9. Noise and Vibration

This section provides a summary of the noise and vibration investigation undertaken, and the potential impacts identified, in regards to with the Project (Mine) during construction and operation. The assessment was undertaken in accordance with the requirements of the Terms of Reference (ToR) and a table cross-referencing these requirements is provided in Volume 4 Appendix C ToR Cross Reference Table. A detailed noise and vibration report is included in Volume 4 Appendix U Mine Noise and Vibration Report.

9.1 Introduction

9.1.1 Approach

The construction and operation of the Project (Mine) has the potential to cause noise and vibration impacts on the surrounding environment. The noise and vibration assessment includes:

- Reviewing the existing noise and vibration environment
- Addressing the acoustic requirements detailed in the Project terms of reference (ToR) in relation to the construction and operation of the Project (Mine)
- Evaluating the potential construction and operational noise and vibration impacts at sensitive locations in terms of planning levels identified in the applicable standards and guidelines
- Defining noise and vibration goals by which potential construction and operational noise and vibration impacts at sensitive locations may be evaluated and assessed
- Evaluating and assessing the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies
- Recommending appropriate impact mitigation measures

9.1.2 Noise and Vibration Monitoring

In order to meet the ToR for the Project (Mine), background and ambient noise monitoring was conducted as part of this assessment. Background noise levels were assessed using a combination of unattended and attended noise monitoring at two representative locations in the vicinity of the Project (Mine). A brief description of each monitoring site is provided in Table 9-1.

Unattended noise monitoring was undertaken using two Rion NL-21 environmental noise loggers at Doongmabulla and Labona homesteads, within the vicinity of the Project (Mine). Measurement at Doongmabulla homestead (Location A) took place between 26 August and 7 September 2011. Measurement at Labona homestead (Location B) took place between 26 August 2011 and 6 September 2011. The instruments were programmed to accumulate environmental noise data continuously over sampling periods of 15 minutes for the entire monitoring period. The data collected by the loggers was downloaded and analysed, and any invalid data removed.

Attended measurements were taken at unattended monitoring locations to supplement logger data. Attended noise measurements were conducted on 26 August 2011 using a Rion NL-21 Sound Level Meter (SLM).

All sampling activities were undertaken with consideration to the specifications outlined in Australian Standard *AS1055:1997 Description and Measurement of Environmental Noise* and *Noise Measurement Manual* (EPA 2000).

Noise monitoring site locations are provided in Figure 9-1 together with the locations of potential sensitive receptors.

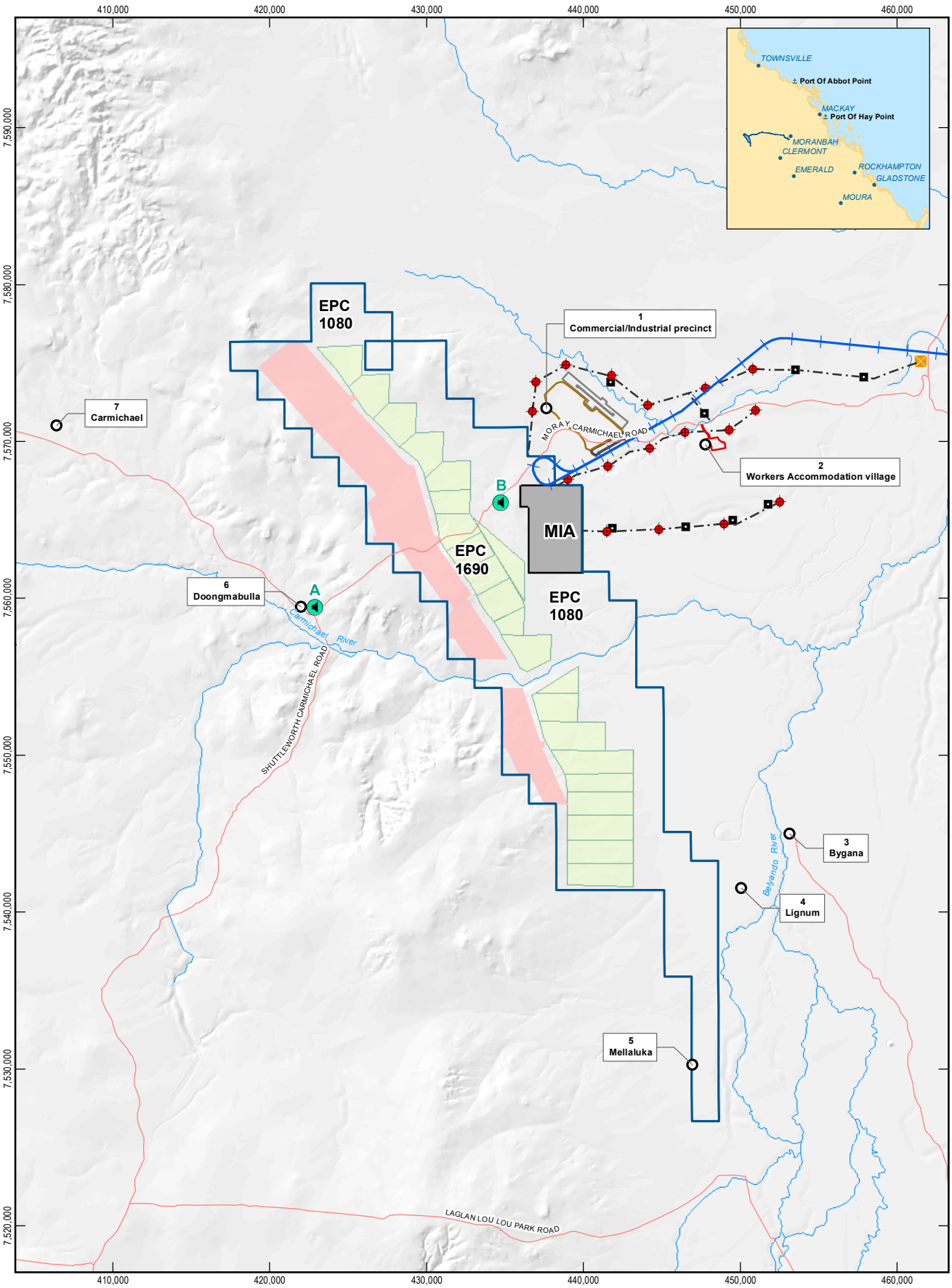
Table 9-1 Noise Survey Location Details

Location	GPS coordinates	Description of noise survey location	Monitoring period
Location A	22° 04.217' S 146° 14.664' E	Doongmabulla Homestead	26 Aug 2011 – 7 Sept 2011
Location B	22° 00.660' S 146° 21.593' E	Labona Homestead [1]	26 Aug 2011 – 6 Sept 2011

1 Labona Homestead will be demolished and therefore is not classified as a sensitive receptor. However, the low background noise level found at this receptor was considered representative of the area.

Vibration monitoring was undertaken on 26 August 2011 at the monitoring locations displayed in Figure 9-1.

Vibration measurements were conducted using an Instantel Minimate Plus vibration logger with a tri-axial geophone to monitor ground vibration peak particle velocity (PPV) in each axial direction. Histograms at one minute intervals were recorded with concurrent site observations.



LEGEND

- Sensitive Receptor
- Noise Logger
- Local Road
- Watercourse
- Mine Infrastructure Area
- Open Cut Blocks
- Underground Mine Plan
- Rail (West)
- Mine (Onsite)
- Mine (Offsite)
- Borehole
- Storage Site (Instream)
- Storage Facility (Offstream)
- Pipeline Network
- Airport Location
- Rail Siding
- Industrial Area
- Workers Accommodation Village

1:350,000 (at A4)

0 2 4 6 8 10 12

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 55

N

Adani Mining Pty Ltd
Carmichael Coal Mine and Rail Project

Job Number 41-25215
Revision C
Date 16-10-2012

Potential Sensitive Receptors and Noise and Vibration Monitoring Locations

Figure 9-1

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Data Source: DME: EPC 1690 (2010)/EPC 1080 (2011); © Copyright Commonwealth of Australia - Geoscience Australia: Mainland, Homestead, Locality, Road, Watercourse (2007); Adani: Alignment Opt9 Rev3 (SP1 & 2) (2012); Gassman/Hyder: Mine (Offsite) (2012); GHD: Sensitive Receptor, Noise Logger (2012). Created by: JVC

9.1.3 Construction Noise Assessment Methodology

9.1.3.1 Construction Methods and Equipment

The Project (Mine) will use standard construction equipment, general trade equipment and specialised equipment as required. Table 9-2 shows the indicative number and type of construction equipment required, with the corresponding noise levels, based on the equipment list from Macro-conceptual Mining Study (Runge Limited 2011). Typical construction equipment noise levels have been obtained from AS 2436 – 2010, *Guide to noise and vibration control on construction, demolition and maintenance sites*.

Table 9-2 Indicative Construction Equipment and Sound Power Levels (SWL)

Construction Phase	Indicative Number of Plant	SWL, dB(A) L_{max}	Total SWL dB(A)L_{max}
Phase 1 Prepare works for mine infrastructure area (MIA) and mine camp construction. Access road construction to Gregory Development Road	Dozer x 1	116	121
	Truck x 2	108	
	Excavator x 1	112	
	Grader x 2	112	
	Roller x 2	110	
Phase 2 Construction of power, water supply and other external services	Excavator x 1	112	115
	Truck x 1	108	
	Backhoe x 1	108	
Phase 3 Permanent access road and rail spur	Scraper x 4	119	127
	Dozer x 3	116	
	Truck x 4	108	
	Excavator x 3	112	
	Grader x 2	112	
	Roller x 2	110	
Phase 4 Dams construction	Scraper x 2	119	124
	Dozer x 1	116	
	Truck x 2	108	
	Excavator x 1	112	
Phase 5 Project power supply	Mobile crane x 1	112	121
	Welder x 2	104	

Construction Phase	Indicative Number of Plant	SWL, dB(A) L_{max}	Total SWL dB(A)L_{max}
	Truck x 3	108	
	Various hand tools including grinders	119	
Phase 6 MIA and CHPP	Truck x 2	108	122
	Excavator x 1	112	
	Grader x 1	112	
	Roller x 1	110	
	Backhoe/bobcat x 1	108	
	Mobile crane x 1	112	
	Various hand tools including grinders	119	

For the purposes of noise level predictions, it has been assumed that all construction equipment in each phase listed in Table 9-2 will be operating at maximum levels. Noise levels have been predicted for worst-case scenario where all phases operate simultaneously under adverse weather conditions. Equipment locations are based on the General Mine Layout (Runge Limited 2011).

In fact, construction machinery will likely move about the study area altering noise impacts with respect to individual receptors. During any given period, the machinery items to be used in the study area will operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at maximum sound power levels at any one time and certain types of construction machinery will be present in the study area for only brief periods during construction. Therefore, the predictions should be considered as conservative estimates.

Note, the workers accommodation village and the industrial precinct are not assessed as sensitive receptors whilst the areas themselves are being constructed.

9.1.3.2 Construction Noise Prediction

Acoustic modelling was undertaken using Computer Aided Noise Abatement (CadnaA) Version 4.2 to predict the effects of construction related noise from the Project (Mine). CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. Ground absorption, reflection and relevant shielding objects are taken into account in the calculations. The Project (Mine) has been modelled based on available data at the time of assessment and, as such, should be used for guidance purposes only.

9.1.4 Blasting Impacts Assessment Methodology

Some blasting will be required to prepare overburden for removal and also coal extraction. Airblast overpressure levels are dependent on a number of factors such as:

- Maximum Instantaneous Charge (MIC) per delay
- Distance from blast to receptor
- Burden depth
- Stemming height
- Meteorology

Ground vibration due to blasting is a function of numerous factors such as:

- Ground conditions including rock structure and strata type
- MIC per hole
- Distance from blast to receptor

Blast effects have been predicted with consideration to the equations given in Australian Standard *AS2187:2006 Part 2 Explosives - Storage and Use - Use of Explosives*. Given the infancy of the Project, details regarding blast design and configuration are not known at this stage. Furthermore, ground conditions including rock structure and strata type can vary significantly in and surrounding a mine site. As such, typical site constants have been used in the blasting assessment.

9.1.5 Offsite Infrastructure Noise Assessment Methodology

Project (Mine) offsite infrastructure is expected to comprise of the following:

- An industrial precinct comprising of general industrial uses such as freight unloading terminals, fuel farms
- A rail siding located adjacent to the Project (Rail)
- An airstrip
- Water supply infrastructure, comprising of a network of pump stations for off-stream water storage

Project (Mine) offsite infrastructure locations are shown in Figure 9-1. A review of potential sensitive receptors surrounding the offsite infrastructure identified that the nearest receptors were over 5 km from the proposed industrial precinct and rail siding, and over 1 km from any of the proposed pump stations.

The potential for noise impacts from pump stations at a separation distance of at least 1 km was considered to be very low and was not further assessed.

The details regarding the airstrip and associated noise sources are not known at this stage of the Project (Mine), therefore calculation of noise impacts from the operation of the airstrip is excluded from this assessment.

The parameters of noise modelling were based on noise levels measured by GHD at similar facilities, or typical noise levels for industrial areas.

9.1.6 Operational Noise Assessment Methodology

Acoustic modelling was undertaken using CadnaA Version 4.2 and implementing the Concawe algorithm to predict the effects of operational related noise from the Project (Mine). Ground absorption, ground terrain, reflection and relevant shielding objects are taken into account in the calculations. The proposed development has been modelled based on available data at the time of assessment and, as such, should be used for guidance purposes only.

For the proposed underground operations, exposed noise sources at the surface such as ventilation fans and overland conveyors have been included in the noise model. The proposed open cut mining method primarily involves draglines with truck and excavator operation with truck haulage to the processing facility. Coal will be hauled from the pit and will be dumped direct to the run of mine stockpile (ROM) located adjacent to the coal handling and processing plant (CHPP) or to a remote ROM for transport via overland conveyor to the CHPP. The CHPP will be located adjacent to the rail loop.

Table 1-15 in Volume 4 Appendix U shows the proposed equipment for the scheduled mining, necessary to provide sufficient capacity to supply coal to meet planned output levels, based on the equipment list from Macro-conceptual Mining Study (Runge Limited 2011). Table 1-16 in Volume 4 Appendix U shows the equipment list and corresponding noise levels. Typical mining equipment noise levels have been obtained from noise assessments conducted on similar projects and GHD's noise source database. Noise sources were modelled based on the mine staging plans shown in Table 1-15 of Volume 4 Appendix U. The mine stages were selected on the basis of worst case scenarios in relation to equipment type, numbers and proximity of mining operations to sensitive receptors.

9.1.7 Legislation, Policies and Guidelines

The *Environmental Protection Act 1994* (EP Act) provides for protection of environmental values, including environmental values relating to maintenance of public amenity. The Environmental Protection (Noise) Policy 2008 (EPP Noise) also applies. The key environmental values for the acoustic environment are outlined within Section 7 of the EPP Noise:

a) *the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and*

b) *the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following –*

   (i) *sleep;*

   (ii) *study or learn;*

   (iii) *be involved in recreation, including relaxation and conversation; and*

   (iv) *the qualities of the acoustic environment that are conducive to protecting the amenity of the community.*

The EPP Noise also sets out acoustic quality objectives in Table 9-3. Based on a typical dwelling façade noise reduction of 10 dB(A) through a partially open window, an external criterion of 40 dB(A)

$L_{Aeq,adj,1hr}$ is recommended for health and well-being in relation to the ability to sleep. This acoustic quality objective is measured at the receptor.

Table 9-3 Acoustic Quality Objectives for Dwellings

Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at receptor) dB(A)			Environmental Value
		$L_{Aeq,adj,1hr}$	$L_{A10,adj,1hr}$	$L_{A1,adj,1hr}$	
Dwelling (for outdoors)	Daytime and evening	50	55	65	Health and wellbeing
Dwelling (for indoors)	Daytime and evening	35	40	45	Health and wellbeing
	Night-time	30	35	40	Health and wellbeing, in relation to the ability to sleep

9.1.7.1 Construction Noise Criteria

The construction phase for the Project (Mine) will include works such as construction of the open cut and underground mining operations, CHPP, workshops, equipment storage, administration building, and other components within the MIA, and associated roads and offsite infrastructure. The majority of construction will occur over a period of 36 to 48 months however, will continue until the Mine reaches full production in 2022. Construction activities will occur seven days per week and 24 hours per day.

For construction works extending outside normal working hours, the World Health Organisation (WHO) guidelines for quality of sleep apply. That is, maximum noise levels should not exceed 45 dB(A). Based on a typical building façade noise reduction of 10 dB(A) through a partially open window, an external criterion of 55 dB(A)L_{max} is recommended for sleep disturbance, assessable at 4 m from the building façade.

9.1.7.2 Operational Noise Criteria

Guidance on the assessment of operational noise impacts is provided within the *Planning for Noise Control* (PNC) guideline (EPA 2004). The guideline includes noise criteria that are designed to protect sensitive receptors from noise significantly louder than the background level and to limit the total noise level from all sources near a receptor, hence protecting the amenity.

In line with the abovementioned guidelines, noise from continuous sources should be limited to 3 dB(A) above the rating background noise level for each period, unless the combined (ambient plus site contribution) noise level would exceed the recommended ambient noise level for the receptor zone. In that case, the noise limit for the site is set so that the combined noise level for the receptor zone does not exceed the recommended level.

Table 9-4 shows the derivations of the $L_{A90,\ 1hr}$ and $L_{Aeq,\ 1hr}$ noise criteria with consideration to PNC guidelines for each monitoring location, based on modelling results. A rural residential area has been selected for setting the recommended outdoor background planning noise level. A Z1 noise area

category (very rural, purely residential, less than 40 vehicles an hour) has been selected for determining the Planning Noise Level (PNL) at the assessed receptor locations.

Table 9-4 shows the Project (Mine) specific noise criteria adopted for this assessment. Refer to Section 9.1.2 (Figure 9-1) for noise monitoring locations. Comparison between the criteria shown in Table 9-4 and the EPP Noise external night-time criterion of 40 dB(A) $L_{Aeq,adj,1hr}$ indicates the PNC criteria are more stringent and therefore will be used in this assessment. By default, adoption of the PNC criteria for the Project (Mine) will ensure compliance with the EPP Noise 40 dB(A) $L_{Aeq,adj,1hr}$ criteria.

Table 9-4 Project (Mine) Specific Noise Levels

Criterion	Logger 1			Logger 2		
	Day dB(A)	**Evening** dB(A)	**Night** dB(A)	**Day** dB(A)	**Evening** dB(A)	**Night** dB(A)
Measured Background, L_{A90}	31	31	27	25	25	22[4]
Acceptable Measured Background L_{A90}	31	31	27	25	25	25
Recommended Background, minL_{A90} (PNC Table 1)	35	30	25	35	30	25
Adjusted Background, minL_{A90} (PNC Table 2)	33	25	25	30	28	25
Measured Ambient L_{Aeq}	48	41	43	44	41	39
Recommended PNL $L_{Aeq, 1hour}$ (PNC, Table 3, Category Z1)	40	35	30	40	35	30
Planning Noise Level (PNC Table 4 adjusted) [2]	38	31	33	34	31	29
Specific/Component Noise Level [1]	36	28	28	33	31	28
Project (Mine) Specific Level, $L_{Aeq, 1hour}$ [3],	**36**	**28**	**28**	**33**	**31**	**28**

1 Project (Mine) Specific/Component Level, $L_{A,eq, 1 Hour}$ = min $L_{A90, 1 Hour}$ + 3

2 There is no significant contribution from existing industrial noise sources, therefore PNC Table 4 adjustments have been applied but not considered in the setting of the project specific noise criteria.

3 Project specific level is taken as the lower of the Specific/Component level and the adjusted PNL

4 As outlined in the PNC, where the measured background noise level is less than 25 dB (A), the minimum background noise level is set to 25 dB (A).

9.1.7.3 Low Frequency Noise Criteria

The *Guideline for the Assessment of Low Frequency Noise* (DERM 2006) is considered to address noise sources with inherent dominant infrasound or (very) low frequency noise (LFN) characteristics. Coal handling and processing plant have the potential to generate LFN components below 200 Hz. The procedure for the initial screening to determine if a more detailed assessment is required is as follows:

- The overall sound pressure level inside residences should not exceed 50 dB(Linear) to minimise risk of complaints of LFN annoyance.
- If the dB(Linear) measurement exceeds the dB(A) measurement by more than 15 dB, a one-third octave band measurement in the frequency range 20 to 200 Hz should be carried out.

9.1.7.4 Sleep Disturbance Criteria

The EPP Noise recommends that for the health and well-being of residents, in relation to the ability to sleep, the following acoustic quality objectives apply, when measured indoors:

- 30 $dBL_{Aeq, adj, 1hour}$
- 35 $dBL_{A10, adj, 1hour}$
- 40 $dBL_{A1, adj, 1hour}$

Where noise levels are measured over a one hour period and are adjusted for tonal character or impulsiveness.

Additionally, the purpose of the PNC is to limit the external maximum noise impact level, according to the number of occurrences likely to occur and the potential noise reduction from outside to inside. Maximum noise levels over the night time period should be restricted to prevent sleep disturbance.

The guideline recommends that instantaneous internal sound pressure levels do not exceed a maximum sound pressure level in the order of 45 dB(A)L_{max} more than 10 to 15 times per night as a rule in planning for short-term or transient events. On this basis, a “mid-range” external noise level of 55 dB(A)L_{max} more than 10 to 15 times per night is considered appropriate for assessment purposes, as a 10 dB outside to inside reduction in noise level through a partially open window is considered typical.

9.1.7.5 World Health Organisation (WHO) Guidelines for Community Noise

The World Health Organization (WHO) discusses the effects of environmental noise in non-industrial environments in its *Guideline for Community Noise* (1999). It examines aspects such as sleep disturbance, annoyance, and speech intelligibility and provides guidance for protecting people from adverse effects induced by excessive noise. It is also referred to in the PNC Guideline’s section on sleep disturbance criteria.

When the noise comprises of a large low frequency component, lower guideline values are recommended as LFN can disturb sleep at lower sound pressure levels. Most people are likely to be highly annoyed should daytime sound pressure levels at outdoor living areas exceed 55 dB(A)L_{eq} for a steady, continuous noise. Moderate annoyance may be felt should daytime outdoor sound pressure level exceed 50 dB(A)L_{eq}. Sound pressure levels during the evening and night should be 5 to 10 dB lower than the level during the day.

When the noise comprises of a large low frequency component, lower guideline values are recommended as LFN can disturb sleep at lower sound pressure levels.

The recommendation of lower noise levels for LFN also applies for outdoor living areas. For intermittent noise, it is necessary to take into account the maximum sound pressure level as well as the number of noise events. Interference to speech intelligibility may be prevented by maintaining background noise to levels of about 35 dB(A) to 45 dB(A).

Table 9-5 summarises the WHO Guideline values. While the WHO Guidelines provide values for sleep disturbance, external amenity and speech intelligibility, these values are less stringent than the PNC goals outlined previously. The WHO 30 dB(A) L_{eq} guideline value equates to 40 dB(A) L_{eq} external (based on typical 10 dB(A) façade reduction – as per Australian Standard *AS3671:1989 Acoustics—Road traffic noise intrusion—Building siting and construction* and indeed WHO recommends 15 dB(A) façade reduction). Given the PNC criterion is 28 dB(A) $L_{eq,\ 1hour}$ outdoor at night-time, it is considered that the adoption of the PNC criteria, as the more stringent guideline, will ensure compliance with the WHO Guidelines.

Table 9-5 Summary of WHO Guidelines for Community Noise

Descriptor	Indoor Guideline Value	Outdoor Guideline Value
Speech intelligibility (dwellings indoors)	35 dB(A) L_{eq} (steady noise)	Not applicable.
Sleep disturbance (Bedrooms)	30 dB(A) L_{eq} (steady noise) 45 dB(A) L_{max} (intermittent noise)	45 dB(A) L_{eq} (steady noise) 60 dB(A) L_{max} (intermittent noise)
Annoyance (daytime and evening)	35 dB(A) L_{eq}	50 dB(A) L_{eq}

9.1.7.6 Blasting Overpressure and Vibration

Section 440ZB of the EP Act provides criteria for the assessment of blasting impacts.

The EP Act states that blasting must not be conducted if:

> (*a) the airblast overpressure is more than 115dB Z Peak for 4 out of any 5 consecutive blasts;*
>
> *(b) the airblast overpressure is more than 120dB Z Peak for any blast; or*
>
> *(c) the ground vibration is —*
>
> *(i) for vibrations of more than 35Hz--more than 25 mm a second ground vibration, peak particle velocity.*
>
> *(ii) for vibrations of no more than 35Hz--more than 10 mm a second ground vibration, peak particle velocity.*

Additional blasting criteria are referred to in the *Noise and Vibration from Blasting* Guideline (EPA 2006).

The guideline recommends that blasting should generally only be permitted during the hours of 9:00 am to 3:00 pm, Monday to Friday, and from 9:00 am to 1:00 pm on Saturdays. Blasting should not generally take place on Sundays or public holidays. Blasting outside these recommended times should be approved only where:

- Blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or
- There is no likelihood of persons in a noise-sensitive place being affected because of the remote location of the blast site.

The guideline provides assessment criteria for blasting noise and vibration limits as shown in Table 9-6. The guideline values have been adopted for this assessment.

Table 9-6 Guideline Blasting Limits

Airblast Overpressure	Ground Vibration
115 dB(lin) peak	5 mm/s Peak Particle Velocity (PPV)
Must not be more than 115 dB(lin) peak for nine out of any ten consecutive blasts initiated, regardless of the interval between blasts, but never over 120 dB(lin) peak for any blast.	Must not exceed a peak particle velocity (PPV) of 5 mm/s for nine out of any ten consecutive blasts initiated, regardless of the interval between blasts, but never over 10 mm/s for any blast.

9.1.7.7 Human Comfort Vibration Criteria

In the absence of any Australian guidelines relating to human comfort criteria for vibration, criteria have been adopted from the British Standard BS 6472 – 2008, *Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting*, which are recognised as the preferred standard for assessing the "human comfort criteria" for residential building types.

Typically, mine activities generate ground vibration of an intermittent nature. Under BS 6472:2008, intermittent vibration is assessed using the vibration dose value (VDV). Table 9-7 includes acceptable values of vibration dose for residential receptors for daytime and night-time periods.

Table 9-7 Vibration Dose Value Ranges and Probabilities for Adverse Comment to Intermittent Vibration (m/s1.75)

Location	Low probability of adverse comment[1]	Adverse comment possible	Adverse comment probable[2]
Residential buildings 16 hour day (0700 – 2300 hrs)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night (2300 to 0700 hrs)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

1 Below these ranges adverse comment is not expected. 2 Above these ranges adverse comment is very likely.

These values represent the best judgement available at the time the standard was published and may be used for both vertical and horizontal vibration, providing that they are correctly weighted. Because there is a range of values for each category, it is clear that the judgement can never be precise.

Whilst the assessment of response to vibration in BS 6472-1:2008 is based on VDV and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of peak particle velocity (PPV), since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels that are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard BS 5228-2:2009 *Code of practice for noise and vibration on construction and open sites – Part 2: Vibration* as shown below in Table 9-8.

Table 9-8 Guidance on the Effects of Vibration Levels

Approximate Vibration Level	Degree of Perception
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.00 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10.00 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

9.1.7.8 Structural Vibration Criteria

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures.*

Table 9-9 presents the short-term vibration guideline values. The vibration criteria presented in this standard exceed the human comfort criteria presented above. Therefore, as indicated above, the human comfort criteria should be the over-riding criteria for the assessment of any vibration.

Table 9-9 Guideline Values for Vibration Velocity

Guideline Values for Velocity, vi(t)[1] [mm/s]		
Line	**Type of Structure**	**Vibration at the Foundation at a Frequency of**

		1Hz to 10 Hz	10Hz to 50Hz	50Hz to 100Hz[2]
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10

1 The term v_i refers to vibration levels in any of the x, y or z axes. 2 At frequencies above 100Hz the values given in this column may be used as minimum values.

9.1.8 Road Traffic Noise

The Project (Mine) has the potential to generate traffic on roads near sensitive receptors such as the mine village once the mine is operational. There is also potential for increase in traffic during the construction phase, however this is not expected to be an issue if the construction occurs within standard hours as shown in Section 9.1.7.1.

The Department of Transport and Main Roads (DTMR) *Road Traffic Noise Management: Code of Practice* (2007) provides guidance for the assessment of road traffic noise. The traffic noise level of an existing state controlled road should not exceed $L_{A10(18hr)}$ 68 dB(A) assessed one metre in front of the most exposed part of an affected noise sensitive place.

9.2 Description of Environmental Values

9.2.1 Potential Sensitive Receptors

The land use surrounding the mine area is rural in nature with a limited number of possible sensitive receptors. . The proposed workers accommodation village and industrial precinct have also been included as sensitive receptors to the Project (Mine) operations.

Receptors 3, 4 and 5 are located on the southern side of the Carmichael River and will not be subject to noise from mining activities until after year 2035 when mining is expected to commence in this area.

Table 9-10 lists potential sensitive receptors identified within approximately 17 km of the Project. Potential sensitive receptors include the workers accommodation village and heavy industrial area. Figure 9-1 (refer to Section 9.1.2) provides a map of the sensitive receptor locations.

The nearest identified sensitive receptor in relation to the proposed nearest operational noise sources is sensitive receptor 1 (Commercial/Industrial Precinct) which is approximately 2.8 km away. The distance to the nearest operational noise source is the minimum distance of the assessed mining year scenarios.

The proposed workers accommodation village and industrial precinct have also been included as sensitive receptors to the Project (Mine) operations.

Receptors 3, 4 and 5 are located on the southern side of the Carmichael River and will not be subject to noise from mining activities until after year 2035 when mining is expected to commence in this area.

Table 9-10 Potential Sensitive Receptors

Potential Sensitive Receptor	Easting	Northing	Approximate Distance from Nearest Operational Noise Source (m)	Description/Comment
1	437661	7572108	2,800	Commercial/Industrial precinct
2	447799	7569804	6,100	Workers accommodation village
3	453157	7544999	7,800	Bygana Homestead
4	450080	7541530	4,800	Lignum_Homestead
5	446973	7530251	11,800	Mellaluka Homestead
6	422016	7559462	7,100	Doongmabulla Homestead
7	406412	7571007	16,900	Carmichael Homestead

9.2.2 Background Noise

Background noise studies were undertaken at Location A (Doongmabulla homestead) and Location B (Labona homestead). Noise monitoring results at both locations are typical of a rural environment with low background noise levels, during day (7:00 am to 6:00 pm), evening (6:00 pm to 10:00 pm) and night (10:00 pm to 7:00 am) periods (refer to Table 9-11). The rating background level (RBL) for each period at monitoring Location A is 31 dB(A), 31 dB(A) and 27 dB(A), respectively. At monitoring Location B the RBL for each period, respectively, is 25 dB(A), 25 dB(A) and 22 dB(A).

The ambient noise level (L_{Aeq}) for each period, respectively, at monitoring Location A was recorded as 48 dB(A), 41 dB(A) and 43 dB(A). At monitoring Location B the ambient noise level for each period, respectively, was recorded as 44 dB(A), 41 dB(A) and 39 dB(A). The background noise levels during night-time periods typically fall to below 25 dB(A) at monitoring Location B and to a lesser extent at monitoring Location A.

Noise levels at monitoring Location A are generally higher due to the influence of birdlife and cattle. Notwithstanding this, both locations were dominated by natural noise sources including insects and birds.

Table 9-11 Summary of Noise Monitoring Results

Location	Background L_{A90} dB(A)	Ambient L_{Aeq} dB(A)

	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)	Day (7 am to 6 pm)	Evening (6 pm to 10 pm)	Night (10 pm to 7 am)
Location A	31	31	27	48	41	43
Location B	25	25	22	44	41	39

*Results are rounded to the nearest integer.

9.2.3 Background Vibration

Measured ground vibration results indicate very low ground vibration levels (in the order of 0.1 mm/s) at all locations which confirms the lack of perceptible vibration at all sites.

9.2.4 Local Meteorology

Noise propagation over long distances can be significantly affected by the weather conditions. In particular, source to receptor winds and the presence of temperature inversions can enhance received noise levels. To account for these atmospheric phenomena, the PNC Guideline specifies procedures to determine the prevalent weather conditions and identify whether these conditions are a feature of the Project Area.

Meteorological data was obtained from the Air Quality Assessment (Volume 4 Appendix S) and used for determining the prevalent weather conditions. The wind rose charts for each season in each time period (day, evening and night) and the Pasquill / Gifford scale of atmospheric stability winter season in the night-time period are presented in Section 7 and Volume 4 Appendix S.

The annual mean rainfall at Carmichael is just over 524 mm and is dominated by the warm months producing convectively driven rainfall. December through March, inclusive, accounts for 65 per cent of rainfall. The wettest month is January with a mean of 129.1 mm and the driest month is May with a mean of 11.2 mm. Given the annual mean rainfall is over 500 mm per year, the site is considered non-arid (as per the PNC Guideline).

Temperature Inversions

Records of the Pasquill Stability Class, a parameter representing the degree of mixing in the atmosphere, can gauge the prevalence and magnitude of temperature inversions. Stability classes are categorised as A to G where Class A applies under sunny conditions with light winds when dispersion is most rapid. Stability Class D applies under windy and/or overcast conditions when dispersion is moderately rapid and Stability Class F and G can occur at night when winds are light and the sky is clear. Stability Classes B, C and E are intermediate conditions between those described above. Temperature inversions may occur during stability classes E, F and G. In particular, stability class F generally represents a range of temperature gradients from 1.5 ºC/100 m to less than 4 ºC/100 m.

The Project (Mine) would operate 24 hours per day including the night-time period when temperature inversions are likely to occur. Analysis of the meteorological data indicates that class F temperature inversions occur more than 30 per cent of the time during night-time in the winter season. As a result of this analysis and given the average annual rainfall is representative of a non-arid environment,

moderate temperature inversion will be considered in this assessment (as per the requirements of the PNC Guideline).

Noise propagation can be increased by wind conditions. The PNC Guideline states that when there is greater than 30 per cent occurrence of wind of up to 3 m/s, in any period (day, evening, night) in any season, from source to receptor, wind should be considered in noise prediction calculations. Analysis of the seasonal wind rose data indicates that easterly winds up to 3 m/s occur more than 30 per cent of the time in autumn season during evening time, therefore wind is considered a feature of the area and the noise model will include a 3 m/s easterly wind (as per requirements of the PNC Guideline).

9.3 Potential Impacts and Mitigation Measures

9.3.1 Overview

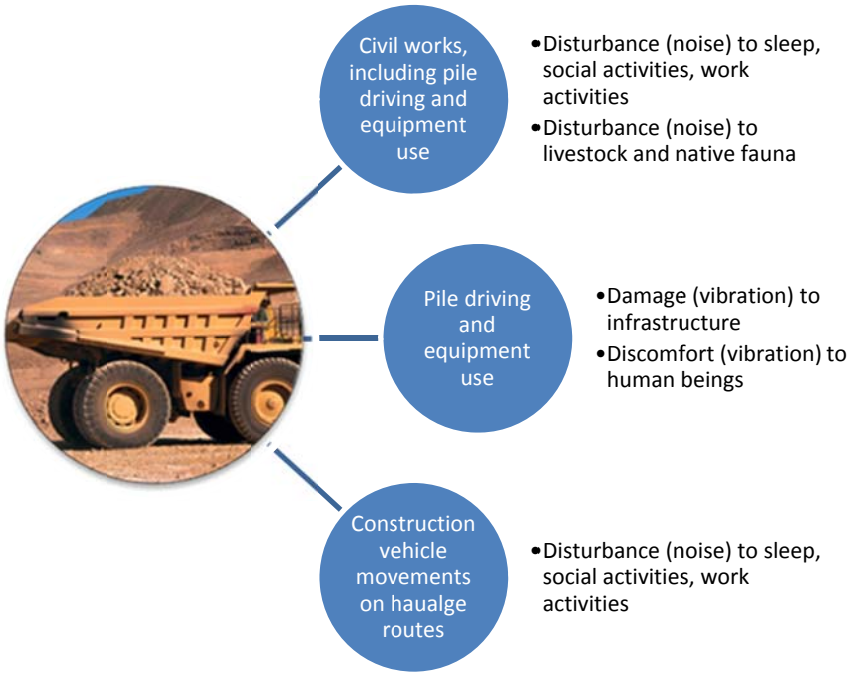
The construction and operation of the Project (Mine) have the potential to cause noise and vibration impacts on the surrounding environment. Impacts to sensitive receptor 1 are excluded as the heavy industrial will not operate during construction of the Project (Mine). Impacts relating to operation of the permanent airport have not been considered at this time, however given that the airstrip is to be located between the Mine site and the mine village the impacts to surrounding sensitive receivers are likely to be intermittent.

Potential construction and operational impacts have been identified and analysed on the basis of a desktop analysis combined with acoustic modelling considering the construction and operational methods, equipment proposed to be used and mine stage plans.

9.3.2 Mine Construction

With regard to the Project (Mine) construction phase, mining (fixed and mobile) equipment and blasting associated with the civil works and construction of the MIA the primary aspects influencing noise and vibration. Figure 9-2 provides a conceptual overview of the potential construction impacts of the Project (Mine).

Figure 9-2 Conceptual Overview of Potential Construction Impacts



9.3.2.1 Civil Works

Construction activities, such as civil works including: earthworks, drainage construction, pile driving and equipment use, and mine construction have the potential to adversely impact on noise sensitive receptors through:

- Disturbance to sleep, social activities and/or work activities
- Disturbance of livestock and native fauna (see Section 9.3.3.4)

Table 9-12 shows the predicted construction noise level at each of the surrounding sensitive receptors for neutral meteorology. Worst case construction noise levels for day time works are predicted to be less than 10 dB(A) at all receptors except at sensitive receptors 3 and 4 where the noise levels are expected to range between 12 and 24 dB(A) and 25 to 37 dB(A) respectively. The predicted impact is conservative as it assumes that construction activities are taking place at the nearest site boundary based on maximum sound power levels.

While most construction work would be completed during daytime hours, some construction activity will occur during evening and night periods to meet the proposed construction schedule. Any construction work outside of normal hours should be conducted with consideration to the WHO Guideline recommended external noise criteria of 55 dB(A). This criterion addresses sleep disturbance, assessable at 4 m from the building façade (refer to Section 9-10).

The results in Table 9-12 indicate that predicted construction noise levels are expected to be well under the 55 dB(A) WHO criteria at all sensitive receptors.

Receptors 3, 4 and 5 will not receive noise from the operation of the Project (Mine) until 2035, once mining commences in that area.

Table 9-12 Predicted Construction Noise Level at Sensitive Receptors

Sensitive Receptor	Predicted Construction Noise Level, dB(A) (Adverse Meteorology)
1 Commercial/Industrial precinct	Not in use during construction of the Project (Mine)
2 Workers accommodation village*	19
3 Bygana Homestead	<10
4 Lignum Homestead	<10
5 Mellaluka Homestead	<10
6 Doongmabulla Homestead	<10
7 Carmichael Homestead	<10

* Note: workers accommodation village does not include noise from construction of the workers accommodation village itself, as there are no sensitive receptors at the workers accommodation village until it is constructed.

9.3.2.2 Construction Traffic

The main traffic that will be generated through the construction phase will be from plant, equipment and material deliveries. Table 9-13 provides the estimated average and worst case daily construction vehicle movements that would occur along Gregory Developmental Road, Elign Moray Road and Moray Carmichael Road.

Potential traffic generated noise was highest at noise monitoring Receptor 7. The estimated traffic generated noise at this location was approximately 12 dB(A) below the DTMR criteria of 68 dB(A)$_{L10,18hr}$. As such the potential impacts of traffic generated noise are expected to fall within the DTMR criteria at all sensitive receptors.

Table 9-13 Estimated Vehicle Movements (Construction phase, Worst-case scenario)

Access Roads	Maximum movements per year	Vehicles per day	Estimated Peak Hour movements
Gregory Developmental Road, Elign Moray Road, Moray Carmichael Road	27,011	74	15

9.3.2.3 Pile Driving and Equipment Use

Construction activities and equipment such as pile driving can lead to high vibration levels potentially resulting in adverse impacts. Assessment of potential vibration impacts is needed to minimise potential adverse impacts on the surrounding sensitive receptors. Pile driving is, as a minimum, expected to be required as part of the construction of the MIA. Ground vibration caused by blasting is covered in Section 9.3.3.4.

Table 9-14 provides details for the predicted ground vibrations levels at various distances for typical construction equipment.

Table 9-14 indicates vibration levels of 0.1 mm/s or less at a distance of approximately 300 m. This is well below the adopted vibration criteria for all nominated plant items, including pile driving. Furthermore, vibration levels produced by construction activities within the mining boundary are expected to be well below the most stringent structural damage criteria of 3 mm/s at receptors located at distances greater than 50 m.

Table 9-14 Predicted Construction Equipment Vibration Levels

Plant Item[1]	Human Perception Preferred Criteria *(Maximum Criteria)*		Predicted Ground Vibration Levels (mm/s PPV)				
	Day	Night	10 m	30 m	50 m	100 m	300 m
Pile Driving (Impulsive)	8.6 *(17.0)*	2.8 *(5.6)*	21.0	4.0	1.9	0.7	0.1
15t Roller	0.28 *(0.56)*	0.2 *(0.4)*	7.5	1.4	0.7	0.2	<0.1
Dozer	0.28 *(0.56)*	0.2 *(0.4)*	3.3	0.6	0.3	0.1	<0.1
7t compactor	0.28 *(0.56)*	0.2 *(0.4)*	6.0	1.2	0.5	0.2	<0.1
Rock Breaking	0.28 *(0.56)*	0.2 *(0.4)*	7.0	1.3	0.6	0.2	<0.1
Backhoe	0.28 *(0.56)*	0.2 *(0.4)*	1.0	0.2	0.1	<0.1	<0.1

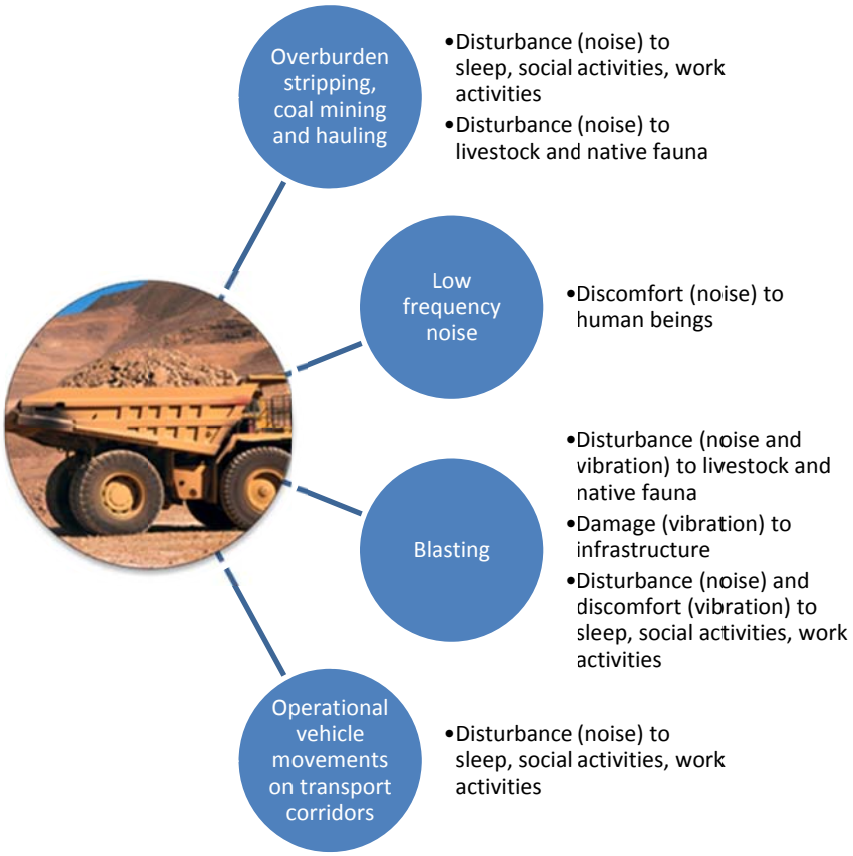
9.3.3 Mine Operation

With regard to the Project (Mine) operational phase, mining (fixed and mobile) equipment and blasting are the primary aspects influencing noise and vibration.

Figure 9-3 provides a conceptual overview of the potential operational impacts of the Project (Mine).

[1] NSW RTA Environment noise management manual

Figure 9-3 Conceptual Overview of Potential Operational Impacts



9.3.3.1 Mine Operations

With regard to the Project (Mine) operational phase, mining (fixed and mobile) equipment and blasting are the primary aspects influencing noise and vibration. Mine operation has the potential to adversely impact on noise sensitive places through:

- Disturbance to sleep, social activities and/or work activities
- Disturbance of native fauna and livestock (see Section 9.3.3.4)

Predicted noise levels during neutral and adverse weather conditions considered the following mine operation scenarios:

- Scenario 1 – Mining operation (Year 2016)
- Scenario 2 – Mining operation (Year 2037)
- Scenario 3 – Mining operation (Year 2067)
- Scenario 4 – Mining operation (Year 2103)

Table 9-15 and Table 9-16 show the predicted operational noise levels at the surrounding sensitive receptors for neutral and adverse weather conditions respectively. Predicted operational noise at sensitive receptor 1 excludes noise generated by the heavy industrial area. The most stringent night-time noise criterion has been provided for comparative purposes.

Noise model results indicate the predicted noise levels for year 2016, 2037 and 2103 are expected to be compliant with the most stringent night-time noise criteria at all assessed surrounding sensitive receptors under neutral and adverse weather conditions. The noise model results also indicate that noise from the heavy industrial area will not adversely impact sensitive receptors 2- 7.

The highest predicted operational noise level is 29 dB(A) expected to occur during year 2067 at sensitive receptor 4 under both neutral and adverse weather conditions. This noise level exceeds night time criteria by 1dB(A). Predicted noise levels at other sensitive receptors do not exceed night time criteria.

It should be noted that the assessment represents potential worst case predictions, in which equipment operates at full capacity and the night time weather conditions are most conducive to noise propagation. It is not expected that this situation would arise on a regular basis.

Table 9-15 Predicted Operational Noise Level at Receptors – Neutral Conditions

Receptor	Night-time criteria Leq dB(A)	Predicted operational noise level, dB(A)			
		Neutral meteorology			
		Year 2016	Year 2037	Year 2067	Year 2103
1 (Industrial precinct)	55	23	22	22	19
2 (Workers accommodation village)	28	21	23	24	19
3 (Bygana homestead)		19	22	26	19
4 (Lignum homestead)		19	22	29	20
5 (Mellaluka homestead)		13	16	18	12
6 (Doongmabulla homestead)		12	16	17	11
7 (Carmichael homestead)		11	13	14	8

*Noise levels at Receptor 1 (Industrial precinct) only include noise from the Project (Mine) operations. Noise from within the industrial precinct is excluded.

Table 9-16 Predicted Operational Noise Level at Receptors – Adverse Conditions

Receptor	Night-time criteria Leq dB(A)	Predicted operational noise level, dB(A)			
		Adverse meteorology (F Class inversion + 2 m/s easterly wind)			
		Year 2016	Year 2037	Year 2067	Year 2103
1 (Industrial precinct)	55	33	34	34	30
2 (Workers accommodation village)	28	21	24	26	20
3 (Bygana homestead)		19	22	26	19
4 (Lignum homestead)		19	22	29	20
5 (Mellaluka homestead)		14	19	22	14
6 (Doongmabulla homestead)		16	20	20	14
7 (Carmichael homestead)		14	16	17	11

Note: *Noise levels at Receptor 1 (Industrial precinct) only include noise from the Project (Mine) operations. Noise from within the industrial precinct is excluded.

9.3.3.2 Operation Traffic

Traffic generation due to the operation of the mine is expected to occur on the re-aligned Moray Carmichael Road accessing the Gregory Developmental Road. Whilst the detailed design of the final road alignment is to be determined, re alignment is only likely to have an impact in the vicinity of Receptor 2 as the other receptors are not in proximity to the Moray Carmichael Road along the proposed haulage routes.

It has been assumed that all vehicle movements would occur along the Gregory Developmental Road, Elgin Moray Road and Moray Carmichael Road (see Table 9-17). The following assumptions were made:

- Operations vehicle movements were assumed to occur 365 days per year.
- Peak hour vehicle movements were assumed to be 20 per cent of daily movements.

Potential traffic generated noise was highest at Receptor 7. The estimated traffic generated noise at this location was approximately 9 dB(A) below the DTMR criteria of 68 dB(A)L10,18hr. As such the potential impacts of traffic generated noise are expected to fall within the DTMR criteria at all sensitive receptors.

Table 9-17 Estimated Vehicle Movements (Operational phase, Worst-case scenario)

Access Roads	Maximum movements per year	Vehicles per day	Estimated Peak Hour movements
Gregory Developmental Road, Elgin Moray Road, Moray Carmichael Road	52,158	143	29

9.3.3.3 Low Frequency Noise

LFN due to operation of the Project (Mine), in particular the coal handling and processing plant, has the potential to adversely impact on noise sensitive places through the annoyance and discomfort to humans located in dwellings.

The predicted operational LFN levels at the nearest surrounding sensitive receptors range between <10 and 42 dB(linear) (Table 3-9 Volume 4 Appendix U). Noise model results indicate the predicted LFN levels are expected to be under the LFN criteria of 50 dB(linear) at all assessed surrounding sensitive receptors (refer to Volume 4 Appendix U Mine Noise and Vibration Report).

9.3.3.4 Blasting

Potential adverse impacts to sensitive receptors associated with blasting may include:

- Disturbance of native fauna and livestock (see Section 9.3.4)
- Annoyance and discomfort to sensitive receptors as a result of airblast overpressure and ground vibration
- Damage to property and infrastructure as a result of ground vibration

Ground vibration and airblast overpressure estimations have been undertaken with consideration to AS2187-2006 and have been based on available information. Typical site constants have been used in the blasting assessment to reflect geological conditions, however ground conditions, including rock structure and strata type, can vary significantly within and surrounding a mine site and this can affect the propagation of vibration and airblast overpressure.

Calculations are based on the distance from the nearest open cut or underground mining boundary, to the sensitive receptors.

Table 9-18 identifies predicted ground vibration and airblast overpressure levels at sensitive receptors based on expected lower and upper site constants. Based on the predicted blast impacts, the predicted airblast overpressure and ground vibration levels at the surrounding sensitive receptors are expected to be below the blasting criteria under all assessed conditions.

Table 9-18 Predicted Blast Impacts

Receptor	Distance from nearest open cut or underground mining boundary (m)	Estimated Airblast Overpressure, dB(Linear) Peak		Estimated Ground Vibration, PPV (mm/s)	
		$k_a = 10$	$k_a = 100$	$K_g = 800$	$K_g = 1600$
1 Commercial/ Industrial precinct	7,700	90.3	110.3	0.1	0.2
2 Workers accommodation village	14,100	82.7	102.7	<0.1	0.1
3 Bygana Homestead	9,900	87.1	107.1	0.1	0.2
4 Lignum_Homestead	6,900	91.7	111.7	0.1	0.3
5 Mellaluka Homestead	12,300	84.4	104.4	0.1	0.1
6 Doongmabulla Homestead	6,300	92.8	112.8	0.2	0.3
7 Carmichael Homestead	13,500	83.2	103.2	<0.1	0.1
Acceptable limits		**115 dB(L)**		**5 mm/s PPV**	

9.3.4 Noise Impacts on Native Fauna and Livestock

9.3.4.1 Livestock

Current research indicates that there are no government policies or widely accepted guidelines with regard to noise criteria for animals. However, information is provided in technical literature and has been reviewed for the Project (Mine).

The noise goals provided in this report are based on human response and annoyance factors and, as such, are not applicable to livestock or other non-human receivers. However, it is recognised that sudden noise has the potential to startle or upset domestic livestock and pets.

Heggies Pty Ltd conducted a literature review as part of their assessment of blasting noise impacts on livestock for the proposed Caval Ridge Coal Mine Project (Heggies 2009). Heggies cites results from a study on the response of farm animals to sonic booms, which indicated that reactions of sheep, horses and cattle to sonic booms (125 dB to 136 dB) were considered slight to mild. The study indicated that analysis of data from 42 herds did not show any evidence that flyovers or proximity to the ends of the active runways had an effect on the milk production of the herds. Animal installations were selected for observations on animal behaviour under sonic boom conditions. Numbers of animals observed in this study were about 10,000 commercial feedlot beef cattle, 100 horses, 150 sheep and 320 lactating dairy cattle. Booms during the test period were scheduled at varying intervals during the morning hours Monday to Friday of each week.

Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125 dB to 136 dB). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, rising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield.

Given these conclusions, it is unlikely that the Project (Mine) would have an adverse effect on livestock in the vicinity of the development. Further details relating to noise impact to fauna species is provided in Volume 2 Section 4 Nature Conservation.

9.3.4.2 Native Fauna

Previous extensive clearing of vegetation in the Project Area for agricultural purposes has reduced the amount of available habitat, and as a result, has minimised the potential for impact by the Project (Mine) on local wildlife.

The effect of noise on wildlife can be similar to the effects observed in humans. Noise can adversely affect wildlife by interfering with communication, masking the sounds of predators and prey, cause stress or avoidance reactions and (in the extreme) result in temporary or permanent hearing damage. Experiments have shown that exposure to noise impulses throughout the night-time sleep period resulted in poorer daytime task performance by animals (see Fletcher & Busnel, 1978).

The learning ability of many animal species, in regard to familiarisation, is discussed by Busnel (1971). The animal's initial reaction to a new noise source is fright and avoidance but if other sensory systems are not stimulated (for instance optical or smell), the animal learns quite quickly to ignore the noise source, particularly when it exists in the presence of man.

Migratory birds have the potential to be influenced by noise from the Project (Mine). Studies of birds (Larkin, 1996) have shown that they will habituate to loud noises that are not biologically meaningful for them. For example if the noise is associated with possible harm such as thunder on a cloudy day, birds will avoid it, but routine noises such as traffic will not disturb them. Examples are provided of sea-birds that voluntarily co-exist with relatively loud noise environments, such as around airports, and birds roosting on light-posts above busy motorways.

Attempts at using noise to deliberately scare birds away from an area, for example to protect farming crops, have been shown to grow less effective over time as birds habituate to the noise. Larkin suggests that keeping the noise as consistent as possible both in the sound produced and the frequency with which it occurs may also help mitigate its effects on birds. Poole (1982) and Algers *et. al.* (1978) shows that birds tend to adapt to steady state noise levels, even of a relatively high level (in the order of 70 dB(A)). Given the predicted steady noise levels around the Project (Mine) are expected to be much less than this level, noise impacts on birds surrounding the Project (Mine) is considered acceptable.

9.3.5 Management and Mitigation

9.3.5.1 Mine Construction

Civil Works

Noise model results indicate construction noise levels are unlikely to cause adverse impacts, and therefore direct mitigation measures are not necessary.

Mitigation measures would only be required upon receipt of a valid complaint. Adani will maintain a stakeholder engagement program throughout construction including:

- Provision of information to nearby residents regarding construction activities and how to contact Adani if noise issues arise
- A continuously monitored community liaison phone number and email address that allows noise complaints to be received and addressed in a timely manner.

If noise complaints are received, these will be entered into Adani's Consultation Manager database and responsibilities assigned for contacting the complainant and investigating the complaint in a timely manner.

In the event that complaint investigations indicate that construction noise levels are unreasonable, there are a range of management measures that may be able to be implemented.

Vibration from Pile Driving and Equipment Use

While construction vibration levels are unlikely to cause adverse impacts, it is considered that implementation of the following management measures will further facilitate minimisation of potential impacts arising from the construction of the Project (Mine):

- Monitor vibration levels during construction to prevent sustained vibration levels causing unacceptable loading.

9.3.5.2 Mine Operation

Based on information available on equipment and plant types and numbers, operation noise levels are unlikely to cause adverse impacts, and therefore direct mitigation measures are not necessary. As noise prediction results indicate that noise levels at the Bygana and Lignum homesteads may approach or slightly exceed the night-time noise criteria, routine noise monitoring will be undertaken at Bygana and Lignum homestead as mining progresses towards these locations.

Noise level predictions should be revisited once final equipment and plant lists are available and to reflect any changes in the mine plan that occur as more detailed design and mine planning progresses. However, it is unlikely that any significant changes in noise levels will occur that cannot be addressed through noise mitigation and attenuation measures.

Adani will also maintain a stakeholder engagement program throughout operation including:

- Provision of information to nearby residents regarding mining activities and how to contact Adani if noise issues arise
- A continuously monitored community liaison phone number and email address that allows noise complaints to be received and addressed in a timely manner.

If noise complaints are received, these will be entered into Adani's Consultation Manager database and responsibilities assigned for contacting the complainant and investigating the complaint in a timely manner. Similarly, if noise monitoring indicates that noise levels are exceeded, this will be treated as an incident. In either case, an investigation will follow the incident investigation procedure established for the mine site and corrective actions arising will be entered into the corrective action register. The stakeholder engagement program will ensure prompt and ongoing communications with the complainant or any other potentially affected parties in relation to the complaint and investigation.

In the event that routine monitoring or complaint investigations indicate that operational noise levels exceed environmental authority criteria, there are a range of management measures that can be implemented. These may include:

- Selection of quieter equipment or maintenance and modification of equipment to reduce noise emissions when operating in proximity to noise sensitive receptors
- Grading haul roads to remove potholes and bumps
- Use of broadband reversing alarms (audible movement alarms) rather than standard tonal reversing alarms
- Partial or full enclosure of noisy stationary plant items.
- Use of earth mounds to block noise

9.3.5.3 Low Frequency Noise

Noise model results indicate the predicted LFN levels are expected to be under the LFN criteria of 50 dB(linear) at all assessed surrounding sensitive receptors and mitigation measures are not required.

9.3.5.4 Blasting

Although predicted airblast overpressure and ground vibration levels are expected to be under the criteria, overpressure levels at sensitive receptors 4 (Lignum) and 6 (Doongmabulla) are predicted to be within 2 to 3 dB of the 115 dB(L) criteria.

It should be noted that the calculations are based on typical site constants which should be verified with the blasting contractor prior to blasting. If predictions indicate that the acceptable limit of 115 dB(L) is likely to be approached or exceeded, and this cannot be confidently addressed by changing blasting parameters, receptors will be notified and consideration will be given to whether receptors at potentially affected homesteads should be relocated away from the blast location during the blasting activity. As this is only likely to affect a small number of individuals at the potentially affected homesteads, this should not cause unnecessary disruption. Engagement with potentially affected landholders and workers on adjacent properties will occur through the stakeholder engagement program and details of engagement will be recorded in the Consultation Manager database.

If airblast levels are likely to exceed the acceptable limits, monitoring will also be undertaken to check the accuracy of predictions and indicate whether further optimisation of the blast parameters is required.

Where monitoring or complaints indicate airblast overpressure or ground vibration levels exceed the environmental protection objectives, modification to blast parameters will be considered. Blast parameters that may be altered to address excessive airblast overpressure include:

- Maximum instantaneous charge
- Stemming height
- Reducing the maximum instantaneous charge by using delays, reduced hole diameter and/or deck loading
- Changing the burden and spacing by altering the drilling pattern and/or delay layout, or altering the hole inclination
- Ensuring stemming depth and type is adequate
- Restricting blasts to favourable weather conditions

It is not proposed to introduce time restrictions to blasting activities given the small number of potentially affected receptors, and that these receptors will be notified ahead of time of proposed blasting activities. Blasting is not expected to take place at night except in extraordinary circumstances.

9.3.6 Noise Impacts on Native Fauna and Livestock

Current research indicates that there are no government policies or widely accepted guidelines with regard to noise criteria for animals. However, information is provided in technical literature and has been reviewed for the Project (Mine) and suggests that native fauna will habituate to routine noises.

It is recognised that sudden noise has the potential to startle or upset domestic livestock and pets. A literature review of the impacts of blasting noise on livestock has concluded that it would be unlikely for the Project (Mine) to have an adverse effect on livestock.

Refer to Volume 4 Appendix U Mine Noise and Vibration and Volume 4 Appendix N1 Mine Terrestrial Ecology Report for further information regarding noise impacts on native fauna and livestock.

9.4 Summary

Baseline noise monitoring was conducted at two locations in the vicinity of the proposed Project Area. Locations were selected as they were considered representative of the acoustic environment for the nearest sensitive receptors located in the vicinity of the mine. Noise levels at monitoring Location A were generally higher due to the influence of birdlife and cattle. Notwithstanding this, both locations were dominated by natural noise sources including insects and birds.

Construction noise during normal hours is not expected to cause adverse impacts at noise receptors. However, in order to reduce the risk of noise impact, it is recommended that the mitigation measures outlined above be taken into consideration during construction of all infrastructures associated with the Project (Mine).

Results indicate that predicted construction noise levels outside of normal hours are expected to be well under the 55 dB(A) WHO criteria at all sensitive receptors. Nonetheless, it is recommended for consideration that particularly noisy activities such as pile driving or blasting are conducted during daytime hours to minimise the potential noise impact at sensitive receptors.

Operational noise modelling results indicate that predicted noised levels for year 2016, 2037 and 2103 are expected to be compliant with the most stringent night-time noise criteria at all assessed surrounding sensitive receptors under neutral and adverse weather conditions, except for receptor 4

(Lignum homestead). The highest predicted operational noise level is expected to occur at receptor 4 with 29 dB(A) during year 2067, causing a marginal exceedance of the most stringent night-time criteria. It is acknowledged that this exceedance is based on worst-case Project (Mine) operations.

Noise model results indicate the predicted LFN levels are expected to be under the LFN criteria of 50 dB(linear) at all assessed surrounding sensitive receptors and mitigation measures are not required.

The proposed off-site infrastructure has been conservatively assessed and included in the operational noise models. Noise impacts associated with the proposed industrial precinct, rail siding and water pumping stations are not expected to cause adverse noise impacts at sensitive receivers.

Given the relatively low projected traffic volumes, traffic noise was predicted to be below the relevant DTMR criteria at the nearest sensitive receptor or monitoring location.

Based on typical site constants, predicted airblast overpressure and ground vibration levels are expected to be under the criteria. However, overpressure levels at sensitive receptors 4 (Lignum) and 6 (Doongmabulla) are predicted to be within 2 to 3 dB of the 115 dB(L) criteria.

Once site constants are verified with the blasting contractor, it is recommended that airblast overpressure be recalculated prior to blasting and mitigation measures identified if required. Airblast overpressure monitoring will be conducted during the initial blasts to assist with the optimisation of the blast parameters and confirmation of predictions. Maximum instantaneous charge and stemming height together with other blast parameters will be modified to achieve airblast criteria.

Based on available literature, it is concluded unlikely that potential noise associated with the Project (Mine) will adversely impact livestock and native fauna. As such, no specific management measures are required.

Although Project (Mine) operations are generally not expected to cause adverse noise impacts, mitigation measures have been identified in the event that exceedance of the noise criteria occurs , or a complaint is received and validated.

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