Appendix 7

Blasting Impact Assessment

ACOUSTICS AND AIR

BULGA OPTIMISATION PROJECT

BLASTING NOISE & VIBRATION IMPACTS ASSESSMENT

REPORT NO. 11057 RP2
VERSION D

DECEMBER 2012

PREPARED FOR

BULGA COAL MANAGEMENT PTY LTD

WILKINSON MURRAY

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ABBREVIATIONS & DEFINITIONS

The following abbreviations and acronyms appear throughout the report.

Terminology	Description
Airblast	(Also referred to as overpressure) Instantaneous increase in air pressure caused by blasting
ANFO	Ammonium Nitrate Fuel Oil
ANZECC	Australian and New Zealand Conservation Council – responsible for blasting guidelines referred to in the approval for the Bulga Coal Mine
BCC	Bulga Coal Complex [The Mine]
BCM	Bulga Coal Mine [The Managers of the Mine]
BOP	Bulga Optimisation Project
DEC	Department of Environment & Conservation (now the EPA)
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
Interburden	The material layer that separates two economic coal layers (seams)
Overburden	The material that lies above the economic coal layer
Overpressure	(See airblast)
MIC	Maximum Instantaneous Charge
Mtpa	Million tonnes per annum (rate of extraction)
PPV	Peak Particle Velocity – the measure of ground vibration caused by blasting
ROM	Run-of-mine – raw coal produced at a mine
Site Law	[Blasting Site Law] An empirically-derived formula based on previous blast monitoring data used for predicting future blast vibration levels

1 INTRODUCTION

This report details the assessment of the potential for noise and vibration impacts upon nearby residential receivers, heritage structures and other infrastructure from blasting operations proposed for the Bulga Optimisation Project (the Project).

When blasting occurs at mines, the energy from the blast can propagate through the ground to the surrounding area in the form of vibration. In addition, the energy can also be released into the air and can propagate over the ground into the surrounding area. This latter phenomenon is a type of low frequency noise which is often termed airblast.

The Project is a State Significant Development under Part 4 of the NSW Environmental Planning and Assessment Act 1979.

This assessment has been undertaken in accordance with the Director-General's Environmental Assessment Requirements issued by the NSW Department of Planning and Infrastructure (DP&I) on 14 December 2011. In relation to impacts from blasting, these are:

> ***Noise, Vibration & Blasting*** *– including a quantitative assessment of potential:*
>
> - *blasting impacts on people, livestock and property;*
> - *reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed, and*
> - *monitoring and management measures, in particular, real-time, attended noise monitoring and predictive meteorological forecasting.*

The NSW Environment Protection Authority (EPA) has also outlined its agency comments for the blasting assessment. Those comments relating to blasting, and the section where they are addressed in this assessment, are outlined in **Table 1-1**.

Table 1-1
EPA Environmental Assessment Noise and Agency Comments

Comment	Section
General	
Vibration from all activities (including construction and operation) to be undertaken on the premises should be assessed using the guidelines contained in Assessing Vibration: a technical guideline (DEC, 2006) *http://www.environment.nsw.gov.au/noise/industrial.htm*	N/A – this requirement applies to activities giving rise to continuous vibration, not blasting
If blasting is required for any reasons during the construction or operational stage of the proposed development, blast impacts should be demonstrated to be capable of complying with the guidelines contained in Australian and New Zealand Environment Council – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration (ANZEC, 1990) *http://www.environment.nsw.gov.au/noise/blasting.htm*	Section 7

2 PROJECT DESCRIPTION

The Bulga Coal Complex (BCC) consists of two existing coal mining operations; the open cut operations (Bulga Surface Operations) and the underground operations (Bulga Underground Operations) using shared coal washing and rail loading infrastructure. The BCC is located in the Hunter Valley region of NSW within the Singleton Local Government Area and is approximately 12 kilometres south-west of Singleton. The existing surface operations are located approximately 4 kilometres to the south-east of the Bulga village and 4 kilometres north of the village of Broke (refer to **Figure 2.1**). The BCC is operated by Bulga Coal Management (BCM).

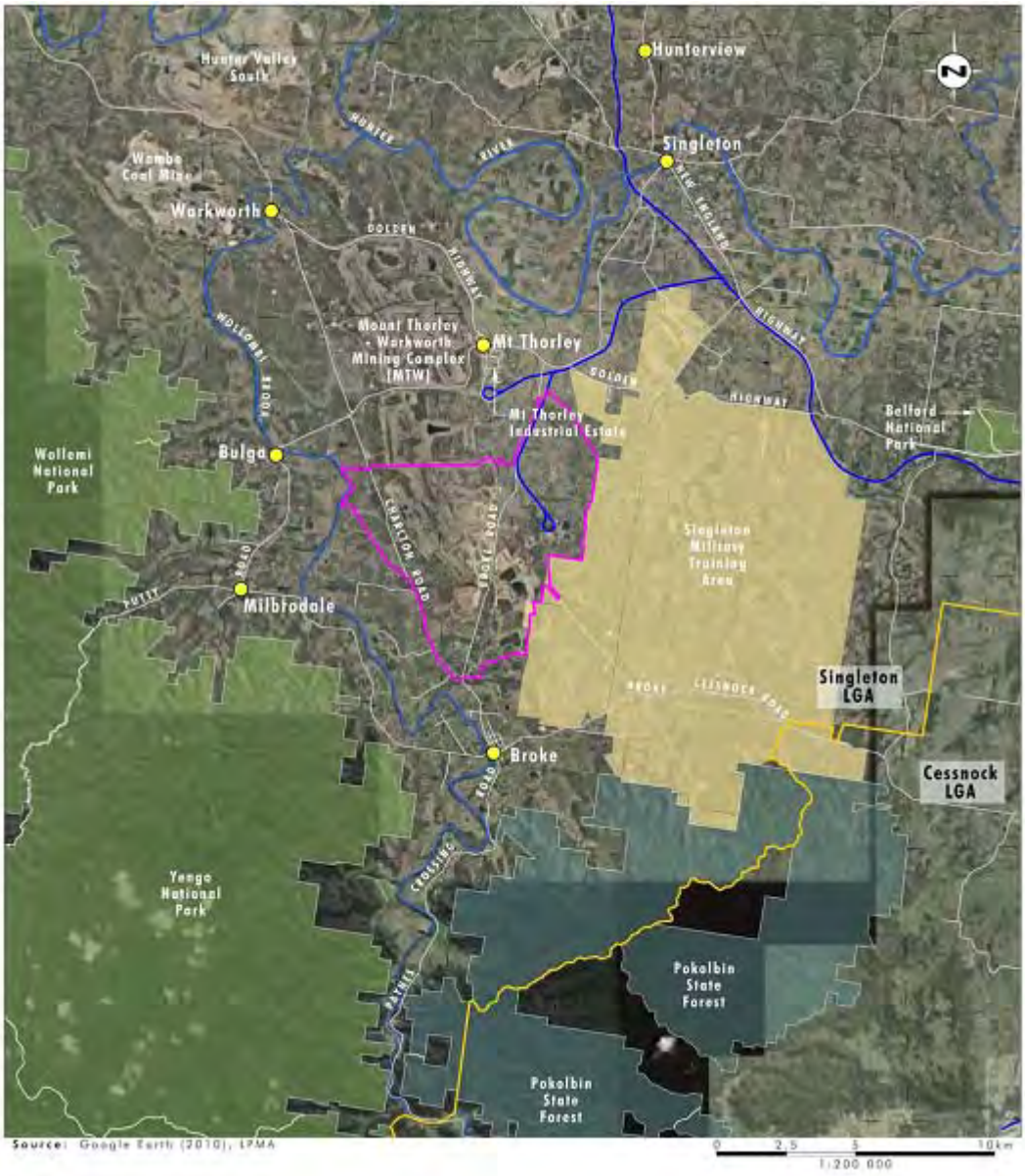


Figure 2-1 Bulga Coal Mine Regional Location

In overview, the Bulga Optimisation Project (the Project) is a proposed continuation of the Bulga Surface Operations for a further approximately 22 years (approximately 10 years beyond the existing consent's expiry date). The Project will allow an additional approximately 200 million tonnes of ROM coal to be mined by open cut methods from land that is largely within the existing BCC disturbance footprint. The Project will enable existing rates of production from the BCC to continue for the life of the Project, optimising utilisation of existing infrastructure at the complex. The Project will not change the current approved maximum production rate from the Bulga Surface Operations nor will it require an increase in the approved throughput of the coal handling and preparation plant. The Project will continue to transport product coal off-site via the existing rail facility. The key features of the Project are shown in **Figure 2-2**

A detailed description of the Project is provided in Section 2 of the Environmental Impact Statement (EIS) prepared to accompany the Development Application for the Project.

Figure 2-2 Key Features of the Bulga Coal Mine (The Project)

3 CONCEPTUAL BLAST DESIGN

The removal of competent overburden (and interburden) material and, in some instances, coal, for the Project would be undertaken using a drill and blast program that would continue for duration of the Project. For the purpose of this assessment, the indicative blast zone envelopes expected across the life of the Project are indicated in **Figure 3-1**.

Figure 3-1 BCM's Proposed Blast Zone Envelopes and Nearby Receivers

There may also be a requirement for blasting in relation to construction activities over the life of the project (eg. road construction related blasting). Such blasting would be of a significantly smaller scale to mine site blasting and would be based on blast charges in the order of 50kg.

The Project's blast program would be designed in consideration of operational, geological and environmental constraints and undertaken in accordance with the BCC's existing Blast & Vibration Management Plan which outlines management, monitoring and notification requirements.

As detailed in the Development Consent DA 41-03-99 (Existing Bulga Surface Operations Consent), blasting will be restricted to the periods 9:00am-5:00pm Monday to Saturday. Any variation to these times would be conditional on receipt of the written consent of the EPA. If blasting for safety or environmental reasons is required outside these hours the EPA will be consulted prior to blasting. The Blast & Vibration Management Plan requires blasts to be limited to times when meteorological conditions are favourable for the containment of noise and airblast emissions.

In normal circumstances, overburden would be blasted prior to its removal and emplacement. Additionally, blasting may also be deployed to win coal from seams that are of sufficient depth. Blasting will usually be conducted daily but only once per day on each of the advancing mine faces of the Project.

The size of individual charges, the nature of stemming material and the stemming procedure will be designed for each blast to maximise the blast efficiency, minimise vibration and airblast impacts and to ensure compliance with the Project's approval limits.

A mixture of ANFO (dry holes) and emulsion blend (wet holes) explosives would continue to be used at the Project.

Blast designs and sizes would vary over the life of the Project and would depend on numerous factors including the depth of coal seams and the design of open cut benches. Blast sizes would typically range between:

- 1,000kg MIC for intermediate coal and interburden blasts; and
- 3,600kg MIC for deep overburden/interburden blasts.

Currently, blasts at the BCC are designed and managed to comply with vibration and airblast criteria. In order to meet these criteria, each blast is designed based on the Project's specific blasting "site law" (an empirically-derived formula for predicting blast vibration levels – discussed further in **Section 6.2**). The Project specific "site law" has evolved based on the monitoring data obtained from previous blasts. BCM has successfully managed its blasting program using this approach for many years.

In the case of the Bulga Surface Operations, the "site law" is expected to evolve further over the life of the Project as the pit gets deeper and the size of the goaf resulting from the Bulga Underground Operations increases. While the precise effect is difficult to ascertain, the fracturing in the goaf caused by subsidence may advantageously inhibit the propagation of blast vibration. The actual effect of the increased goaf on blast vibration propagation (if any) will be factored into the Project specific site law as monitoring data is obtained from future blasts.

Receivers and infrastructure on the eastern side of the Project will not have goaf between them and pit areas where blasts will be carried out and thus will not be buffered by goaf. This may require the use of a different site law in these locations.

4 NOISE & VIBRATION SENSITIVE RECEIVERS

Land use in the local area is dominated by agricultural operations and open cut coal mining.

The BCC is bounded to the north by the Mt Thorley / Warkworth Coal mine and to the north-east, south and west by mine-owned and private residential receivers and other heritage-significant structures. Those receivers and structures potentially worst affected by blasting activities associated with the Project are listed in **Table 4-1** and shown in **Figure 3-1**.

Table 4-1 Receivers Considered in this Blasting Assessment

Receiver No.	Receiver Name	Easting	Northing
	Residential Receivers		
2s	Mine Owned	324011	6388489
6	Mine Owned	323740	6387363
8	Marland	326416	6387627
23	Hungerford	324240	6375597
33	Stevens and Company Pty Limited	322464	6377201
37	Earl	321750	6377262
56	Lambkin	321563	6376387
97	Lambkin	320662	6377402
147	Mine Owned	318834	6377904
149	McInerney	320101	6378526
151	Lewis	319892	6379354
160	Dwyer	318369	6379628
195	Kennedy	317751	6380531
197	Kennedy	316570	6380295
198	Orton	314968	6381037
217s	Russell	317002	6381919
217m	Russell	316733	6382059
226	Vassallo	314684	6382894
232	Medhurst	314947	6383440
307	Mobberley	315062	6386183
318B	Miller Pohang Coal Company Pty Ltd	315151	6385023
323	Poulsen	326127	6388439

Receiver No.	Receiver Name	Easting	Northing
	Heritage Structures		
BH5	Blaxland House	318743	6378821
BH6	General Cemetery	320619	6377545
BH14	'Charlton'	316564	6382152
BH7	McNamara's Dairy Cottage	321326	6377485
BH13	Stone wall	321857	6377402
-	Murinbin House Group	325009	6376090
-	St. Andrews Anglican Church	322063	6375412
-	War Memorial	322500	6374827
-	Maria Immaculate R.C. Church	322152	6375211
-	Albert Hall	324512	6375480
-	Mount Leonard Estate Homestead	326229	6375253
-	War memorial Gates	314296	6385401
-	'Mt Leonard' Homestead	315463	6384101
-	Mt. Leonards Public School (now Scout Hall)	314859	6385011
-	Bulga Bridge over Wollombi Brook	314227	6385588
-	'Milbrodale' Estate	313216	6381376
-	Brick Farm House	322003	6389816
-	'Minimbah' and Outbuildings	330100	6388724

The assessment has also considered the potential impact of blasting on infrastructure including the following private, public infrastructure and prescribed assets:

- the proposed Northern Dam (an approximately 3000 ML water storage dam);
- the towers of the 330kV Transmission Lines;
- the Broke Fordwich PID Pipeline, Broke potable water pipeline and other services infrastructure located adjacent to the proposed realignment of Broke Road; and
- local public roads.

The location of these infrastructure items is indicated in **Figure 2.2**.

5 AIRBLAST & VIBRATION CRITERIA

Blasting within the Project area has the potential to cause both annoyance to humans and, at higher levels, structural damage within surrounding properties and infrastructure. The criteria used to assess the potential for these impacts are detailed below. These criteria have been derived with reference to the DP&I's Director-General's Requirements for the EIS that govern the impact assessment requirements for the Project, and also consider the EPA's agency comments for the EIS.

5.1 Criteria for the Minimisation of Human Annoyance from Blasting

The potential for human annoyance from blasting is assessed against the criteria identified in *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration* prepared by the Australian and New Zealand Environment Council (1990). Human annoyance criteria for blasting for any privately-owned residence or other sensitive locations are:

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

5.2 Criteria for the Prevention of Structural Damage to Buildings

At sufficiently high levels, airblast may cause structural damage to some building elements such as windows.

Australian Standard (AS) AS 2187.2-2006 *Explosives – Storage and Use – Part 2 Use of explosives* states that "…*From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133dB*."

For assessment of damage to residences due to blast vibration transmitted through the ground, *AS 2187.2-2006* recommends frequency-dependent criteria for vibration damage, derived from British Standard 7385-2 and United States Bureau of Mines Standard RI 8507. These are in practice less stringent than the human comfort criterion of 5 mm/s noted above (Section 5-1), and hence need to be considered only in the case of mine-owned receivers. For the frequencies typical of blast vibration, a value of 10 mm/s peak particle velocity (PPV) represents a conservatively low estimate of the level above which structural damage may possibly occur.

In respect of the potential for structural damage to heritage-significant sites and structures, guidance is taken from internationally-recognised standards given the absence of a suitable Australian Standard.

The German standard DIN 4150: Part 3 Effects of Vibration on Structures includes a building type 'Particularly Sensitive' which is assigned vibration limits of 3 mm/s (at less than 10Hz), 3 to 8 mm/s (at 10-50Hz) and 8 to 10 mm/s (at 50-100Hz). Swiss Standard SN640 312:1978 also includes a 'Particularly Sensitive' structural type which is assigned vibration limits of 3 mm/s (at 10 to 30Hz) and 3 to 5 mm/s (at 30 to 60 Hz).

In the absence of an Australian Standard which refers specifically to the assessment of structural vibration impacts in heritage buildings, it is recommended that an initial peak particle velocity (PPV) criterion of 3 mm/s be conservatively adopted for heritage structures. However, the vibration criterion of 3 mm/s may be increased for specific structures where devoted structural analysis indicates that it may be appropriate to do so. Any amendment to the base criterion would be noted in the Blast Management Plan.

5.3 Criteria for the Prevention of Structural Damage to Infrastructure

Blasting from the Project has the potential to undermine the structural integrity of infrastructure within and adjacent to the Project.

While the German standard DIN 4150: Part 3 does include a criterion of 50 mm/s for "plastic" pipelines – both the Broke Fordwich PID and Broke potable water pipelines are constructed of high density polyethylene – there is no Australian or internationally endorsed Standard that prescribes criteria for the prevention of structural damage to other infrastructure such as dam walls, transmission line towers and roads.

Criteria for the assessment of vibration impacts on other types of infrastructure have been drawn from other previously-approved Hunter Valley mining projects, and in particular, the Ravensworth Operations Project (refer: *Ravensworth Operations Projects – Blast Emissions Impact Assessment* by Heggies Pty Ltd (22 December 2009)).

The criterion adopted by this assessment to ensure prevention of structural damage to the proposed Northern Dam is 25 mm/s.

The criteria adopted by this assessment to ensure prevention of structural damage to the 330 kV transmission line towers proposed for realignment through the Project are 100 mm/s for suspension towers and 50mm/s for tension towers or as otherwise agreed with the asset owner.

The criterion adopted for the Broke Fordwich PID Pipeline, Broke potable water Pipeline and other services infrastructure (collectively referred to as services infrastructure) located along the realigning Broke Road easement is 100 mm/s.

The criterion adopted by this assessment to ensure prevention of structural damage to public roads surrounding the mine from blasting vibration is 100 mm/s.

These criteria represent a minimum threshold below which vibration will not cause structural damage to the infrastructure. Where required, these vibration limits may be increased on an individual basis following devoted structural analysis of the infrastructure prior to and after blasting in consultation with the asset owner.

6 PREDICTION OF AIRBLAST & VIBRATION IMPACTS

6.1 Prediction Methodology

Airblast and ground vibration levels from blasting are related to the "scaled distance" from the blast, which is defined as:

- Scaled distance = $D/W^{(1/3)}$ for airblast; and
- Scaled distance = $D/W^{(1/2)}$ for ground vibration.

D is the distance from the blast in metres and W is the MIC of explosive, in kg ANFO equivalent.

Predictive curves relating scaled distance to airblast and ground vibration levels have been derived from measurements conducted at numerous sites.

For this assessment, Wilkinson Murray has used data from over 7,000 records of blasts undertaken in the Hunter Valley, NSW to derive relationships between scaled distance and airblast or vibration. These relationships are designed to predict not the mean level of airblast or vibration, as in a standard "site law", but the 95th percentile value, representing the level which would be exceeded by only 5% of blasts, given the use of current blast practice and the current level of variability in airblast or vibration for the same scaled distance.

The raw data, and the derived prediction curves, are shown in **Appendix A**.

For airblast, a curvilinear relationship with log(Scaled Distance) was required to adequately explain the data:

$$\text{Airblast (dB)} = 201.1 - 62.313 \log(SD) + 10.79 (\log(SD))^2$$

where SD is the airblast-scaled distance (as per formula given above).

For vibration, a linear relationship with log(Peak Particle Velocity) was derived:

$$\text{Log(Peak Particle Velocity)} = 3.015 - 1.4359 \log(SD)$$

where SD is the vibration-scaled distance (as per formula given above).

These formulae were used to predict vibration and airblast levels at all potentially-affected locations assuming a surface blast at the nearest point of each blast envelope.

Figure 3-1 indicates the indicative maximum likely blast sizes to be used within given regions of the Project for assessment purposes. This assessment has predicted potential blast impacts to receivers and infrastructure by assessing all blasts from each of these blast regions, rather than just the nearest one. Maximum likely blast sizes assessed ranged between MIC 1000 kg and MIC 3600 kg, with the latter currently expected to be restricted to deep in-pit blasts of thick overburden between the Mt Arthur and Piercefield seams.

It should be noted that the blast airblast prediction model assumes that there is no intervening terrain between the location of the blast and the modelled receiver. In reality, the worst case blasts modelled in the assessment would be undertaken only in the deeper areas of the pit which are often screened from receivers by thick overburden walls. For this reason, the predicted levels of airblast from in-pit blasts predicted in this assessment are likely to be conservative.

6.2 Reconciliation of Vibration Prediction Model with the Project's "Site Law"

The data used to derive the Wilkinson Murray blast vibration "site law" used in this assessment is derived from over 7000 blasts in the Hunter Valley in similar geology to that present in the Project Area. Indeed, many of these blasts relate to mining operations accessing the same seams being targeted by the Project. This data covers a wide variety of pit depths and blast sizes, including blasts of similar sizes to the maximum blasts proposed for the Project. Notwithstanding this, it is instructive to compare the Wilkinson Murray "site law" used in the assessment with the "site law" presently adopted by BCM, as advised by its Drill Manager as:

[BCC Blast Vibration Site Law] PPV = 1174*(SD)^-1.6

Where SD is the vibration-scaled distance (as per formula given in **Section 6.1**).

Figure 6-1 indicates that the Wilkinson Murray and BCC "site laws" are in good agreement and that the Wilkinson Murray site law used in this assessment is the more conservative.

As described in **Section 6.1**, the Wilkinson Murray site law represents the 95% percentile blast curve (ie, the level below which vibration from 95% of all blasts will lie) rather than a mean blast curve.

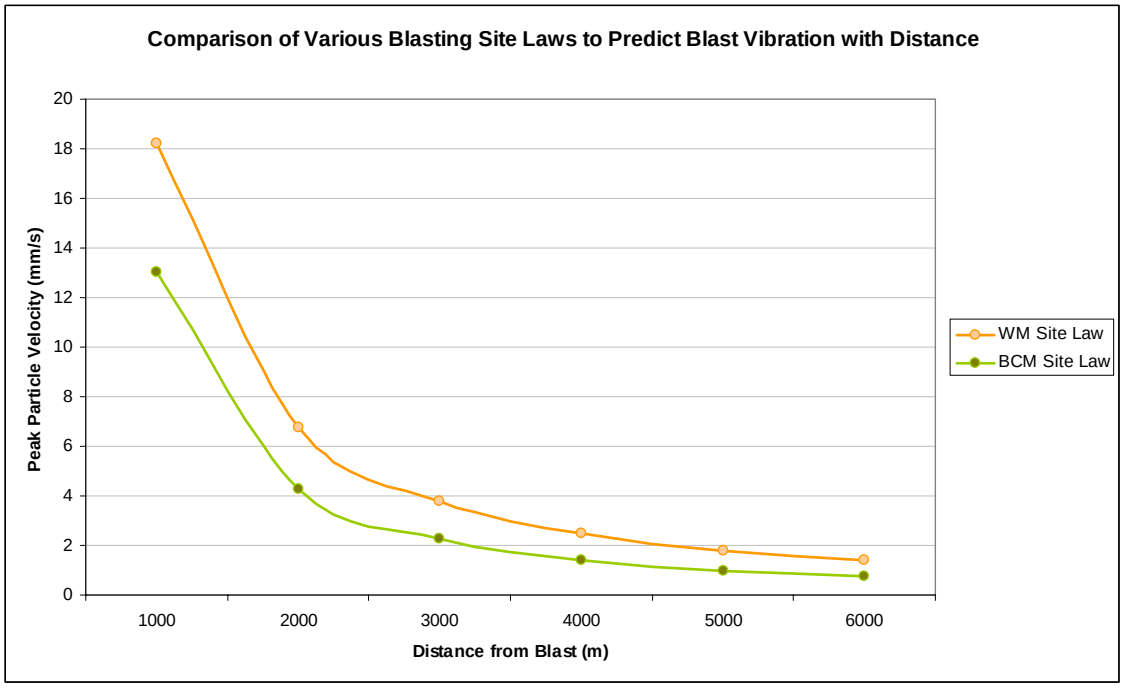


Figure 6-1 – Comparison of Wilkinson Murray and BCC Blast Vibration Site Laws

6.3 Predicted Airblast and Vibration Levels at Residences

Based on the predictive equations outlined in **Section 6.1**, **Table 6-1** indicates the predicted airblast and ground vibration expected at the nearest mine-owned and privately-owned receivers and heritage structures from each of three blast zones identified in **Figure 3-1**. The predicted airblast and ground vibration stated for each receiver is the level expected to be exceeded 5% of the time. These predictions are based on the indicative maximum blast sizes and using the conservative Wilkinson Murray blasting site law (**Section 6.1**).

The 5% exceedance levels are the levels that should be compared to the 5% exceedance criteria of 115 dBLinear (dBL) for airblast and 5mm/s (residences) and 3 mm/s (heritage structures) for vibration. Peak or maximum blasting levels are not presented because these levels are typically caused by geological anomalies, which are unpredictable.

Table 6-1 Predicted Airblast and Vibration Levels Resulting from Blasting within Bulga Coal Mine Pits (5% Exceedance Levels)

Receiver No.	Receiver Name	Distance from Blast Zone (m)			Airblast (dB)			Ground Vibration (PPV)		
		3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone	3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone	3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone
Residential Receivers										
2s	Mine Owned	6200	5630	4150	112	112	112	1	1	1
6	Mine Owned	4940	4700	2910	113	113	113	2	2	2
8	Marland	6670	6510	5060	112	112	112	1	1	1
23	Hungerford	6430	6010	4920	112	112	112	1	1	1
33	Stevens and Company Pty Limited	4360	3880	3540	113	113	112	2	2	1
37	Earl	4190	3680	3780	113	114	112	2	3	1
56	Lambkin	5020	4520	4620	113	113	112	2	2	1
97	Lambkin	4110	3600	4330	113	114	112	2	3	1
147	Mine Owned	4400	3880	5500	113	113	111	2	2	1
149	McInerney	3040	2770	4110	115	115	112	4	4	1
151	Lewis	2450	2200	3770	116	117	112	5	5	1
160	Dwyer	3572	2920	4720	114	115	112	3	3	1
195	Kennedy	3500	2690	4920	114	115	112	3	4	1
197	Kennedy	4460	3550	6090	113	114	111	2	3	1
198	Orton	5870	4290	7310	112	113	111	1	2	0
217s	Russell	3800	2340	5150	114	116	112	3	5	1
217m	Russell	4050	2450	5370	114	116	111	2	4	1
226	Vassallo	6080	3860	7130	112	113	111	1	2	0
232	Medhurst	5920	3450	6790	112	114	111	1	3	1
307	Mobberley	6840	3740	6850	112	114	111.2	1	2	1
318B	Miller Pohang Coal Company Pty Ltd	6270	3100	6520	112	116	111.2	1	3	1
323	Poulsen	7120	6930	5340	112	112	111.4	1	1	1

Receiver No.	Receiver Name	Distance from Blast Zone (m)			Airblast (dB)			Ground Vibration (PPV)		
		3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone	3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone	3600kg MIC Zone	3000kg MIC Zone	1000kg MIC Zone
Heritage Structures										
BH5	Blaxland House (Site BH5)	3630	3060	5040	114	115	112	3	3	1
BH6	General Cemetery (Site BH6)	3810	3350	4170	114	114	112	3	3	1
BH14	'Charlton' (Site BH14)	4040	2350	5430	114	116	111	3	5	1
BH7	BH7 – McNamara's Dairy Cottage	3780	3330	3740	114	114	112	3	3	1
BH13	BH13 – Stone wall	3890	3440	3510	114	114	112	3	3	1
-	Murinbin House Group	6200	5890	4510	112	112	112	1	1	1
-	St. Andrews Anglican Church	5890	5440	5250	112	112	111	1	1	1
-	War Memorial	6530	6090	5710	112	112	111	1	1	1
-	Maria Immaculate R.C. Church	6100	5650	5420	112	112	111	1	1	1
-	Albert Hall	6540	6180	5000	112	112	112	1	1	1
-	Mount Leonard Estate Homestead	7510	7220	5740	112	112	111	1	1	1
-	War memorial Gates	7090	4020	7420	112	113	111	1	2	0
-	'Mt Leonard' Homestead	5490	2700	6170	112	115	111	2	4	1
-	Mt. Leonards Public School (now Scout Hall)	6410	3380	6810	112	114	111	1	3	1
-	Bulga Bridge over Wollombi Brook	7230	4140	7520	112	113	111	1	2	0
-	'Milbrodale' Estate	7430	5720	8860	112	112	111	1	1	0
-	Brick Farm House	7090	5270	5000	112	112	112	1	2	1
-	'Minimbah' and Outbuildings	10040	9960	8720	111	111	111	1	1	0

Notes:

1 Airblast and ground vibration levels likely to result from MIC 1,000kg, 2,000kg and 3,600 kg blasts respectively.

2 Shading indicates exceedance of either of the Human Annoyance (residential receivers only) criterion or the Building Damage blasting criterion (all receivers).

3 dB = decibel / PPV = Peak Particle Velocity

The results of **Table 6-1** indicate that most receivers considered by this assessment will not be impacted by blasting activities. **Table 6-1** does indicate however, that exceedances of the airblast and ground vibration criteria may occur at a small number of receivers where no management measured are implemented and the theoretical maximum blast charges are deployed. The management of potential blast impacts is discussed further in **Section 7**. In summary, **Table 6-1** concludes:

In relation to residential receivers:

- Predicted airblast levels will likely exceed the 115dB human comfort criterion (**Section 5.1**) at two private residential receivers 217s and 217m where the theoretical maximum blast charges are deployed;
- Predicted airblast levels will likely exceed the 115dB human comfort criterion (**Section 5.1**) at one mine-owned residence 151, where the theoretical maximum blast charges are deployed;
- Predicted airblast levels will be less than the 133dB building structural damage criterion at all residences (**Section 5.2**), and
- Predicted ground vibration levels from blasting will likely comply with the 5mm/s human comfort criterion (**Section 5.1**) at all residential receivers.

In relation to heritage structures:

- Predicted airblast levels at all heritage structures will be less than the 133dB structural damage criterion (**Section 5.2**);
- The structural damage vibration criterion (for heritage structures) of 3mm/s (PPV) (**Section 5.2**) would be exceeded at 'Charlton' (Site BH14) and the 'Mt Leonard' Homestead where the theoretical maximum blast charges are deployed.

These predictions are based on assuming the 95% percentile (airblast and vibration) levels rather than the median levels that may be expected at receivers, and in this sense, are conservative. Further, the assessment is conservative in that predicted impacts are based on the theoretical maximum blast charge being deployed at all areas of the blast zone.

Further, **Table 6-1** intimates that airblast and vibration compliance can be achieved for all properties – including the aforementioned potentially impacted receivers – by using smaller instantaneous charge sizes. Other blasting techniques, such as the use of detonation management systems, can also be deployed to achieve similar results. The relevant amenity and structural criteria are able to be observed at all receivers simply by controlling the instantaneous blast size as required.

Each blast undertaken for the Project will be designed and managed to meet the stated Project blast criteria by having regard to an evolving site law based on the results obtained from the monitoring of blasts carried out at the site. Additional management strategies proposed for managing blasts according to the criteria presented in this assessment are discussed further in **Section 7**.

6.4 Predicted Airblast and Vibration Levels within other Infrastructure

The walls of the BCC's proposed Northern Dam are located 2,700m from the nearest mining blast zone. At this distance, the level of ground-borne blast vibration will not exceed 5 mm/s within the dam walls for even the highest of the blast charges proposed for the project (MIC: 3,600kg). These maximum vibration levels are significantly lower than the structural damage criterion of 25 mm/s (**Section 5.3**).

At its closest passing, the 330kV transmission line will pass within 260m of BCC's 1000kg MIC blast zone, and within 1560m of its 3,600kg MIC blast zone (refer **Figure 3-1**). At these distances, the level of ground-borne blast vibration within either of the transmission line's suspension and tension towers is predicted to remain below 50 mm/s. This is significantly lower than the structural damage criterion for suspension towers of 100 mm/s but is close to the 50 mm/s on the tension towers (**Section 5.3**). The blast design process will be managed to achieve compliance as discussed in **Section 7**.

The structural damage criterion for public roadways adopted for this assessment of 100 mm/s (**Section 5.3**) would potentially be exceeded where roads pass within 310m of the 3,600kg MIC blast zone, within 280m of the 3,000kg MIC blast zone or within 160m of the 1,000kg MIC blast zone. If no mitigation measures were employed by BCM the structural damage criteria could be exceeded on Charlton Road, Broke Road and services and pipelines located adjacent to roads due to the potential maximum instantaneous blast sizes. Management strategies relating to these assets are discussed in **Section 7.**

6.5 Construction-related Blasting

The blast sizes required for construction activities – typically MIC 50kg - are much smaller than blast sizes required for the open cut mining operations (up to MIC 3,600kg - **Section 3**). Consequently, it is highly unlikely that airblast and vibration from construction blasts will exceed the criteria identified above. As for mine all blasts, all construction blasts will be designed to achieve compliance with relevant blast criteria.

7 MITIGATION OF POTENTIAL BLASTING IMPACTS

7.1 Mitigation of Predicted Airblast & Vibration Impacts

Managing airblast and blast-induced vibration impacts would continue to be undertaken at the BCC in accordance with the existing Blasting Management Plan which continues to evolve with the Project.

BCM will continue to design blasts so that relevant blasting criteria (**Section 5**) are complied with at all residences and heritage structures. BCM will achieve this by designing blasts according to its evolving blast "site law" which is based on the results of ongoing blast monitoring. The lower predicted levels in **Table 6-1** demonstrate that the blasting criteria can be satisfied at all residences with appropriate management. Should it be required, blast vibration and airblast may be further minimised by implementing other blast management strategies such as the use of detonation management systems.

BCM will undertake structural assessment of any heritage item for which an exceedance of the 3 mm/s structural damage criterion is predicted to occur for the maximum MIC size proposed, in order to ascertain its capability of withstanding blast vibrations. Any such structural assessments will be noted in the Project's Blast and Vibration Management Plan.

7.2 Managing Potential Flyrock Impacts

Flyrock is any material ejected from the blast site by the force of the blast. Flyrock would be managed through appropriate blast design in order to minimise flyrock risk to the public using Charlton and Broke Roads and to livestock. Blasting at BCC and at other mines has confirmed that flyrock can be controlled.

Consistent with advice previously received from the NSW Division of Resources and Energy (DRE) and the appropriate roads authority (Singleton Council), sections of Charlton and Broke Roads within 500m of blasting activities would be closed and public access restricted during blasting events by use of road closure signs and sentries at either end of the roadways. This practice is already implemented for the Bulga Surface Operations for blasts in close proximity to public roads.

7.3 Managing the Potential for Structural Damage to Broke Road, Associated Services and the Broke Fordwich PID and potable water Pipelines

Section 6.4 identifies the potential for exceedances of the structural damage criterion for those sections of Charlton and Broke Roads and associated services and the adjacent Broke Fordwich PID Pipeline and Broke potable water pipeline.

As outlined above, those sections of public road within 500m of blasting activities will necessarily be closed to the public to protect against impacts during the blast. For these sections of road, BCM will inspect affected areas prior to and immediately following the blast to inspect its structural integrity. Any damage to road surfaces caused by blasting will be barricaded off to ensure safe passage of traffic whilst repairs are undertaken.

Water pipeline routes will be inspected for any leaks following any blasts within 500m. As the pipelines are buried, visual inspections of the pipelines themselves will be undertaken only if there exists evidence that the integrity of the pipeline has been compromised. BCM will make good any damage to the pipelines caused by blasting, including compensation for losses suffered as a result of the disruption to supply.

As is the current management practice, BCM will continue to design blasts such that blast vibration levels at any infrastructure item identified do not exceed the vibration criteria identified in **Section 5.3** unless previously agreed with the asset owner. Mobile blast monitoring units will be deployed to monitor vibration levels as required.

7.4 Other Management Measures

Due to the Project's proximity to adjoining mining operations, there is a very small possibility of concurrent blasting which may result in cumulative airblast and vibration impacts on nearby residences and structures. BCM currently liaises, and will continue to liaise, with the operators of these mining operations so that blasts at the BCC are coordinated to remove the possibility of concurrent blasting and therefore cumulative airblast and vibration impacts.

7.5 Blast and Vibration Management Plan

BCM will implement the following blast management practices over the life of the Project:

- undertaking blasts in accordance with the BCM Blast and Vibration Management Plan which will be updated to include the management controls identified above;
- continue the use of real time blast monitoring systems, which has monitors at locations deemed to be indicative of nearby receivers (refer to **Section 8**);
- conduct a structural survey of heritage sites prior to any predicted exceedances of 3 mm/s to ascertain a better understanding of their capability of withstanding blast vibrations. Any changes to noted vibration limits will be recorded in the Project's updated Blast and Vibration Management Plan;
- inspect sections of closed roads prior to and immediately following blasts to inspect their structural integrity. Any damage to road surfaces caused by blasting that are found, will be barricaded off to allow safe passage of traffic whilst repairs are undertaken;

- inspect the water pipeline easements for any leaks following any blasts within 500m;
- undertake periodic inspections of the blast monitoring system to determine its effectiveness and representativeness, and
- review individual blast monitoring results after each blast to assess compliance.

8 BLAST MONITORING

Airblast and vibration resulting from each blast of the blasting program will be monitored in accordance with the Blast and Vibration Management Plan. This involves monitoring at selected locations identified as being representative of the receivers potentially most impacted by blasting. The monitoring program will use methods consistent with the ANZECC guideline.

The monitoring locations will be reviewed regularly in response to newly-acquired monitoring data, changes to blast locations or changes to blast management strategies and also revised in accordance with the Plan as required.

9 CONCLUSION

This assessment identifies that blasting at the Bulga Optimisation Project (the Project) will comply with relevant airblast and vibration criteria for most residences around the mine site. The assessment does predict however, that unmitigated, maximum scheduled blast charges could theoretically give rise to airblast and vibration impacts to a limited number of nearby residences and heritage structures. However, in practice all blasts at the Project would necessarily be designed in accordance with the existing Blast & Vibration Management Plan and specifically, with direct reference to the results of ongoing blast monitoring with a view to removing the possibility for these predicted blasting impacts.

The assessment indicates the potential for blasting vibration to exceed the structural damage criteria for roads and pipelines for short sections of Broke Rd and the adjacent Broke Fordwich PID pipeline very near to proposed blast zones. In practice, the Project would remove the potential for blasting impacts by controlling each blast charge to ensure that the resulting blast vibration within any infrastructure identified in this assessment does not exceed the relevant structural damage criterion.

For those sections of Broke Road and Charlton roads within 500m of blast zones, BCM will inspect roads prior to their re-opening to ensure they are free of fly rock, dust or structural damage. Any damage to road surfaces caused by blasting will be barricaded off to ensure safe passage of traffic whilst repairs are undertaken.

No impacts to the proposed Northern Dam or the 330 kV transmission line are predicted to result from blasting at the Project.

The blast sizes required for construction activities – typically MIC 50kg - are much smaller than blast sizes required for the open cut mining operations (up to MIC 3,600kg - **Section 3**).

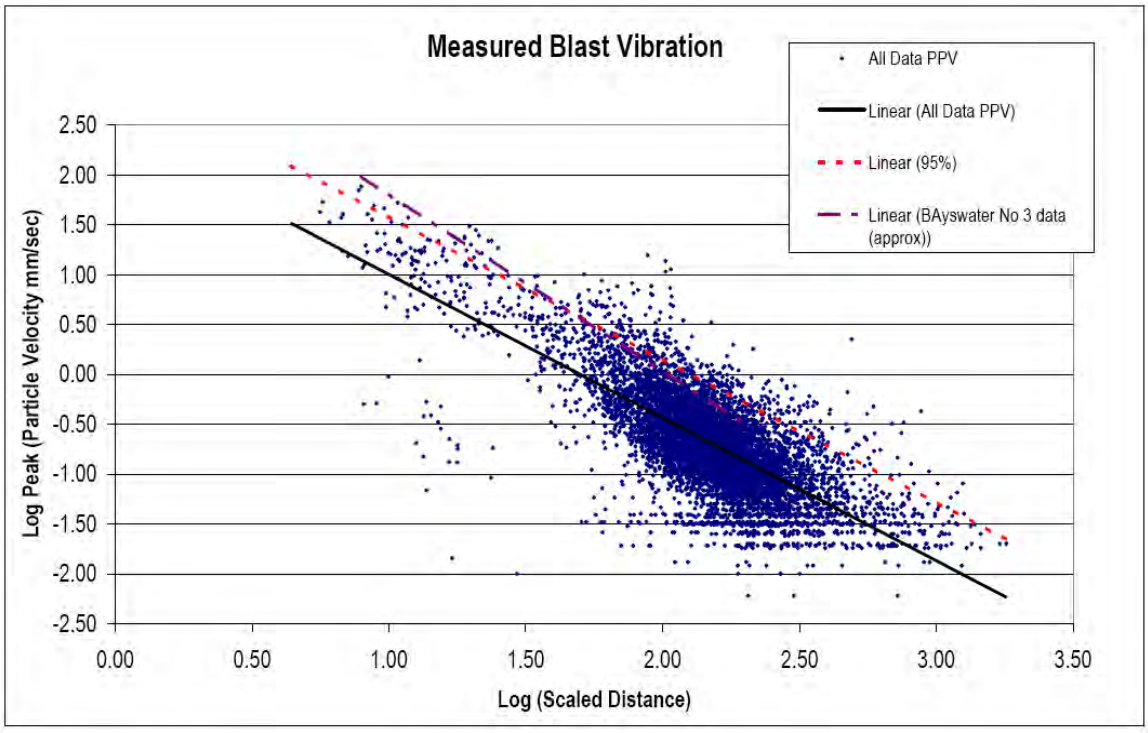
Due to the small size of construction-related blasting (typically MIC 50kg) relative to the blast sizes proposed for the open cut mining operations (up to MIC 3,600kg), it is highly unlikely that construction blasts will give rise to airblast and vibration emission levels in excess of the criteria identified in this assessment. However, given the potential for localised blasting impacts, construction blasts will also be managed in accordance with the BCM Blast Management Plan to ensure compliance with blast criteria.

APPENDIX A

BLASTING PREDICTION CURVES

For this study, Wilkinson Murray has derived predictive equations for vibration and airblast using measurement data from approximately seven thousand blasts. Figure C.1 illustrates the measured data and associated linear trend lines for vibration.

Figure C.1 Measured Peak Particle Velocity (PPV) from Blasts at Hunter Valley Coal Mines



The figure shows a revised best fit line, a 95 percentile line, and also the previously-adopted 95 percentile based on 1999 data from Bayswater No 3. The correlation with the old data is close, although the new 95 percentile shows slightly lower vibration levels at shorter scaled distance – in the order of 0.2 to 0.3millimetres per second (mm/s).

Figure C.2 shows data for airblast. Analysis of these data showed that the relationship between measured peak airblast and scaled distance is better defined with a polynomial equation (blue) at close range rather than a standard linear equation (red). At relatively low values of scaled distance, the new polynomial 95 percentile curve is approximately 5 decibels (dB) lower than the linear trend line derived from the previous Bayswater No 3 data.

Figure C.2 Measured Peak Airblast from Blasts at Hunter Valley Coal Mines