Book" requirements for Type D sediment basins (DECC, 2008). These dams would be operated such that the water that accumulates after a rainfall event would be discharged from the dam within five days of the rainfall event subject to water testing confirming that the water quality satisfies the criteria on the Site's environmental protection licence. This procedure would effectively re-instate the capacity of the dam to collect the runoff from the next rainfall event. The procedure to be adopted to manage sediment-laden runoff would be assembled in the appropriate Water Management Plan.

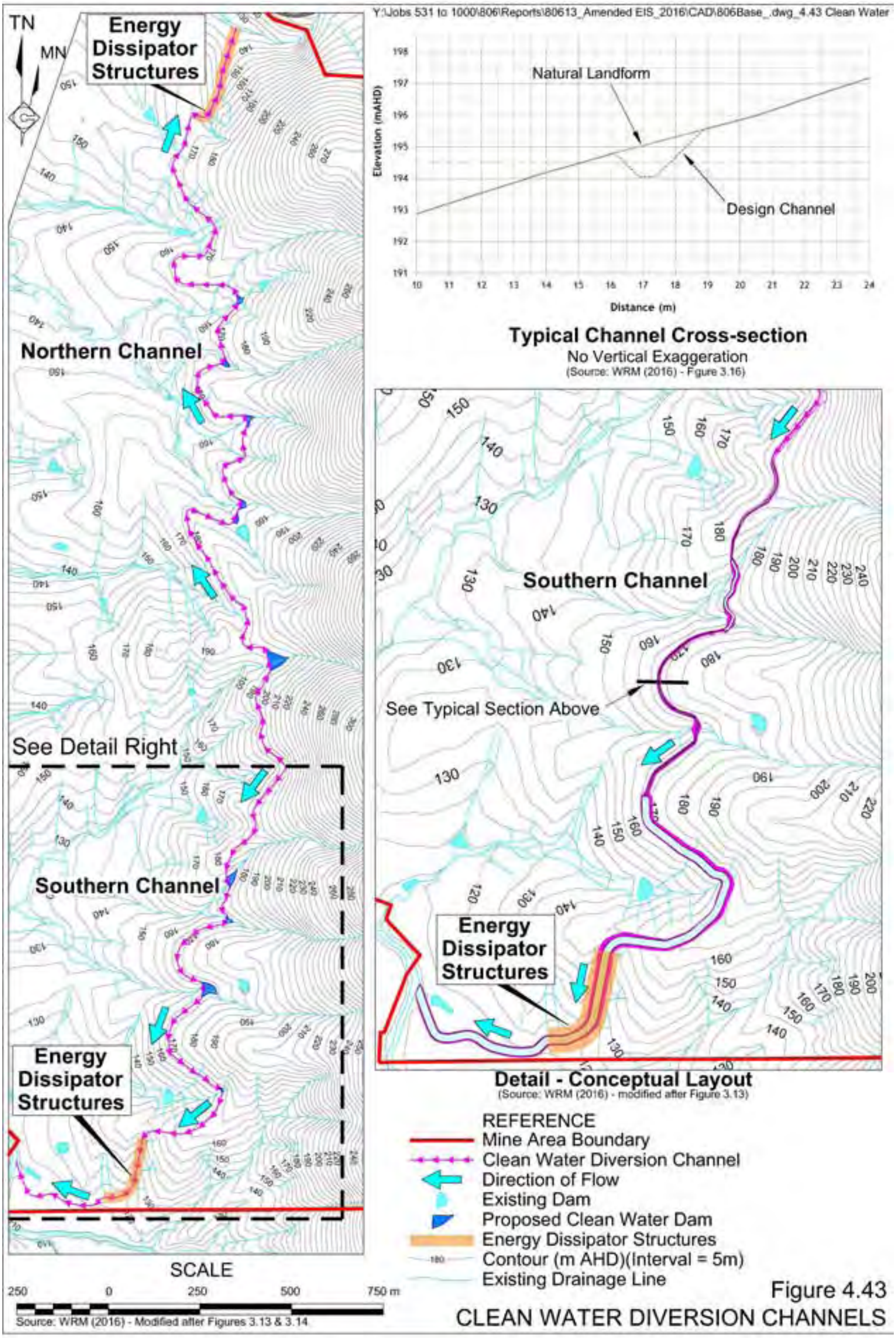


Figure 4.43
CLEAN WATER DIVERSION CHANNELS

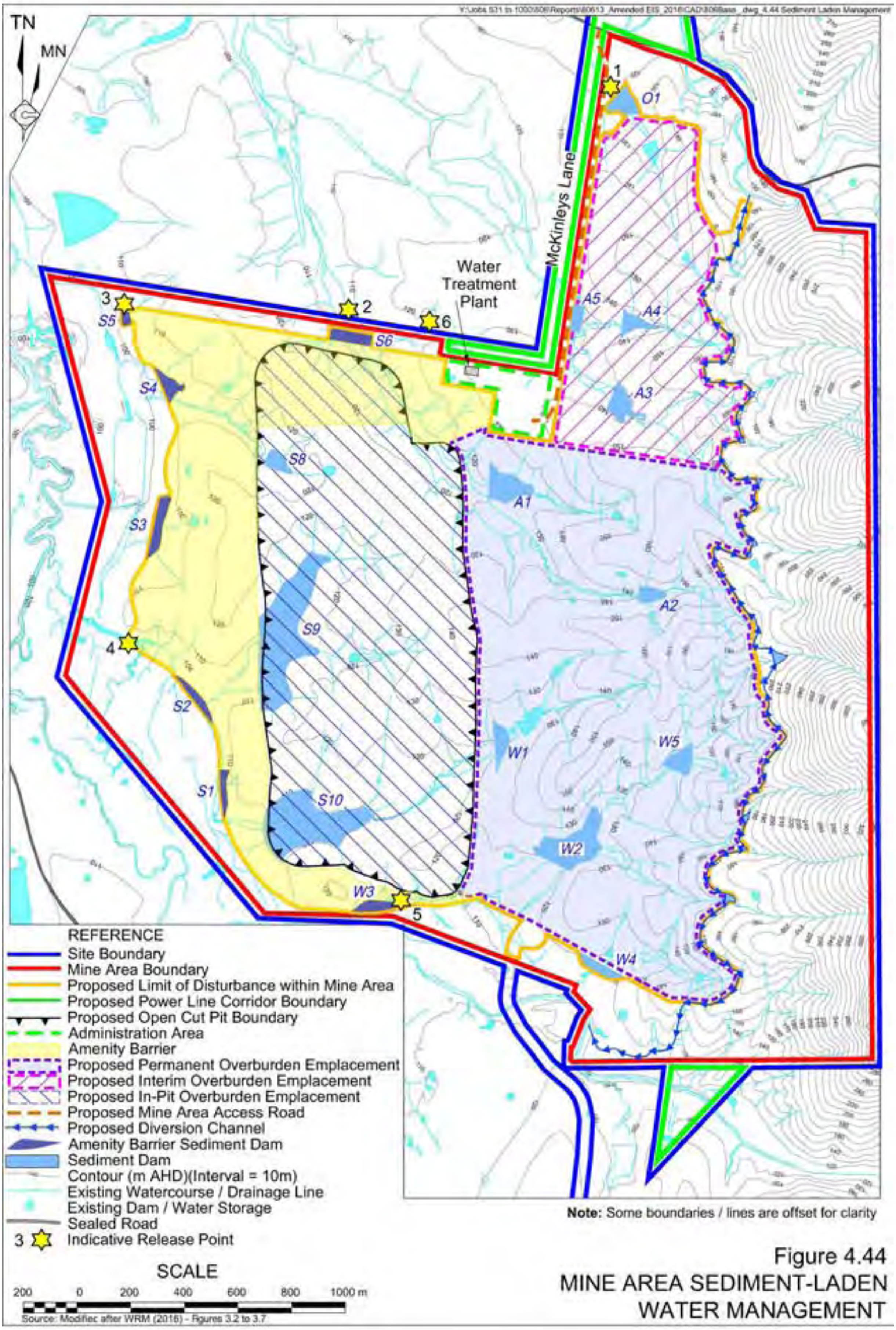


Figure 4.44
MINE AREA SEDIMENT-LADEN WATER MANAGEMENT

The water released from the sediment dams would be directed to one of the five proposed release points (Points 1 to 5) around the western and northern boundaries of the Mine Area (see **Figure 4.44**). Invariably, water released from the sediment dams would be dispersed across grassed slopes via a pipe spreader downslope from the subject dams to achieve slow flow rates and further reduce concentrations of suspended solids before reaching the nearby watercourses.

Private Haul Road

The greatest potential for sediment-laden water to be generated within the private haul road corridor, and therefore require management, would be during its construction. The road would be constructed using standard road construction techniques and practices to contain sediment-laden water throughout the construction period and until all disturbed slopes are fully stabilised. The road construction activities would be undertaken in accordance with a detailed erosion and sediment control plan which would form part of the Construction Water Management Plan. The document would specify the locations of sediment fences, straw bales and the use of sediment basins downslope from the construction areas.

The southern section of the private haul road would cross six minor watercourses, all of which would require box or pipe culverts to ensure free drainage is maintained in those catchments (**Figure 4.41**). Details of the culverts and associated sediment controls would be included in the Construction Water Management Plan.

Once constructed, runoff from the northern section of the private haul road would be managed through suitably sized table drains and cross-drainage to the east. Runoff from the road itself would not be concentrated, rather it would be allowed to flow across the adjoining slope towards the watercourse located approximately 100m to 150m east of the road.

Runoff from the southern section of the private haul road would similarly flow off the road surface onto the adjoining slopes or be managed by suitably sized table drains directing runoff to the upslope side of the road and then via grassed or rock-lined channels to the culverts beneath the road.

4.7.4.4 Saline Water Management

Environmental Dams

Groundwater inflows and surface runoff within the open cut pits would have elevated salinity levels and an increased risk of elevated levels of dissolved metals and hydrocarbons. The saline water would be managed on site in a closed water management system within an area referred to as the "saline water zone", an area comprising all open cut pits and three environmental dams. **Figure 4.45** displays the footprints of the three environmental dams within the boundary of the proposed open cut pit. The actual area of saline water zone would vary throughout the life of the amended Project.

From Year 1 of mining, any water accumulating in the open cut pits would be pumped to either or both Environmental Dams 1 and 2 (ED1 and ED2) positioned immediately south of the northern section of the western and northern amenity barrier, i.e. until the end of Year 10 when the dams would be removed to allow the northward progression of the Main Pit. Prior to the removal of Environmental Dams 1 and 2, the Applicant would construct a third dam, namely Environmental Dam 3 (ED3) over the backfilled Avon and Bowen Road Pits through the retention of a depression within the backfilled overburden. Environmental Dams 1, 2 and 3 would have a nominal capacity of approximately 310ML, 1 000ML and 1 550ML respectively. The dams would be constructed/excavated in a manner that would maximise the storage of water and minimise infiltration through the floor of and any constructed walls to the dams. The design of ED1 and ED2 would be finalised following site specific geotechnical testing with the ultimate sizing and design of ED3 determined following verifications of the storage requirement based on monitoring and updated modelling as well as local specific geotechnical testing.

The surface catchment areas for the three environmental dams would vary throughout the operational life of the amended Project. **Table 4.50** displays the catchment areas draining to the saline water zone dams within the five nominated operational years of the amended Project.

Table 4.50
Saline Water Zone Catchment Areas

Water Storage	Catchment Area (ha)				
	Year 0.5	Year 2	Year 4	Year 8	Year 15
Environmental Dam 1	4.0	25.0	20.6	10.9	0.0
Environmental Dam 2	12.4	18.3	16.8	16.8	0.0
Environmental Dam 3	0.0	0.0	0.0	0.0	13.2
Main Pit	28.7	54.3	135.2	141.8	90.8
Source: WRM (2016) – Table 3.3					

Figure 4.46 displays a simplified schematic of the proposed saline water management system to be adopted within the Mine Area.

Water Treatment

As discussed in Section 2.11.5, the Applicant would commence treating saline water in an on-site water treatment plant from early in Year 4 given there would not be sufficient storage capacity within the Mine Area and the need to reduce the quantity of saline water on site by the time coal extraction ceases.

The water treatment plant would remove up to 913ML of saline water from the Mine Area annually. This annual treatment capacity would only be required during extended wet periods. The Applicant proposes that, following treatment, the water would have an electrical conductivity of less than approximately 400µS/cm, i.e. similar to naturally occurring flows within the Avon River and Waukivory Creek and would be used for irrigation purposes on the adjoining Speldon Partnership Dairy, other adjacent properties owned by the Applicant and/or on rehabilitated areas of the interim or final landforms. In the event that conditions are unsuitable for irrigation, which would invariably be during high flows in the river, the Applicant would discharge the treated water into the Avon River from Release Point No. 6 (see **Figure 4.44**) (subject to conditions of the Site's environment protection licence).

It is noted that during Year 4 when WRM (2016) predicts 905ML of saline water would need to be treated, that quantity of water would be sufficient to irrigate between 226ha and 181ha of land at conservative annual irrigation rates of 4ML/ha to 5ML/ha respectively. This area of land represents less than 15% of the land owned by the Applicant within and adjacent to the Mine Area. Hence, there would be no difficulties for this proposed quantity of treated water to be irrigated on the Applicant's land within or adjacent to the Mine Area.

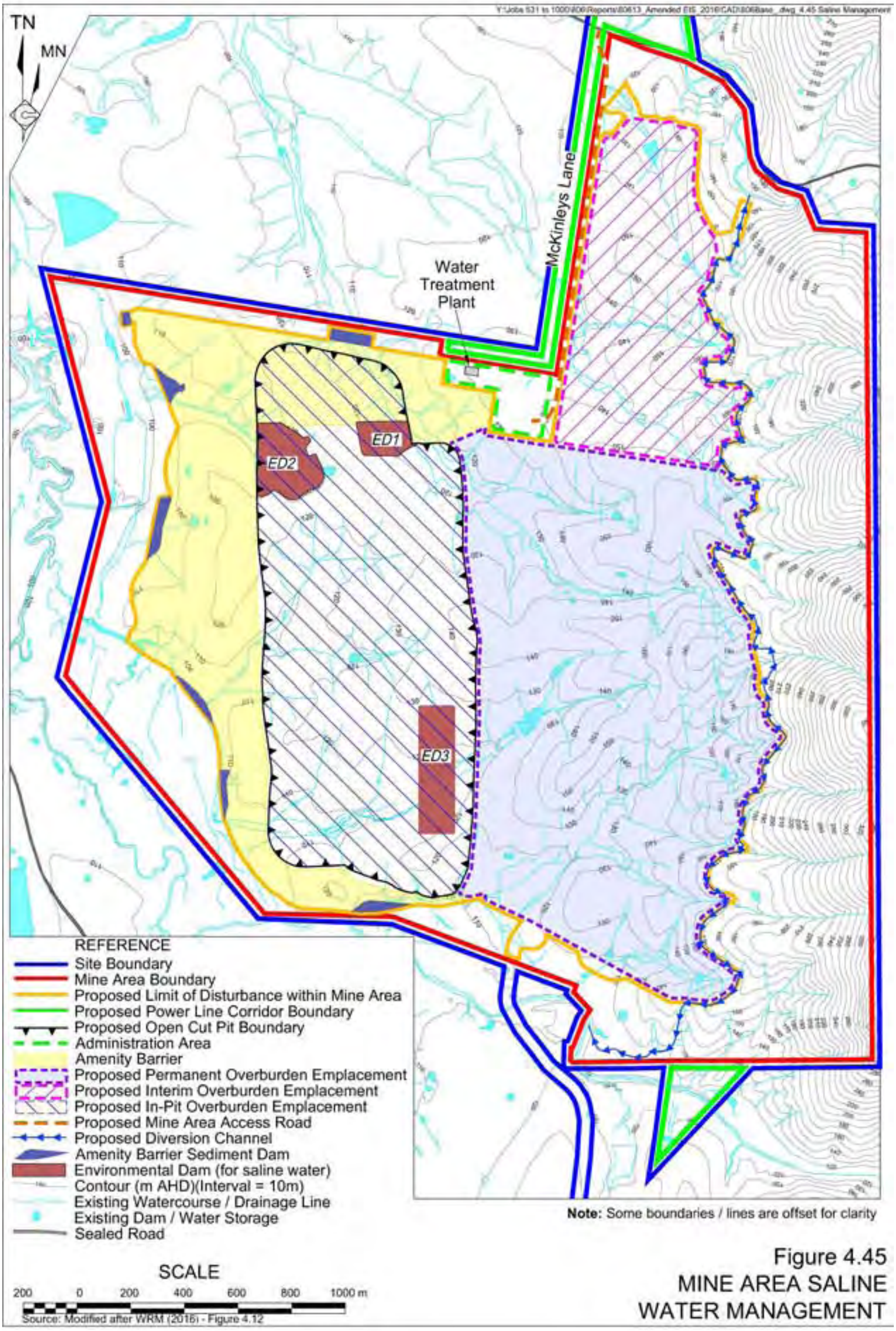


Figure 4.45
MINE AREA SALINE WATER MANAGEMENT

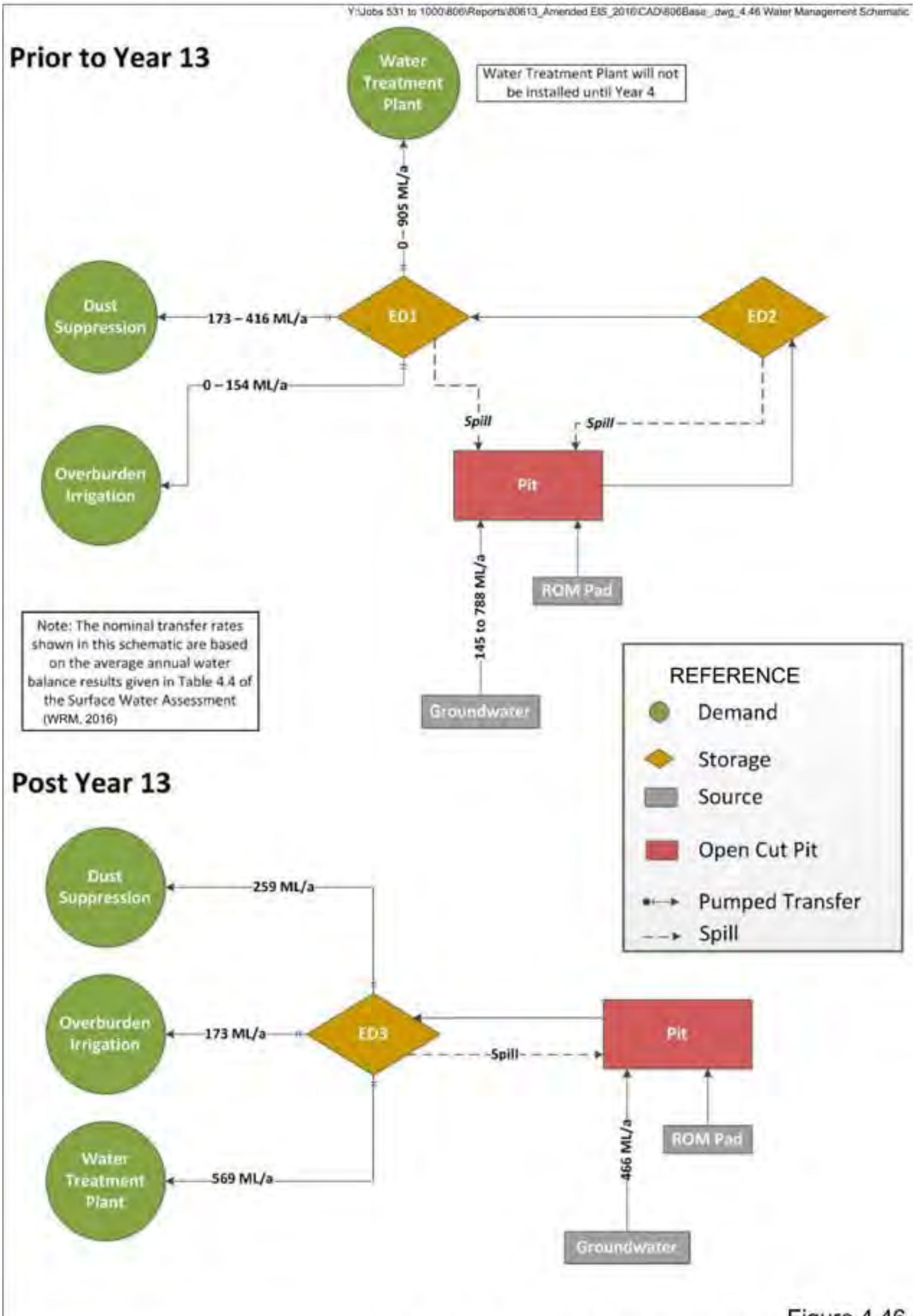


Figure 4.46
SALINE WATER MANAGEMENT SCHEMATIC

Source: WRM (2016) Figure 3.1

An estimated average of 6.9t of solidified salt material would be produced daily from the water treatment plant. The Applicant would consider a range of options for the disposal of salt including transportation off site to a waste facility authorised to accept the material, to a reprocessing facility to recover the useful salt species or directly to an end user.

4.7.4.5 Operational Water Management

Each of the three water management systems outlined in Section 4.7.4.3 would be adapted throughout the life of the amended Project, with each evolving to achieve the required control at the respective stage of operation.

WRM (2016) has compiled indicative surface water management layouts for six stages during and beyond the life of the amended Project, namely at:

- Year 0.5;
- Year 2;
- Year 4;
- Year 8;
- Year 15; and
- Final landform.

Figures 4.47 to **4.49** display the indicative water management layout for each of the six stages referred to above.

The key features of the operational water management system are as follows.

1. Construction of the clean water diversion channels (see **Figure 4.43**) as early as possible in areas away from the watercourses to allow sufficient time for establishment of a grassed channel coverage prior to their use.
2. Construction of Environmental Dams 1 and 2 early during Year 1.
3. Formation of Environmental Dam 3 commencing during Year 10.
4. Progressive construction of sediment dams throughout the life of the amended Project. **Table 4.51** lists the proposed volume of each dam, together with the maximum catchment area that would collect water for each dam.
5. The sizing of each sediment dam within the Mine Area to contain the projected sediment-laden water from the contributory catchment. In the longer term, as the bulk of the land within the Mine Area would be returned to grazing, the total capacity of the dams would be reduced to ensure the harvestable rights dam capacity for the final landform is equivalent to or less than the permissible total volume of 194ML.
6. Maintaining sufficient equipment within the Mine Area to enable the transfer of water between the open cut pits and water storages, when required.
7. Progressive re-establishment of new watercourses on the final landform to mimic the pre-mining drainage patterns.

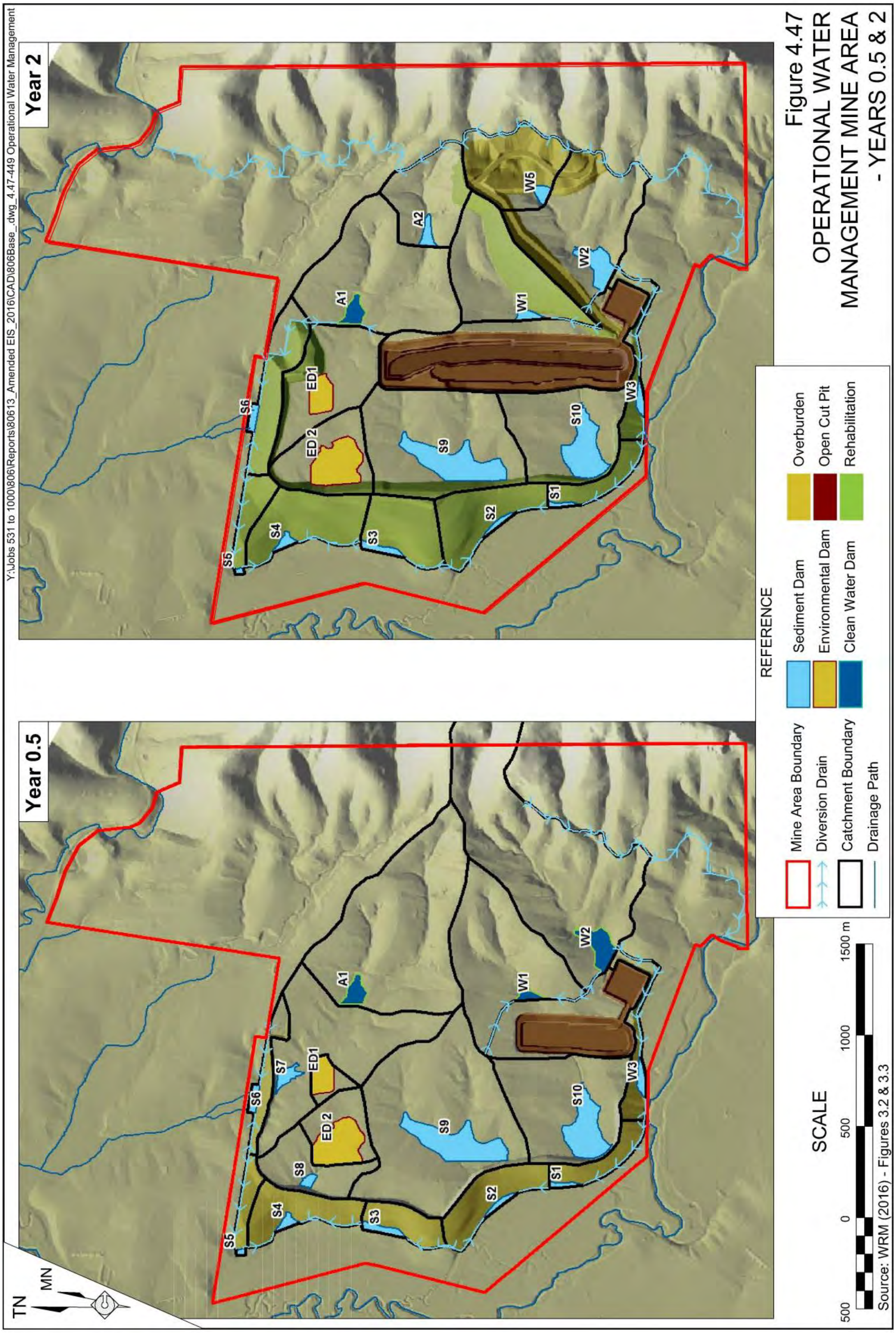


Figure 4.47
OPERATIONAL WATER MANAGEMENT MINE AREA - YEARS 0.5 & 2

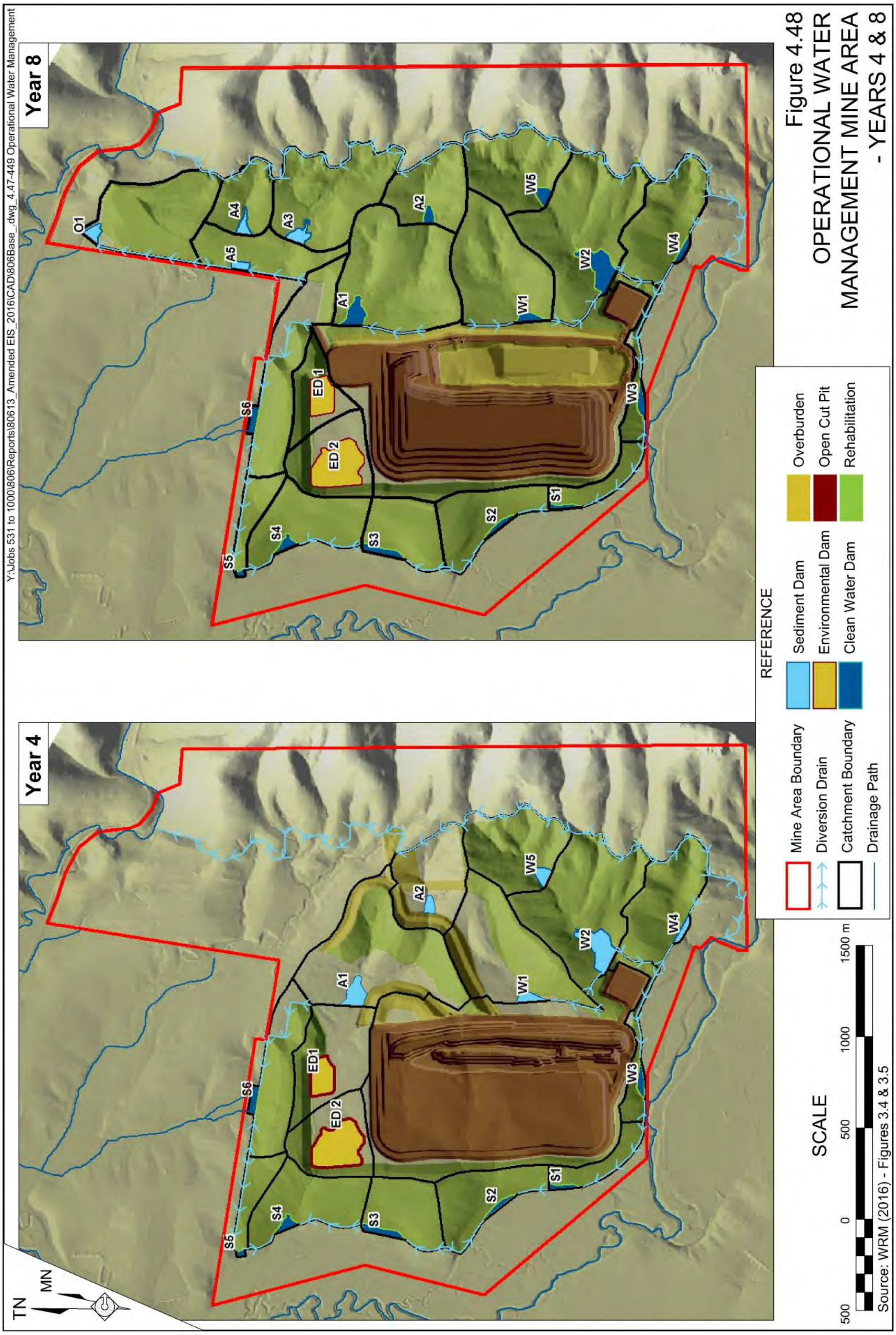


Figure 4.48
OPERATIONAL WATER MANAGEMENT MINE AREA - YEARS 4 & 8

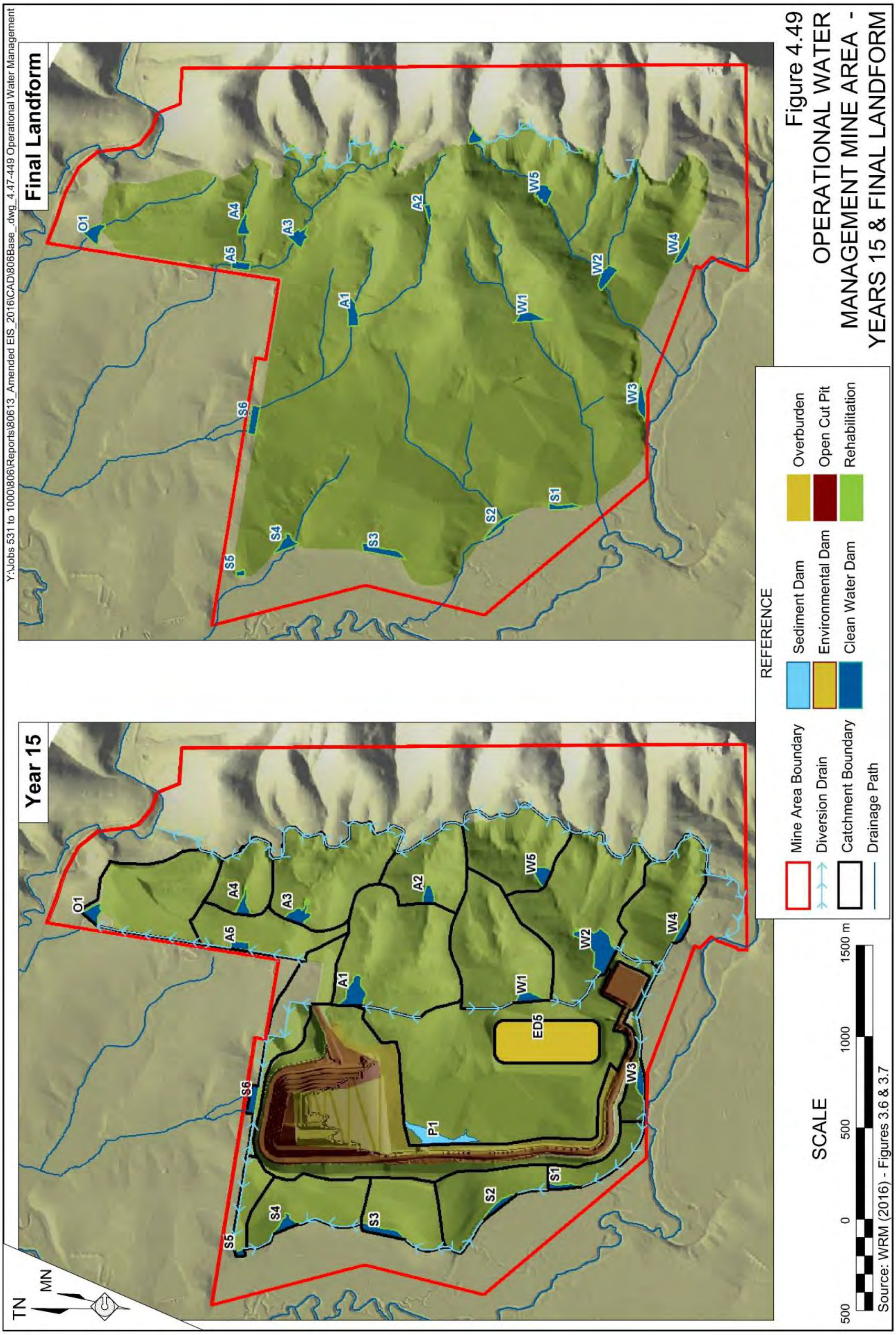


Figure 4.49
OPERATIONAL WATER MANAGEMENT MINE AREA - YEARS 15 & FINAL LANDFORM

Table 4.51
Sediment Dam Capacity Requirements

Sediment Dam*1	Catchment Area*2 (ha)	Settling Zone (ML)	Total Volume Required (ML)
A1	62.4	44.6	66.9
A2	19.0	13.6	20.4
A3	27.5	19.7	29.6
A4	10.9	7.8	11.7
A5	14.8	10.6	15.8
O1	25.2	18.1	27.1
P1	76.1	54.5	81.7
S1	6.8	4.9	7.3
S2	15.6	11.2	16.8
S3	14.0	10.0	15.0
S4	18.3	13.1	19.7
S5	6.3	4.5	6.8
S6	24.2	17.3	26.0
S7	37.5	26.8	40.3
S8	12.6	9.0	13.5
S9	66.7	47.7	71.6
S10	34.7	24.9	37.3
W1	36.7	26.3	39.4
W2	76.9	55.1	82.6
W3	7.0	5.0	7.5
W4	20.4	14.6	21.9
W5	20.1	14.4	21.6

*1 See **Figures 4.47**, **4.48** and **4.49**
*2 Maximum catchment area reporting to sediment dam over mine life

Source: WRM (2016) – Table 3.4

4.7.4.6 Site Water Balance

A site water balance has been undertaken to establish, the capacity required to store the projected combined saline water zone and surface water inflows within the environmental dams or voids throughout the life of the amended Project under a comprehensive range of rainfall scenarios. An understanding of this information is required to ensure sufficient storage is available and water management/treatment infrastructure is in place in advance and at all times to:

- prevent unauthorised discharges;
- ensure water is available for on-site dust suppression; and
- ensure the quantity of water is progressively reduced to a practical and manageable level at the end of coal extraction and prior to the commencement of mine closure and final rehabilitation activities.

WRM (2016) prepared the site water balance using the OPSIM model to simulate the operation of the water management system over the life the amended Project though the consideration of:

- rainfall and evaporation;
- catchment runoff and collection;
- open cut inflows (surface water and groundwater);
- pit dewatering;
- pump and gravity transfer;
- water storage filling and spilling; and
- water extraction, usage and transfer.

A brief overview is provided below, outlining the source of data used when assembling each of the components of the site water balance.

Rainfall and Evaporation: 126 years of daily rainfall and lake evaporation data has been used (including climatic variations). Results for wet (90th percentile) annual periods and dry (10th percentile) annual periods are displayed in Table 4.6 and Table 4.7 of WRM (2016).

Catchment Runoff Yield: Runoff was generated using the Australian Water Balance Model using input parameters reflecting the various land use types present throughout the life of the amended Project (based on experience reported at the nearby Stratford Coal Mine).

Open Cut Inflows and Pit Dewatering: Data assembled by AGE (2016) for each of the modelled years (**Table 4.52**) were adopted for pit inflows for the model.

Table 4.52
Groundwater Inflow Estimates

Mine Year	Total Groundwater Inflow Rate (ML/yr)	Recoverable Groundwater Inflow Rate*
0.5	181	145
2	500	400
4	994	795
8	794	635
15	588	470

* 80% of Total Groundwater Inflow Rate
Source: Total Groundwater Inflow Rate: Figure 4.38
Recoverable Groundwater Inflow Rate: WRM – Table 4.7

Pump and Gravity Transfer: It was assumed that maximum daily transfer by water pump or gravity would be 8.64ML.

Water Storage, Filling and Spilling: Stored water volumes were simulated on a daily basis as the sum of inflows and outflows from each dam.

Water Extraction Usage and Transfers: Demand for dust suppression water on the internal road network would vary from 173ML/yr to 416ML/yr (see **Table 4.53**). This is recognised as a minimum as further water could be applied to inactive areas. Annual throughput for the water treatment plant would be up to 913ML.

Table 4.53
Dust Suppression Demand

Haul Road Parameters	Year 0.5	Year 2	Year 4	Year 8	Year 15
Total Length (km)	4.50	11.20	11.80	13.40	11.00
Watered Road Width (m)	22	22	22	22	22
Average Daily Dust Suppression (ML)	0.42	0.76	0.79	0.95	0.88
Average Annual Dust Suppression (ML)	153	276	290	345	321
Average Annual Dust Suppression (OPSIM realisations) (ML)	173	257	310	416	259
Source: WRM (2016) – Table 3.8					

With the inclusion of all of the above inputs to the site water balance model, WRM (2016) recorded the following outflows and inflows throughout the life of the amended Project.

Outflows

- Total outflows to meet the identified water demand would range between approximately 173ML/yr and 1 441ML/yr.
- Evaporation from dam and pit water surfaces would range between approximately 35ML/yr and 163ML/yr.
- No overflows would occur throughout the life of the amended Project.
- Net outflows in Year 8 and Year 15 would be required to dispose of excess water accumulated in the Saline Water Zone to allow backfilling of the remaining open cut pit void and decommissioning of Environmental Dam 3.

Inflows

- Combined runoff and direct rainfall would contribute between approximately 168ML/yr and 784ML/yr;
- Groundwater would contribute a large proportion of the total water inflows (between approximately 145ML/yr and 788ML/yr); and
- Beyond Year 2, total inflows would be relatively high, due to the size of the Saline Water Zone catchment area. Therefore, without a mechanism to dispose of excess water, e.g. water treatment, stored water inventories could be expected to increase significantly over this period.

The site water balance modelling shows that without a water treatment plant, beyond about Year 4 there would be limited potential to store saline water within the Mine Area without creating operational issues within the open cut pits. Furthermore, the modelling identified that there would an excessive quantity of saline water accumulated by the end of Year 16 such that its management would be problematic. It is noted that by the end of Year 16, the Applicant would be able to progressively transfer any water remaining in Dam ED3 into the Main Pit to then enable the dam to be backfilled.

The introduction of a water treatment plant in Year 4 with a capacity to treat 2.5ML/day or 913ML/yr would effectively balance the saline water management and prevent excessive quantities of water from accumulating within the saline water zone.

An important outcome from the water balance modelling is the lack of need to extract water from the Avon River, Waukivory Creek or the on-site sediment dams throughout the operational life of the amended Project, i.e. beyond perhaps during Year 1. The water from the on-site sediment dams, once of an acceptable quality, would be directed via approved Release Points 1 to 5 (see **Figure 4.44**) to the existing creek / river system to maintain environmental flows (subject to the Site's environment protection licence conditions) or irrigated on interim or final landforms within the Mine Area.

4.7.4.7 Site Salt Balance

The main source (up to approximately 75%) of salt would be groundwater inflows, although some surface runoff from overburden material would also contribute to the overall salt load. The results of the modelling of the saline water zone show the salinity of the stored water would fluctuate with rainfall and evaporation, making it unsuitable for release.

Some salt would be transferred from the Saline Water Zone back to the overburden via dust suppression on haul roads and overburden. The remainder will be removed from the system via the proposed water treatment plant.

The quantity of salt produced by the water treatment plant would be dependent on the volume and salinity of the water treated. This would vary on a daily basis due to changes in groundwater inflow rates and climatic conditions. The results of the water balance model show that there would be an average of 6.9 tonnes of solidified salt material produced daily or approximately 2 520t/yr from the start of Year 4 (a 13 year period of operation). Based on the average annual salt balance, the water treatment plant would generate a total of approximately 32 800 tonnes of solidified salt material over the life of the amended Project.

The Applicant would consider a range of options for the disposal of the salt including transportation off site to a waste facility authorised to accept the material, to a reprocessing facility to recover the useful salt species or directly to an alternate end user.

4.7.5 Assessment of Impacts

4.7.5.1 Introduction

The design and operational safeguards, together with the results of the computer modelling outlined in Section 4.7.4, assisted WRM (2016) to assess the residual impacts within and in the vicinity of the Site for those potential impacts outlined in Section 4.7.3. The residual impacts are outlined in the following subsections. The assessment of impacts have been compiled in recognition of the general goals nominated in the NSW Water Quality and River Flow Objectives.

4.7.5.2 Downstream Flows

Downstream flows could be impacted by the extraction of water from the Avon water source; the diversion of upstream clean water; interception of runoff in the saline water zone; temporary changes in runoff characteristics; loss of baseflow recharge and discharges from the water treatment plant, each of which is separately assessed.

Avon River Water Source Extraction

The requirement for water during the site establishment and construction stage and the first year of operations would be up to approximately 153ML. In the unlikely event that some or all of this volume cannot all be obtained from on-site sources, the shortfall could be pumped from the Avon River using the Applicant's existing entitlement of 267ML/yr for its five water access licences. AGE (2016) and WRM (2016) predict initial groundwater inflows to the Avon Pit in Year 1 (of approximately 231ML/yr) together with surface runoff captured within the Mine Area, will provide the bulk, if not all of its water requirements in Year 1. The Applicant would ensure sufficient water access licences/entitlements are held prior to Year 1 and during subsequent years to match the groundwater inflows to the open cut pits.

In the unlikely event that the Applicant needs to rely significantly on pumping water from the creek/water systems during the site establishment and construction stage or Year 1, the impacts on downstream flows would be comparable to those when the former licence holders were pumping from the creek/river system.

Beyond Year 1, when it is predicted that groundwater and surface inflows captured in the saline water zone would satisfy all on-site requirements, the Applicant would not need to pump any water from the creek / river system. Under these circumstances, the opportunity could arise whereby the Applicant could assign the use of the licenced water for short periods to nearby or adjoining landowners who would like to use the water for irrigation or other agricultural-related practices. In any event, the flow as a result of the ongoing operation of the amended Project, would not impact upon downstream flow beyond what the NSW Office of Water has permitted.

Clean Water Diversion to Avon River Flows

The construction of the southern and northern clean water diversions upslope from the area of disturbance within the Mine Area would intercept runoff that would normally flow to the Avon River or Waukivory Creek. The losses within each of the Avon River and Waukivory Creek catchment areas diverted to Oaky Creek by the northern clean water diversion channel would result in a corresponding 16.8% increase to the catchment area of Oaky Creek over the life of the amended Project.

The southern diversion channel would effectively divert runoff from the lower sections of Waukivory Creek to an inflow point further upstream, thereby increasing flows for a 1km section of the creek. This increase amounts to approximately 1% of the existing Waukivory Creek catchment to the upstream of this confluence.

Once the final landform is in place and the diversion channels no longer function, the proportional losses would be negligible. The capacity of the dams retained on site would comply with the harvestable right dam capacity for the Applicant's landholding.

Interception of Runoff in the Saline Water Zone

The saline water zone would capture some runoff that would normally flow into Waukivory and Oaky Creeks. **Table 4.54** lists the proportional loss of the surface runoff catchments within both Waukivory Creek and the Avon River (to its confluence with Oaky Creek).

Table 4.54
Proportional Loss of Surface Runoff Catchment

Mine Year	Waukivory Creek upstream of Avon River	Avon River upstream of Oaky Creek[1]
Year 0.5	0.3	0.2
Year 2	0.6	0.4
Year 4	1.4	0.8
Year 8	1.4	0.8
Year 15	0.6	0.5
[1] includes impacts on Waukivory Creek		
Source: WRM (2016) – Table 4.10		

The largest impact would occur between Years 4 and 8 when up to 1.4% of the total catchment of Waukivory Creek and 0.8% of the Avon River catchment (to the Oaky Creek confluence) would be lost.

It is noted however, that the mean annual rainfall in the upper Avon River and Waukivory Creek catchments is higher than within the Site and it is therefore likely that the upper catchment contributes proportionally more surface water runoff than the Mine Area catchments. As a consequence, the proportional loss of catchment areas is therefore a conservative estimate of catchment loss to the receiving watercourses.

Temporary Change in Runoff Characteristics

Throughout the life of the amended Project, enhanced infiltration and reduced runoff would occur within the overburden emplacements, i.e. until the revegetation of the final landform is well established. The retention of runoff within the various sediment dams would reduce runoff into the creeks, albeit for a short period until the water achieves a quality which would be acceptable for it to be released. This reduction would be partly compensated by the re-direction of upslope runoff around the proposed disturbance areas that would normally flow through the Mine Area and use of treated water for irrigation of adjacent landholdings, thereby decreasing the requirements for extractions from the river/creek system under licence and/or the volume of runoff harvested for agricultural purposes.

WRM (2016) estimates that, ignoring the indirect benefits arising from the use of treated water, the greatest reduction in surface water flows would occur in Year 1 (55.1ML) and least in Years 8 and 15 (0ML). Throughout the life of the amended Project, the mean total reduction in flow would be approximately 171ML. WRM (2016) notes that these changes are an order of magnitude smaller than the volume of water retained in the saline water zone. Following the stabilisation of slopes and watercourses on the final landform, the clean water diversion channels would be decommissioned which would allow upslope runoff to again flow through the Mine Area to the Avon River and Waukivory Creek.

Loss of Baseflow Recharge

Throughout the life of the amended Project, a temporary loss of water from within the Quaternary alluvium of between 0.02ML/day and 0.53ML/day is predicted, the majority of which would comprise saline water originating from the Permian strata which would otherwise have presented as sub-surface discharge to the alluvium. Loss would average approximately 0.27ML/day.

The baseflow reduction at the end of coal extraction would be approximately 0.27ML/day which is approximately 2.6% of the naturally occurring median flow in the Avon River (10.2ML/day). Approximately 10 years after the cessation of coal extraction, groundwater levels, and hence base flows to the surrounding watercourses are predicted to return to near pre-mining levels.

Discharge from the Water Treatment Plant

Whilst the Applicant intends to use as much of the treated water as possible to irrigate pastures on the adjoining Speldon Partnership Dairy, its other adjacent landholding and rehabilitation areas, it is envisaged that on occasions, coinciding with periods of prolonged high rainfall, that irrigation may not be practical. Under those circumstances, the Applicant would discharge the treated water from the northern boundary of the Mine Area (at Licenced Discharge Point 6 – see **Figure 4.44**) from where it would overflow via an existing drainage path to the Avon River. WRM (2016) estimates that the flow rate in the Avon River under these circumstances are likely to be in excess of 25ML/day which would mean the water discharged from the Mine Area would amount to less than 10% of flow in the Avon River, a level considered to have negligible impact.

Conclusion

Amended Project

The combined effect of the potential streamflow impacts attributable to the amended Project identified in the previous subsections would vary from reach to reach of the impacted sections of the Avon River, Waukivory and Oaky Creeks, with the amended Project potentially impacting 14.9km of these watercourses upstream of the Avon River/Oaky Creek confluence. Excluding extraction under the provision of the Applicant's water access licences, the assessment concluded the following.

1. The amended Project would not impact on:
   - the Avon River upstream of the Waukivory Creek confluence;
   - Waukivory Creek upstream of the southern diversion channel outlet; or
   - Oaky Creek upstream of the northern clean water diversion channel outlet.
2. The amended Project would increase flows in:
   - the downstream 3.3km of Oaky Creek to the Avon River confluence by up to 13.3%; and
   - the 1.1km reach of Waukivory Creek immediately downstream of the southern diversion channel outlet by up to 0.5%.

3. The amended Project would decrease flows in:
   - the 4.4km reach of Waukivory Creek upstream of the Avon River confluence by up to 2.1%; and
   - the Avon River downstream of the Mine Area (to Oaky Creek) by up to 1.5%. The relative impact on the Avon River and downstream waterways would reduce significantly downstream due to the contribution of other tributaries to total streamflow.

Cumulative Impacts

Overall, whilst there would be a range of changes to flows in the watercourses within and around the Mine Area throughout the life of the amended Project, the changes would be comparatively minor and unlikely to cause any noticeable impacts. Importantly, the pre-mining flow conditions in the various local watercourses would return within approximately 10 years of the cessation of coal extraction.

The long-term catchment loss attributable to the Stratford Extension Project would be in the order of 2.1km^2 (Gilbert & Associates, 2012). These losses are not within the Waukivory or Oaky Creek catchments. The cumulative reduction in flow in the Avon River, i.e. between the amended Project and the Stratford Mining Complex would be approximately 4.8% adjacent to the Mine Area and 4.4% downstream of its confluence with Oaky Creek. WRM (2016) records that approximately two-thirds of the above reductions would be attributed to the Stratford Mining Complex with the remaining third attributed to the amended Project.

4.7.5.3 Impacts of Streamflow Loss on Other Surface Water Users

The reductions in streamflows attributed to the amended Project that were outlined in Section 4.7.5.2 would, to a small degree, affect the frequency and duration of low flow periods in the Avon River which could, in turn, increase the likelihood that cease-to-pump requirements are invoked more frequently.

Through their review of the historical flow record and the minor reduction in flows attributable to the amended Project, WRM (2016) has established that had the amended Project been in place for the 12 year period of Avon River streamflow records, the amended Project would have caused the total duration of cease-to-flow periods to increase from 533 days to 691 days (i.e. from approximately 13.9% of the time to 16.8% of the time).

4.7.5.4 Impacts upon Downstream Water Quality

The quality of water within the Avon River and Waukivory and Oaky Creeks has previously been described in Section 4.7.2.6.

The impacts upon water quality in these watercourses attributed to the amended Project would reflect:

i) runoff from sediment dams;

ii) runoff from revegetated landforms;

iii) occasional discharges of water from the water treatment plant; and

iv) reductions in saline water inflows to the alluvial groundwater system which in turn contributes to baseflow in the local watercourses.

It is noted that the planned water management system would result in no saline water accumulating in the open cut pits being discharged to the surrounding watercourses, i.e. the amended Project would operate as a “no discharge” mine in terms of saline mine water.

Based upon the geochemical investigations undertaken by RGS Environmental (RGS, 2016) involving a series of static and kinetic leach tests of overburden and interburden, the water captured in sediment dams is expected to be relatively good quality and, as such, suitable for release.

WRM (2016) established that the discharge of treated water during periods of high flow in the Avon River would have negligible impacts upon water quality.

The Applicant has identified six release points around the margin of the Mine Area (see **Figure 4.50**) at which only water satisfying the discharge quality limits on the Site’s environment protection licence would be released. The releases would invariably be undertaken within five days of the rainfall event that generated the runoff into the sediment dams. **Figure 4.50** also displays the locations of the current external monitoring locations that the Applicant would continue to monitor throughout the life of the amended Project. Surface water monitoring is addressed further in Section 4.7.6.

Table 4.55 lists potential water quality discharge limits, some or all of which could be included in the EPL for the amended Project.

Table 4.55
Potential Water Quality Discharge Limits

Analyte	Units	Limit Value
pH	pH Unit	6.5 to 8.0
Electrical Conductivity	µS/cm	30 to 465
Total Suspended Solids	mg/L	50
Turbidity (low flow)	NTU	2 to 25
Turbidity (high flow)[1]	NTU	2 to 50
Arsenic	mg/L	0.0240
Cadmium	mg/L	0.0002
Chromium[1]	mg/L	0.0080
Copper[1]	mg/L	0.0040
Lead[1]	mg/L	0.0040
Manganese	mg/L	1.9000
Nickel	mg/L	0.0110
Selenium	mg/L	0.0110
Zinc[1]	mg/L	0.0250
Iron	mg/L	0.3
Oil and Grease	mg/L	10.0
Ammonia as Total Ammonia	mg/L	0.900
Total Nitrogen as N	mg/L	0.25
Total Phosphorus as P	mg/L	0.02
[1] 80th percentile of receiving water quality monitoring data		
Source: WRM (2016) – Table 4.15		

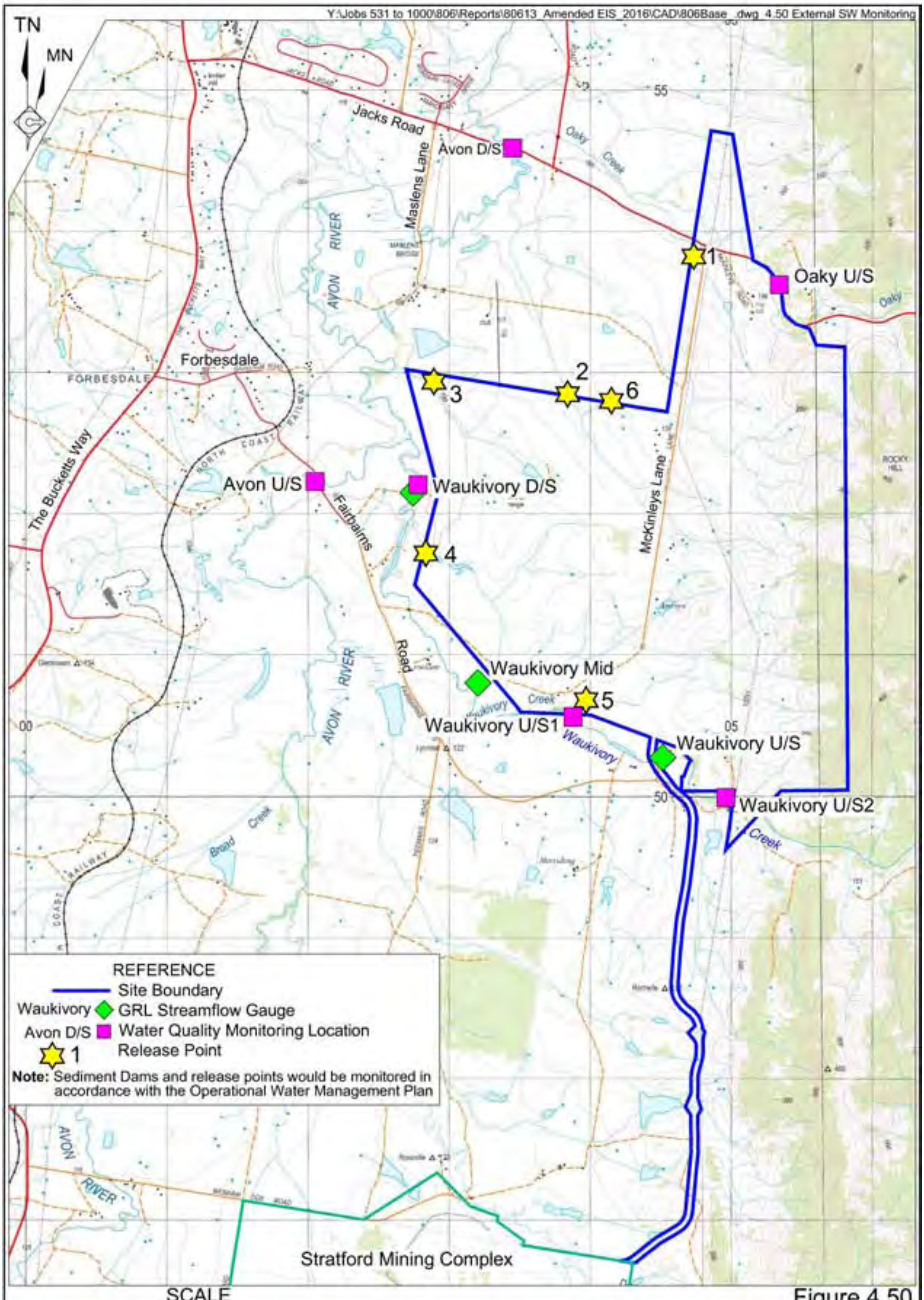


Figure 4.50
EXTERNAL SURFACE WATER QUALITY MONITORING LOCATIONS

The limits listed in **Table 4.55** are based upon the NSW Water Quality Objectives for the protection of aquatic ecosystems in upland rivers of the Manning River catchment as well as the ANZECC (2000) trigger values for 95% protection of freshwater species. Where the 80th percentile of the Applicant's water quality monitoring data for the Avon River and Waukivory and Oaky Creeks exceeds the guideline value, the 80th percentile value has been adopted.

Based on the assembled information from RGS (2016), and the potential water quality discharge limits (**Table 4.55**), the quality of the water would be comparable to, or higher than that of surface water runoff elsewhere within the Avon River or Waukivory Creek catchments. As a feeder catchment for the larger downstream Manning River catchment, which supplies a number of towns with drinking water through the MidCoast Water's Manning Scheme, the quality of the surface water released from the Site would not impact downstream water quality or impact upon the MidCoast Water's Manning Scheme.

4.7.5.5 Flooding

The amended Project has the potential to influence existing flood flows in three areas.

1. Adjacent to the western section of the western and northern amenity barrier and the embankment for the ROM pad.
2. In the vicinity of the bridge crossing Waukivory Creek along the alignment of the private haul road.
3. Within Oaky Creek as a result of the redirected flows from the upstream northern clean water diversion.

The impacts relating to 1. and 2. above arising from flooding within the Avon River and Waukivory Creek have been established by WRM (2016) using hydrological and two-dimensional hydrodynamic flood models calibrated to recent flood events. WRM (2016) – Appendix C presents a detailed flood study including figures presenting the impacts of the amended Project in terms of flood levels and velocities for a range of annual exceedance probabilities. **Figure 4.51** displays the modelled 1 in 100 Annual Exceedance Probability (AEP) flood level for both the Avon River and Waukivory Creek once the western and northern amenity barrier, ROM pad and Waukivory Creek bridge are constructed.

Amenity Barrier and ROM Pad Flooding Impacts

The minor encroachment of southern sections of the proposed western and northern amenity barrier onto the edge of the Avon River and Waukivory Creek floodplains in a 1 in 100 AEP flood event would cause an increase in the flood level of up to 0.1m in two small areas adjacent to the southern section of the barrier. The modelled velocity increase in the vicinity of the barrier would be 0.4m/s in three localised areas adjacent to the barrier. Where flood flow velocities are predicted to be relatively high, there may be a need for localised scour protection at the toe of the western section of the western and northern amenity barrier.

Figure 4.21 and Figure 4.22 of WRM (2016) display the area of flood affectation during both 1 in 10 AEP and 1 in 100 AEP events, superimposed on the footprint of the western and northern amenity barrier, with the predicted flood levels and flood velocities for a 1 in 10 AEP and a 1 in 100 AEP flood event shown on Figures 4.23 to Figure 4.26 of WRM (2016). The results of the assessment indicate that negligible wide-scale and relatively minor local increases in flow velocities and depth would be experienced under both 1 in 10 and 1 in 100 AEP flood events.

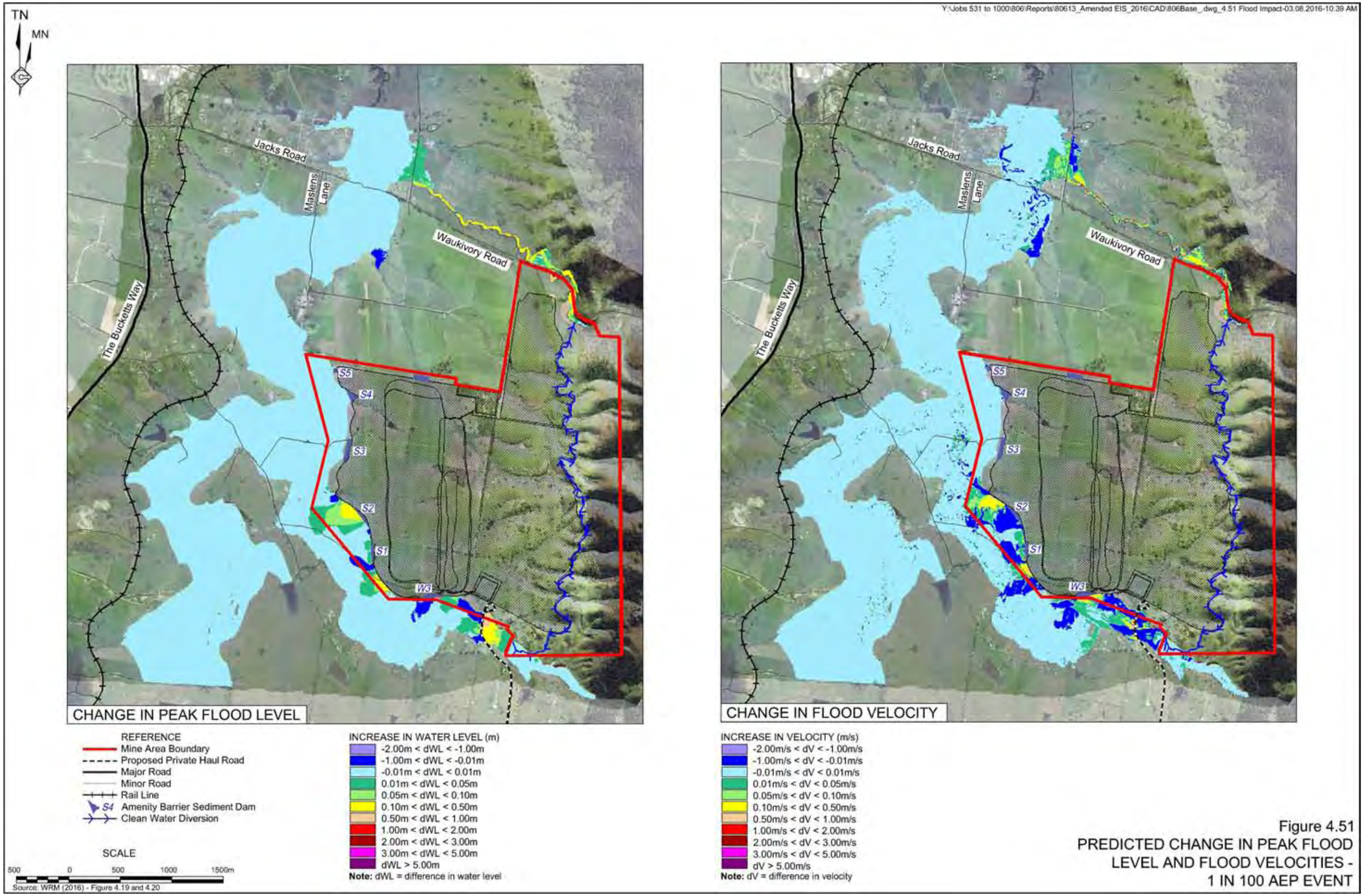


Figure 4.51
PREDICTED CHANGE IN PEAK FLOOD LEVEL AND FLOOD VELOCITIES - 1 IN 100 AEP EVENT

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Waukivory Creek Bridge Crossing

Localised increases in water levels of up to 0.1m would occur in two small areas (adjacent to Dam S2 and between Dams S1 and W3) and flood velocities of up to 0.4m/s would occur in three small areas (adjacent to Dams S1, S2 and W3) during a 1 in 100 AEP flood event (see **Figure 4.51**). In order to avoid floodwaters entering the amenity barrier sediment dams, the spillway for each dam would be constructed at an elevation above the 1 in 1 000 AEP flood level. Localised scour protection would be provided when Dams S1, S2 and W3 are constructed.

The predicted flood-related impacts would not occur beyond the end of the life of the amended Project as the pre-mining landform adjacent to the watercourses would be re-instated.

The Applicant proposes to construct the bridge across Waukivory Creek with a low profile and approach ramps, principally to minimise flood-related impacts. WRM (2016) established through the flood modelling discussed above and displayed in **Figure 4.51** that flood levels upstream of the bridge would increase by between 0.5m and 1m during a 1 in 100 AEP flood, albeit in a section of creek that is comparatively narrow. Localised increases in flood velocities of up to 3m/s would occur where flood waters overtop the low level approach ramps to the bridge. All increased flood levels would occur on resource company-owned land.

Oaky Creek

The northern clean water diversion channel diverting runoff from the undisturbed upslope catchments north to Oaky Creek would increase the 1 in 10 AEP design discharge in Oaky Creek to that of the pre-mine 1 in 20 AEP flood. This would result in an increase in the potential bank erosion within Oaky Creek, especially at “pinch points” along the channel. However, the increased risk is relatively small, and would only occur during the life of the amended Project, i.e. until the northern clean water channel is decommissioned. Consequently, it is anticipated that impacts on Waukivory Creek would be negligible. WRM (2016) notes that the increases in flood levels occur predominantly on land owned by the Applicant with the exception of 375m of Oaky Creek.

Climate Change Impacts

The flooding assessment also established that the floodplain behaviour of the Avon River and Waukivory Creek is relatively insensitive to modelled climate change impacts. WRM (2016) calculated that for a 30% increase in annual rainfall, flood levels would be 0.4m higher than the base case. By comparison, this increase amounts to only one sixth of the level generated by a 1 in 100 AEP flood.

Conclusion

As a result of the calibrated flood modelling, it is determined that a 1 in 100 AEP flood event would not significantly impact upon the amended Project’s infrastructure. The 1 in 100 AEP flood within the Avon River and Waukivory Creek would encroach slightly on the sections of the proposed western and northern amenity barrier. These changes are predicted to be localised and negligible. WRM (2016) determined that these changes will not significantly alter or affect the downstream characteristics of a flood, with no impacts expected on downstream developments or properties as a result of the amended Project. The design of the amended Project would effectively ensure that, with the exception of the private haul road in the vicinity of Waukivory Creek, the major components of the Site would remain unaffected directly by a

1 in 100 AEP flood event and the Applicant would be in a position to continue mining, i.e. subject to access to the Mine Area being available via the public road network. The Applicant would not transport coal to the Stratford Mining Complex during flooding. With this outcome, there would be no unsustainable social and economic cost to the community.

4.7.5.6 Geomorphic Stability

WRM (2016) examined the potential for the amended Project to affect the stability of the key watercourses near the Site, namely the Avon River and Waukivory and Oaky Creeks, principally through the re-direction of runoff from the southern and northern clean water diversion channels. WRM (2016) concludes that the amended Project would have no significant impact on the Avon River or Waukivory Creek channels whereas potential exists for increased bank erosion in Oaky Creek. However, after examining the changes in channel velocity, stream power and shear stress, the potential for the change in hydraulic conditions was assessed to be small and have no significant impact on the geomorphic stability of Oaky Creek. Notwithstanding this conclusion, WRM (2016) recommended that photography and ground surveys along Oaky Creek would be appropriate to establish whether any erosion control measures are required.

4.7.5.7 Compliance with Legislative Requirements

All of the legislative requirements principally relate to the provisions/requirements of the *Water Management Act 2000*.

Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2009

The amended Project would not require the use any water from the Avon River Water Source unless dry conditions prevail during the site establishment and construction stage and Year 1 operations and require some extraction from the Avon River and/or Waukivory Creek. Beyond Year 1, all supplies would be obtained from the following sources, in order of priority.

- Groundwater and surface water that has come into contact with coal (saline water).
- Treated water from the water treatment plant (beyond Year 4).
- Water captured in the sediment dams constructed as part of the water management system (either as exempt works or authorised under the Harvestable Rights provisions).

In the event on-site supplies are insufficient, water would be pumped from the adjacent reaches of the Avon River or Waukivory Creek under the provisions of the Applicant’s water access licences. As there are no individual daily extraction limits specified for the Avon River Water Source, the daily extraction would be limited to that proportion of the total daily extraction limit equivalent to the Applicant’s share entitlement of the Water Source.

The Applicant would undertake annual water accounting consistent with the rules of the water sharing plan and submit a report detailing the results to DPI-Water.

Harvestable Rights Dam Capacity

Based on the NSW Office of Water calculator, the maximum harvestable rights dam capacity (MHRDC) at the Rocky Hill Coal Project is approximately 0.10ML/ha. The Applicant currently has contiguous landholdings over the proposed Mine Area of 1 790ha, with options to increase this to 1 935ha once development consent is granted. This equates to a MHRDC of 194ML/yr.

On cessation of coal extraction activities, a number of the proposed site water management dams would be progressively decommissioned or reduced in capacity once no longer required to control downstream runoff quality, with the aggregate capacity of the dams to be retained to assist in supplying water for post-mining land use activities not exceeding the MHRDC for the Applicant's contiguous landholding.

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 Central Rivers catchments. Natural resources features to be protected and enhanced are identified, along with actions to achieve key outcomes. The amended Project is consistent with the objectives of the SWMOP and CAP, because:

- surface disturbance is restricted to defined areas within the Site. Impacts would be mitigated within the site water management system. Erosion and sediment controls would be designed and operated in accordance with the Blue Book requirements (DECC, 2008);
- any extraction of water would be in accordance with licensing provisions; and
- discharges from the Mine Area would only occur if water complies with the Site's environment protection licence.

4.7.6 Monitoring

4.7.6.1 Water Quality

The Applicant would undertake a program of water quality monitoring to:

i) confirm the quality of water being generated/collected on site is generally consistent with that presented in **Table 4.55**;

ii) confirm that water to be released off site complies with the limits identified in **Table 4.55** or the Site EPL and is of suitable quality to enter the Avon River/Waukivory Creek catchments and to potentially be used downstream within the Manning River Catchment as a drinking water source through MidCoast Water's Manning Scheme; and

iii) establish the extent (if any) to which runoff from the Mine Area is having an adverse impact on water quality within the surrounding creek/river network.

Figure 4.50 displays the locations external to the disturbance area where monitoring is proposed to continue, i.e. within the Mine Area and within the surrounding stream / river network, typically on a monthly basis initially and/or immediately following substantial rainfall events (i.e. >25mm in 24hrs). The Applicant would undertake additional surface water monitoring within the disturbance area to assist in understanding the relationship between the various activities being undertaken and water quality. Details of this monitoring would be outlined in the Water Management Plan for the amended Project.

The Applicant would also undertake a program of water quality checks, as required, to ensure that the treated water produced within the water treatment plant is consistent with the performance criteria for the plant.

All relevant results would be presented in the Annual Review for the amended Project with the results from the sites listed in the environment protection licence included in the Annual Return for the licence.

4.7.6.2 Water Management Structures

The Applicant would construct all water management infrastructures in accordance with the "Blue Book" (DECC, 2008) and undertake a visual inspection of the structural integrity of the full range of water management structures on a monthly basis or immediately following substantial rainfall events. Any required recommendations/repair work would be undertaken as soon as practicable after the inspection. Should any major deficiencies or problems be identified, the Applicant would engage the assistance of a suitably experienced and qualified civil / drainage engineer to provide recommendations as to the works necessary to rectify those deficiencies.

4.7.7 Conclusion

The design of the amended Project, in terms of separating the surface water streams into clean water, sediment-laden water and saline water management streams, would ensure that potential surface water impacts are managed appropriately. The installation and operation of a water treatment plant to treat the excess saline water would reduce the need for surface storages with a capacity to store the projected groundwater and surface water inflows under a range of rainfall scenarios. Sufficient water would be available for ongoing operations such as on-site dust suppression throughout the life of the amended Project.

Flooding events equal to a 1 in 1 000 AEP flood event would not significantly affect the amended Project or alter the surrounding environment.

With the implementation of all surface water mitigation and management measures proposed for the Site, it is assessed that surface water would be appropriately managed with negligible impacts on the surrounding environment or downstream surface water users, and within the provisions set out in the respective legislative requirements.