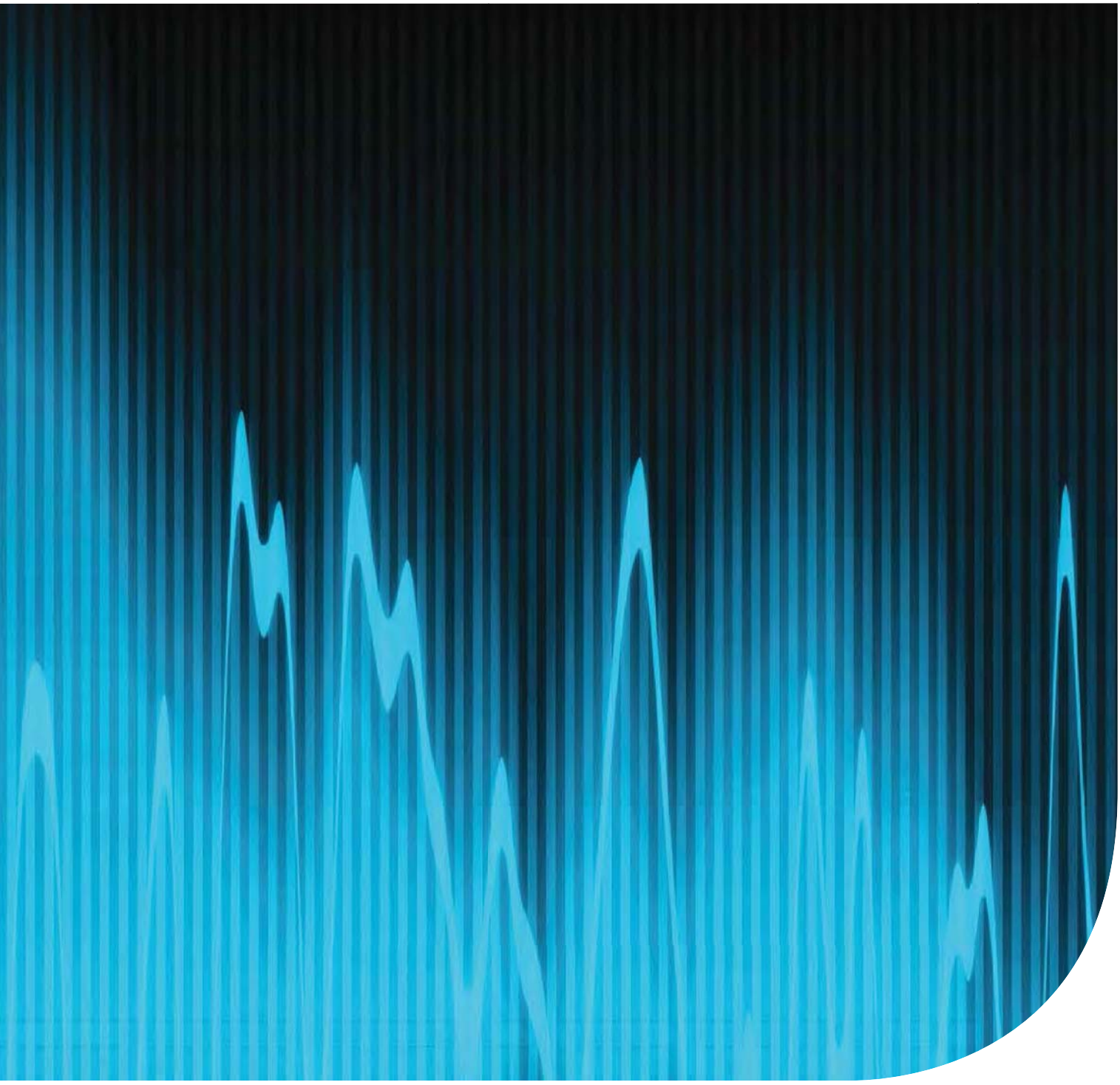
RASP Mine Modification 4

Concrete batching plant and TSF2 (Blackwood Pit) extension | Noise impact assessment

Prepared for Broken Hill Operations Pty Ltd | 29 March 2017



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RASP Mine Modification 4

Final

Report J16127RP1 | Prepared for Broken Hill Operations Pty Ltd | 29 March 2017

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1 Introduction

EMM Consulting Pty Limited (EMM) has been engaged by Broken Hill Operations Pty Ltd (BHOP) to complete a noise assessment for the proposed Modification 4 of Project Approval PA 07_0018 (PA) for the RASP Mine, Broken Hill, NSW.

BHOP is seeking to modify its PA to allow for the construction and operation of an on-site concrete batching plant and the extension of the life of the Blackwood Pit Tailings Storage Facility.

This report presents an assessment of noise from the proposed construction works and future operations and potential impacts on the surrounding community. This report also provides recommended construction noise management measures.

This report references the project approval and noise guidelines as follows:

- NSW Department of Planning and Environment (DP&E), *Project Approval (PA07_0018)*), March 2015;
- NSW Environment Protection Authority (EPA), *NSW Industrial Noise Policy* (INP), 2000;
- NSW Department of Environment and Climate Change (DECC), *Interim Construction Noise Guideline*, 2009;
- NSW Department of Environment, Climate Change and Water (DECCW), *NSW Road Noise* Policy (RNP), 2011;
- World Health Organisation (WHO), *Guidelines for Community Noise*, 1999; and
- Broken Hill Operations, *Noise Monitoring Management Plan* (NMMP), updated December 2015.

2 Background

2.1 Existing operations

The RASP Mine is located in the centre of the City of Broken Hill and mining has been occurring at the site for over 130 years. Existing approved mining operations at RASP Mine consist mainly of underground operations, surface hauling of material to the processing plant and dispatch of concentrate products.

Historically, attended noise monitoring completed for RASP Mine has shown that noise emissions from site satisfy the criteria at all nearby receivers. Previous noise assessment completed for the site has also shown that existing site noise complies with the relevant criteria during assessable meteorological conditions.

2.2 Proposed construction

BHOP is seeking to modify its PA to install a concrete batching plant (CBP) on site and extend the life of the Blackwood Pit Tailings Storage Facility (TSF2). The proposed construction works will be restricted to daytime hours between 7 am and 6 pm Monday to Friday, 8 am to 1 pm on Saturdays, and no work on Sundays or public holidays. The construction of both the CBP and the TSF2 is expected to span approximately one year and three months. The construction will be completed in several stages and comprises the construction of the CBP initially, following by the construction of supporting infrastructure for the TSF2 to extend its life. Each stage of the construction will occur separately and hence will not be completed concurrently. The expected duration for each stage are presented in Table 2.1.

Table 2.1 Proposed duration for each construction activity

Construction works	Activity	Approximate duration
CBP	CBP and noise bund	5 weeks
TSF2	Embankment 2	21 weeks
	Spillway	4 weeks
	Embankment 3	16 weeks
	Embankment 1 (including retaining wall)	15 weeks

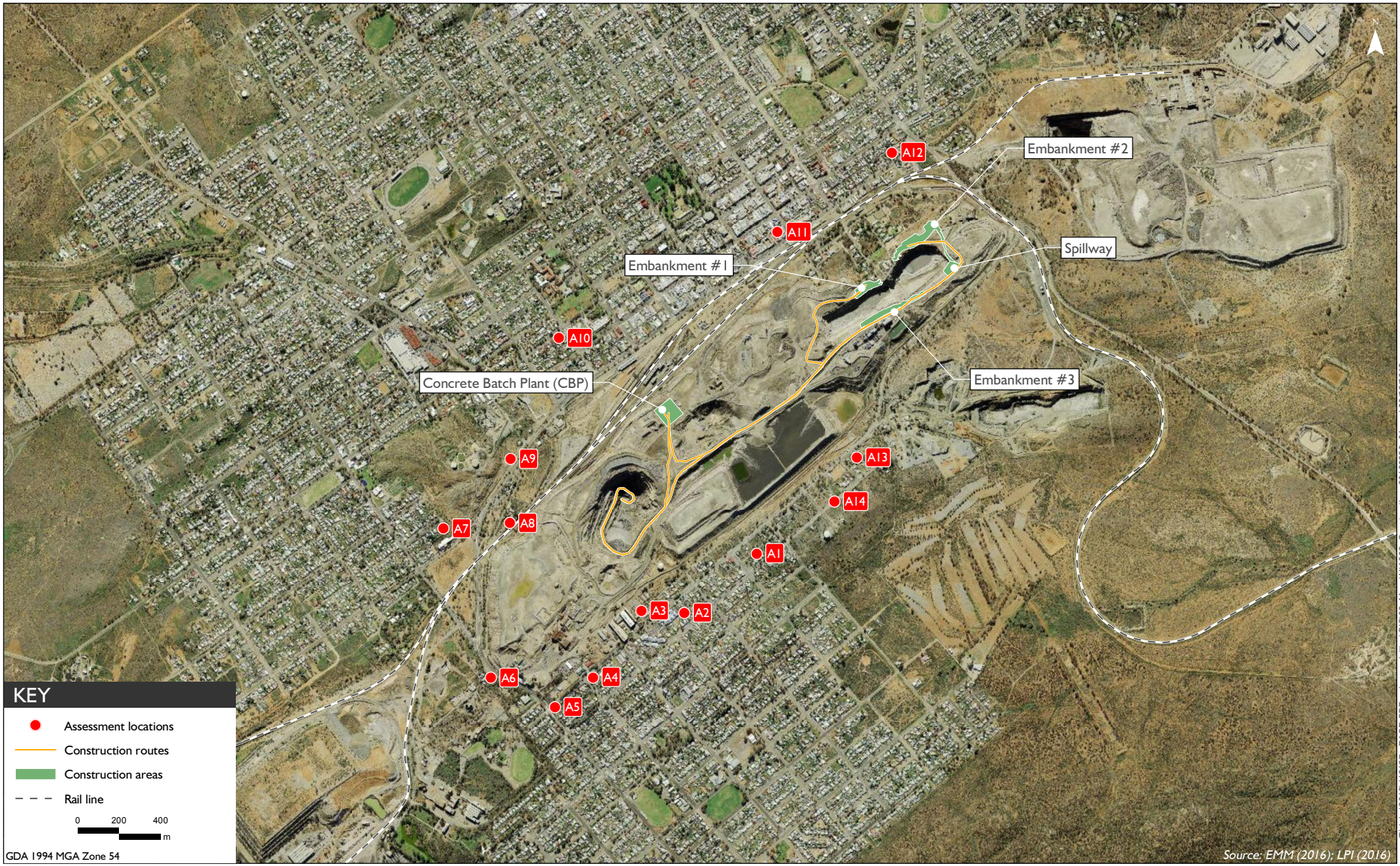
Notes: 1. Each construction activity will occur separately.

2. The order in which these construction activities we be completed will be decided by the contractor.

The CBP will be contained in a concrete structure and will be located relatively in the centre of the site. The operation of the CBP will allow BHOP to produce their own fibercrete and concrete for site use. BHOP currently source their concrete products from a local supplier. Further, once the CBP becomes operational, which is planned to occur immediately after its construction, BHOP will be able to produce and use their own concrete for the extension of the TSF2. The CBP will therefore eliminate its current concrete truck traffic offsite.

The extension of the TSF2 will involve the construction of three embankments (including a retaining wall) and a spillway to increase its storage capacity and subsequently increase the life of this facility for an additional three years.

The locations of the CBP and proposed construction works are shown on Figure 2.1.



Location of proposed construction works

RASP Mine Modification 4
Noise Impact Assessment
Figure 2.1

2.3 Future operations

The proposed modification will involve no change to the existing approved mining operations at RASP Mine. The only change will be the operation of the CBP which will be operational 24 hours daily. The CBP will comprise mainly of a cement silo, storage bunkers for aggregate, a hopper, conveyors and conveyor drives. The CBP will be contained within a concrete building. A front-end loader (FEL) will be used to load aggregates into the hopper. Agitator trucks will be used to transport the fibercrete of concrete around site. However, it is noted that the main purpose of the CBP will be to produce fibercrete to support underground works.

Aggregates, fibres and admixtures will be delivered by external suppliers through the front gate and to the CBP by trucks using existing haulage routes. Cement will be delivered by rail and unloaded at RASP Mine's current rail siding and then transported to the CBP by trucks using the existing mine haulage route. All deliveries will be limited to daytime hours only between 7 am and 6 pm Monday to Saturday and 8 am to 6 pm on Sundays and public holidays.

This assessment addresses future site noise from existing approved mining operations and CBP operations combined.

2.4 Assessment locations

Representative assessment locations are provided in Table 2.2 and are shown on Figure 2.2. These are consistent with locations in previous assessments and the PA. It is noted that Proprietary Square is a residential area located north of the site, immediately north of the TSF2. However, this property is mine-owned and therefore is not considered noise sensitive and has not been included in this assessment.

Table 2.2 Assessment locations

Assessment location ID	Location	Coordinates (MGA56)	
		Easting	Northing
A1	Piper St North	544110	6462598
A2	Piper St Central	543763	6462312
A3	Eyre St North	543555	6462322
A4	Eyre St Central	543324	6462003
A5	Eyre St South	543140	6461859
A6	Bonanza and Gypsum Sts	542833	6462000
A7	Carbon St	542604	6462718
A8	South Rd	542923	6462744
A9	Crystal St	542926	6463052
A10	Garnet and Blende Sts	543158	6463633
A11	Crystal St	544210	6464144
A12	Crystal St	544761	6464527
A13	419 Eyre St	544592	6463059
A14	Piper St North	544532	6462860

EMM

Assessment locations

RASP Mine Modification 4
Noise Impact Assessment
Figure 2.2

3 Noise criteria

3.1 Project approval

Condition 17 of Schedule 3 of the project approval (PA 07_0018), modified (Mod 3 - Block 7 Extension) and approved in March 2015, provides noise limits the project must meet during its operational phase. These noise limits are consistent with the project specific noise levels as derived in accordance with the NSW Environment Protection Authority (EPA) *Industrial Noise Policy* (INP) (2000) in previous noise assessments. These limits are provided in Section 3.2. An extract of the PA is provided in Appendix A.

3.2 Operational noise criteria

Operational noise criteria for the site reproduced from PA 07_0018 are provided in Table 3.1. The initial aim of this assessment is to demonstrate that site can achieve these noise criteria during future operations, including the proposed CBP.

Table 3.1 Operational noise criteria

Assessment location ID	Location	Operational noise criteria, $L_{Aeq(15\text{-}min)}$, dB		
		Day[1]	Evening[2]	Night[3]
A1	Piper St North	38	37	35
A2	Piper St Central	38	37	35
A3	Eyre St North	44	41	39
A4	Eyre St Central	44	41	39
A5	Eyre St South	44	41	39
A6	Bonanza and Gypsum Sts	48	41	39
A7	Carbon St	35	35	35
A8	South Rd	48	39	39
A9	Crystal St	46	39	39
A10	Garnet and Blende Sts	42	41	35
A11	Crystal St	46	39	39
A12	Crystal St	46	39	39
A13	419 Eyre St	38	35	35
A14	Piper St North	35	35	35

Notes: *1. Day period: Monday – Saturday: 7 am to 6 pm, on Sundays and Public Holidays: 8 am to 6 pm.*

2. Evening period: Monday – Saturday: 6 pm to 10 pm, on Sundays and Public Holidays: 6 pm to 10 pm.

3. Night period: Monday – Saturday: 10 pm to 7 am, on Sundays and Public Holidays: 10 pm to 8 am.

3.3 Sleep disturbance criteria

Operational noise limits above consider the average noise emission of a source over 15 minutes and are appropriate for assessing noise from relatively steady-state sources, such as engine noise from mobile plant and processing equipment. Noise from activities such as a front-end loader loading material in a hopper is however intermittent (rather than continuous) in nature, and as such, needs to be assessed using the L_{A1} or L_{Amax} noise metrics.

The potential impact of intermittent noise is the disturbance of the sleep of nearby residents. Assessment of sleep disturbance is required in accordance with the INP and associated Application Notes. The INP Application Notes recognise that the current sleep disturbance criterion is not ideal. The assessment of potential sleep disturbance is complex and poorly understood and the EPA believes that there is insufficient information to determine a suitable alternative criteria.

In the interim, the INP Application Notes suggests that the $L_{A1(1\text{-}min)}$ level of 15 dB above background noise level is a suitable screening criteria for sleep disturbance for the night-time period. Guidance regarding potential for sleep disturbance is also provided in the NSW Department of Environment, Climate Change and Water (DECCW) *Road Noise Policy* (RNP) (2011). Based on a number of studies that have been conducted into the effect of maximum noise levels on sleep, the RNP acknowledges that at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance. However, the RNP provides the following conclusions from the research on sleep disturbance:

- maximum internal noise levels below 50 to 55 dB are unlikely to awaken people from sleep; and
- one or two noise events per night, with maximum internal noise levels of 65 to 70 dB, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade including a partially opened window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB at the facade of a residence are unlikely to cause sleep disturbance affects. Furthermore, the World Health Organisation (WHO) *Guidelines for Community Noise* (1999) suggests that levels below 45 dB inside dwellings are unlikely to wake sleeping occupants. The corresponding external noise level in the free field, assuming partially opened windows is 52 dB L_{Amax}. The WHO guideline criteria have also been adopted for the assessment of sleep disturbance.

The sleep disturbance criteria adopted for this assessment derived in accordance with the INP Application Notes for all assessment locations are listed in Table 3.2 along with the WHO guideline criteria. The sleep disturbance criteria only apply during the night period. The descriptors L_{Amax} and $L_{A1(1\text{-}min)}$ may be considered interchangeable which is accepted by the EPA.

Table 3.2 Sleep disturbance noise criteria

Assessment location ID	Location	Sleep disturbance screening criteria, L_{Amax}, dB	WHO guideline criteria, L_{Amax}, dB
		Night[1]	Night[1]
A1	Piper St North	45	52
A2	Piper St Central	45	52
A3	Eyre St North	49	52
A4	Eyre St Central	49	52
A5	Eyre St South	49	52
A6	Bonanza & Gypsum Sts	49	52
A7	Carbon St	45	52
A8	South Rd	49	52
A9	Crystal St	49	52
A10	Garnet & Blende Sts	45	52
A11	Crystal St	49	52

Table 3.2 Sleep disturbance noise criteria

Assessment location ID	Location	Sleep disturbance screening criteria, L_{Amax}, dB	WHO guideline criteria, L_{Amax}, dB
		Night[1]	Night[1]
A12	Crystal St	49	52
A13	419 Eyre St	45	52
A14	Piper St North	45	52

Notes: 1. Night period: Monday – Saturday: 10 pm to 7 am, on Sundays and Public Holidays: 10 pm to 8 am.

3.4 Construction noise criteria

3.4.1 Interim construction noise guideline

The type of equipment and plant items and type of activities, as well as the locations of the proposed construction works relative to receivers and existing operations confirm that a construction noise assessment approach is appropriate for this assessment.

The assessment and management of noise from construction works is completed using the NSW Department of Environment and Climate Change *Interim Construction Noise Guideline* (ICNG), which provides two methods for the assessment of construction noise emissions:

- quantitative: suited to major construction projects with typical durations of more than three weeks; and
- qualitative: suited to short term infrastructure maintenance (less than 3 weeks).

The method for a quantitative assessment requires a more complex approach, involving noise emission predictions from construction activities to the nearest sensitive receivers, whilst the qualitative assessment methodology is a more simplified approach that relies more on noise management strategies. Due to the anticipated duration of the construction works, this assessment has adopted a quantitative assessment approach.

The ICNG recommends standard hours for normal construction work which are Monday to Friday from 7 am to 6 pm, Saturdays from 8 am to 1 pm, and no work on Sundays or public holidays. The proposed construction works will only occur during the ICNG standard hours.

Where noise levels from construction works during standard hours are above the noise affected level, all feasible and reasonable mitigation should be adopted.

3.4.2 Noise management levels

The ICNG provides noise management levels for residential receivers during standard hours and these are reproduced in Table 3.3.

Table 3.3 ICNG residential noise management levels

Time of day	Management level $L_{Aeq(15\text{-}min)}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15\text{-}min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: i) times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Source: ICNG (DECC 2009).

Further, the ICNG provides noise management levels for other sensitive land uses (non-residential receivers) for standard hours and these are reproduced in Table 3.4.

Table 3.4 ICNG noise management levels at other sensitive land uses

Land use	Management level, $L_{Aeq(15\text{-}min)}$ (applies when properties are being used)
Classrooms at schools and other educational institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB
Community centres	Depends on the intended use of the centre Refer to the recommended 'maximum' internal levels in AS2107 for specific uses

Source: ICNG (DECC 2009).

Table 3.5 is an extract from the ICNG and provides noise management levels for commercial and industrial land uses for standard hours.

Table 3.5 ICNG noise management levels at commercial and industrial land uses

Land use	Management level, $L_{Aeq(15\text{-}min)}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)

Source: ICNG (DECC 2009).

3.4.3 Project construction noise management levels

The construction noise management levels (NMLs) for this assessment have been based on background noise levels (RBLs) used in previous noise assessments for the RASP Mine which are considered to be relevant to the assessment of the proposed construction works. The NMLs for construction standard hours adopted for this assessment were derived in accordance with the ICNG for all assessment locations and are presented in Table 3.6.

Table 3.6 Construction noise management levels for standard hours

Assessment location ID	Location	Background noise level, dB(A)	NML, $L_{Aeq(15\text{-}min)}$, dB RBL + 10 dB
A1	Piper St North	33	43
A2	Piper St Central	33	43
A3	Eyre St North	39	49
A4	Eyre St Central	39	49
A5	Eyre St South	39	49
A6	Bonanza & Gypsum Sts	43	53
A7	Carbon St	30	40
A8	South Rd	43	53
A9	Crystal St	41	51
A10	Garnet & Blende Sts	37	47
A11	Crystal St	41	51
A12	Crystal St	41	51
A13	419 Eyre St	33	43
A14	Piper St North	30	40

4 Noise assessment methodology

This section provides the noise modelling methodology and assumptions for the proposed construction works and future mining operations.

4.1 Noise modelling

Quantitative modelling of construction and operational noise was completed using Brüel & Kjær Predictor Version 11 noise prediction software. This software calculates total noise levels at assessment locations from the concurrent operation of multiple noise sources. The model incorporated factors such as:

- the lateral and vertical location of plant and equipment;
- source-to-receiver distances;
- ground effects;
- atmospheric absorption;
- topography; and
- meteorological conditions.

Three-dimensional digitised ground contours of the site and surrounding land were incorporated to model topographic effects. Equipment was modelled at locations and heights representative of proposed construction activities and future operations.

4.1.1 Cumulative construction noise

The construction noise modelling was based on information received from BHOP. The construction works are proposed to only occur during the ICNG standard hours of 7 am to 6 pm Monday to Friday and 8 am to 1 pm on Saturdays. No construction work will occur on Sundays or public holidays.

Each construction scenario was carefully reviewed to identify constructions works that would results in worst case noise at offsite locations. Acoustically significant plant and equipment items to be used for these constructions works were modelled and hence considered worst case. Further, the positions of acoustically significant sources represent typical worst case noise conditions (ie at the highest and most exposed topographical points).

To determine the worst case noise from the proposed construction activities, construction noise levels predicted for each activity were added to existing site noise levels. Existing site noise levels for all assessment locations were referenced from the RASP Mine noise monitoring report *RE: RASP Mine - EPL noise monitoring program summary report* completed by EMM in October 2015. This report summarises the monitoring results from the 12-month monitoring program (from November 2014 to October 2015). Site noise contributions determined by the monitoring program were mostly recorded during the night period, although given daytime operations are equivalent to night-time operations, these levels are considered to be worst case. The monitoring program demonstrated that site noise from existing approved operations satisfied the relevant noise criteria at all assessment locations.

It is noted that the CBP will be commissioned immediately following its construction and therefore was modelled as operational (combined with existing approved mining operations) for the construction assessment of Embankment 2, the spillway, Embankment 3 and Embankment 1. The proposed construction activities are summarised in Table 4.1.

Table 4.1 Construction activities

Construction activity[1]	Works required	Approximate duration[3]
CBP	Site preparation and grading	4 weeks
	Install noise bund and waste rock surface	3 weeks
	Erect plant	2 weeks
	Spray chemical suppressant	≤1 week
Embankment 2	Site preparation (remove vegetation & infrastructure)	≤1 week
	Remove surface material from base of embankment	≤1 week
	Grouting (if required)	≤1 week
	Construct embankment	12 weeks
	Final capping	≤1 week
	Install sand chimney drain and liner	4 weeks
	Install crest and surface finish	≤1 week
	Spray chemical suppressant	≤1 week
Spillway	Excavation and shape surface	2 weeks
	Install sill beam	≤1 week
	Seal road using concrete	≤1 week
	Spray chemical suppressant	≤1 week
Embankment 3[2]	Site preparation (grouting if required)	≤1 week
	Construct embankment	8 weeks
	Final capping	≤1 week
	Install sand chimney drain and liner	4 weeks
	Install crest and surface finish	≤1 week
	Spray chemical suppressant	≤1 week
Embankment 1[2]	Construct road from Kintore Pit to Embankment 1	≤1 week
	Re-engineer current pit safety bund and complete drainage works	2 weeks
	Site preparation (remove vegetation & infrastructure)	≤1 week
	Remove surface material from base of embankment	≤1 week
	Fill cracks at edge of pit	≤1 week
	Construct embankment	8 weeks
	Final capping	≤1 week
	Install sand chimney drain and liner	4 weeks
	Install crest and surface finish	≤1 week
	Make and install gabion baskets and complete retaining wall	≤1 week

Notes: *1. Each construction activity will occur separately.*

2. The order in which these construction activities we be completed will be decided by the contractor.

3. Some of these weeks within the same construction activity may overlap.

4.1.2 Future operational noise

The noise modelling for the CBP operation was based on information provided by BHOP. This included the layout of the CBP area and design plans. All plant and equipment items for the CBP were modelled at locations and heights as per these plans and representative of typical concrete batching plat activities. Preliminary noise modelling identified that some of the activities associated with the operations at the CBP would require the implementation of noise mitigation measures to comply with the current PA criteria. These mitigation measures were adopted in the noise model and are as follows:

- concrete structure around the CBP (to primarily mitigate the batching and slumping processes noise);
- rubber lining of the inside of the hopper; and
- construction of a 6 m high bund on the north and west ends of the CBP area.

4.1.3 Acoustically significant plant and equipment

Modelled construction noise sources and associated sound power levels are summarised in Table 4.2. These levels are based on data provided by BHOP or otherwise have been supplemented using EMM's database of equipment used for similar projects. Single octave sound power levels are provided in Appendix B.

Table 4.2 Modelled sound power levels for worst case acoustically significant noise sources

Plant or equipment item	Sound power level, dB(A)
Construction of CBP and TSF2	
Excavator	104
Haul truck	112
Concrete agitator truck	103
Roller	109
Dozer (eg D8)	116
Watercart	112
CBP operations	
Front-end loader (eg Volvo L50F)	102
Conveyor drives	94
Conveyors	75 (per linear metre)
Concrete agitator truck	103
Batching process	109[1]
Slumping process	113[1]
Cement deliveries (from train loadout facility)	102
Aggregates deliveries (from site gate)	102

Notes: 1. Mitigated operational activities.

4.2 Meteorology

Prevailing conditions based on the detailed analysis of meteorological data recorded between January 2014 and September 2016 by the Bureau of Meteorology Automatic Weather Station (BoM AWS) located at the Broken Hill Airport were adopted in accordance with the methods outlined in the INP (EPA 2000). It was identified that no prevailing wind conditions were a 'feature' of the area during the day, evening or night period. Therefore calm meteorological conditions were adopted for all assessment periods. It was also identified that temperature inversions (F or G class temperature inversion) are infrequent and found not to be feature of the area (<30%). Notwithstanding, this assessment has adopted the F class temperature inversion parameter for the purpose of this assessment during the night period, and is considered to be worst case. Modelled meteorological conditions are presented in Table 4.3. The results of the meteorological data analysis are provided in Appendix C.

Table 4.3 Modelled meteorological conditions

Period	Condition	Temperature	Humidity	Wind speed	Wind direction	Temperature gradient
Day[1]	Calm	20°C	70%	Nil	n/a	D class
Evening	Calm	10°C	90%	Nil	n/a	D class
Night	Calm	10°C	90%	Nil	n/a	D class
	Temperature inversion	10°C	90%	Nil	n/a	F class

Notes: 1. Consistent with ICNG standard hours.

5 Noise assessment results

5.1 Cumulative noise during construction

Predicted site noise levels for each construction activity combined with existing approved operational noise are shown in Table 5.1. It is noted that the CBP will be commissioned soon after its construction is complete, and hence was modelled as operational during the construction of Embankment 2, the spillway, Embankment 3 and Embankment 1. Noise levels predicted to be above the NMLs are indicated by bold font and grey shading.

Modelling results show that site noise from standard hours construction works is predicted to satisfy the ICNG NMLs at most assessment locations. The exceptions were at locations A12, A13 and A14. At location A13, construction noise levels are predicted to be marginally (1 dB) above the NMLs during the construction of Embankment 3. A 2 dB change in noise levels is generally not perceptible by the human ear and therefore noise impact from the construction of Embankment 3 is unlikely at this location.

At location A12 construction noise levels are predicted to be moderately above the NMLs by 3 dB during the construction of Embankment 2. Previous attended noise monitoring completed for RASP Mine has shown that daytime ambient noise levels at this location are generally elevated due to frequent traffic movements and industrial noise in the area which would mask some of the noise from the proposed construction works. Ambient noise of 54 dB to 57 dB $L_{Aeq,15min}$ are typical measured levels and are therefore similar to or higher than the worst case predicted construction noise levels presented in Table 5.1.

Finally at location A14, construction noise levels are predicted to be above the NMLs by 3 dB, 2 dB, 4 dB and 3 dB during the construction of Embankment 2, the spillway, Embankment 3 and Embankment 1 respectively.

It is important to note that the modelled construction works represent worst case scenarios for each relevant activity and therefore are considered worst case for the duration of the relevant activity. It can also be said that it is anticipated that noise levels from the proposed construction works would be at times lower than the predicted levels shown in Table 5.1.

Given construction noise levels are predicted to be moderately (3 dB to 4 dB) above the NMLs at locations A12 and A14 during the construction of the embankments, it is recommended that feasible and reasonable mitigation measures be implemented during construction works associated with the extension of the TSF2. A source ranking analysis of the modelled noise activities identified dozer operations as one of the main contributors to total predicted levels at locations A12 and A14. At location A14, truck and watercart movements were also identified as main noise contributors. Feasible and reasonable mitigation measures recommended during construction works along with the ones currently adopted at RASP Mine are discussed in Section 6.

Table 5.1 Cumulative construction noise results

Assessment location ID	Day ICNG criteria $L_{Aeq(15\text{-}min)}$, dB	Predicted combined operational and construction noise levels, $L_{Aeq(15\text{-}min)}$, dB									
		CBP[1]		Embankment 2[2]		Spillway[2]		Embankment 3[2]		Embankment 1[2]	
		Predicted level	Level above NML, dB	Predicted level	Level above NML, dB	Predicted level	Level above NML, dB	Predicted level	Level above NML, dB	Predicted level	Level above NML, dB
A1	43	37	Nil	41	Nil	41	Nil	41	Nil	41	Nil
A2	43	36	Nil	39	Nil	39	Nil	40	Nil	40	Nil
A3	49	40	Nil	42	Nil	42	Nil	42	Nil	42	Nil
A4	49	37	Nil	42	Nil	42	Nil	42	Nil	42	Nil
A5	49	37	Nil	38	Nil	38	Nil	39	Nil	39	Nil
A6	53	35	Nil	36	Nil	36	Nil	36	Nil	36	Nil
A7	40	38	Nil	38	Nil	38	Nil	38	Nil	38	Nil
A8	53	39	Nil	40	Nil	39	Nil	40	Nil	40	Nil
A9	51	40	Nil	40	Nil	40	Nil	40	Nil	40	Nil
A10	47	38	Nil	40	Nil	39	Nil	39	Nil	39	Nil
A11	51	38	Nil	47	Nil	43	Nil	45	Nil	49	Nil
A12	51	39	Nil	**54**	3	46	Nil	46	Nil	49	Nil
A13	43	35	Nil	43	Nil	43	Nil	**44**	1	43	Nil
A14	40	36	Nil	**43**	3	**42**	2	**44**	4	**43**	3

Notes: *1. Predicted in combination with existing RASP Mine noise levels.*

2. Predicted in combination with existing RASP Mine noise levels and CBP operational noise levels.

5.2 Future operational noise

Predicted future site noise levels following the completion of the construction works are shown in Table 5.2. Noise levels have been predicted based on the meteorological conditions provided in Table 4.3.

Modelling results showed that during future operations (existing approved operations and CBP operation combined) site noise levels are predicted to satisfy the criteria at all assessment locations.

Table 5.2 Future operational noise results

Assessment location ID	Predicted future $L_{Aeq(15\text{-}min)}$ noise levels, dB			Criteria, $L_{Aeq(15\text{-}min)}$, dB			Exceedance, dB		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
A1	<38	<37	<35	38	37	35	Nil	Nil	Nil
A2	<38	<37	<35	38	37	35	Nil	Nil	Nil
A3	<44	<41	<39	44	41	39	Nil	Nil	Nil
A4	<44	<41	<39	44	41	39	Nil	Nil	Nil
A5	<44	<41	<39	44	41	39	Nil	Nil	Nil
A6	<48	<41	<39	48	41	39	Nil	Nil	Nil
A7	<35	<35	35	35	35	35	Nil	Nil	<1
A8	<48	<39	<39	48	39	39	Nil	Nil	Nil
A9	<46	<39	<39	46	39	39	Nil	Nil	Nil
A10	<42	<41	<35	42	41	35	Nil	Nil	Nil
A11	<46	<39	<39	46	39	39	Nil	Nil	Nil
A12	<46	<39	<39	46	39	39	Nil	Nil	Nil
A13	<38	<35	<35	38	35	35	Nil	Nil	Nil
A14	<35	<35	<35	35	35	35	Nil	Nil	Nil

5.3 Cumulative noise

Perilya Broken Hill Limited is seeking to continue mining operations at Perilya North Mine located to the east of the site. The construction works for the Perilya North Mine have the potential to occur at the same time as that of the project. Further, cumulative operational noise from Perilya North Mine and the project combined has been considered.

EMM completed a review of the noise assessment prepared by Muller Acoustic Consulting Pty Ltd (MAC) in January 2017 for the Perilya North Mine. The MAC assessment shows that $L_{Aeq(15\text{-}min)}$ noise levels from Perilya North Mine during construction and operational stages are predicted to be well below the construction management level (NML) (by at least 10 dB) and operational criteria (by at least 8 dB) during worst case meteorological conditions at the potentially most affected representative assessment location (A12) for the RASP Mine project. A desktop analysis identified that predicted noise levels from Perilya North Mine would not influence construction (refer to Table 5.1) or operational noise levels (refer to Table 5.2) generated by the RASP Mine project. Therefore, cumulative noise from Perilya North Mine and the RASP Mine project combined is not anticipated to cause additional impact at any of the assessment locations.

5.4 Sleep disturbance

Activities considered in this assessment included a front-end loader loading aggregate in the CBP hopper. A review of sound power level data obtained from measurements taken for similar activities on other industrial sites identified typical levels for such activity being up to 111 dB L_{Amax}. For the subject site, a sound power level of 117 dB L_{Amax} was conservatively adopted to allow for further variants possible from operator performance. Predicted L_{Amax} noise levels from RASP Mine future operations at all assessment locations are provided in Table 5.3.

The predicted L_{Amax} noise level satisfies the sleep disturbance screening criteria at all assessment locations. The predicted L_{Amax} noise level also satisfies the WHO guideline criteria at all assessment locations and therefore confirms that potential maximum noise levels from future site operations are unlikely to cause sleep disturbance at any of the assessment locations. Therefore, based on a conservative sound power level of 117 dB L_{Amax} or lower, no sleep disturbance impact is expected during worst case meteorological conditions.

Table 5.3 Predicted L_{Amax} noise levels

Assessment location ID	Night-time predicted L_{Amax} noise levels, dB		Sleep disturbance screening criteria, L_{Amax}, dB	WHO guideline criteria, L_{Amax}, dB
	Calm	F class temperature inversion		
A1	38	40	45	52
A2	37	40	45	52
A3	38	41	49	52
A4	34	37	49	52
A5	32	35	49	52
A6	34	37	49	52
A7	35	38	45	52
A8	38	41	49	52
A9	38	41	49	52
A10	42	45	45	52
A11	37	40	49	52
A12	31	34	49	52
A13	38	41	45	52
A14	38	41	45	52

6 Noise management

6.1 Existing noise management

6.1.1 Adopted management measures

Best management practices are currently used to minimise site noise offsite and include the following:

- independent noise audits are undertaken as instructed by the EPA from time to time;
- noise awareness information is provided in employee and contractor inductions;
- the crusher has been located behind the ore stockpile and in a gully to minimise noise;
- conveyors and transfer stations prior to the grinding circuit have been enclosed;
- silencers were installed on haul trucks and noise suppression kits on the front-end loaders used on the ROM pad, container stockpile and rail loading areas;
- plant are properly maintained to ensure rated noise emission levels are not exceeded; and
- loaded mining ore transport trucks follow the designated approved heavy vehicle route through Broken Hill that was designed to minimise impacts;

To ensure that site noise levels achieve the criteria at offsite locations, noise mitigation measures have been implemented or are in the process of being implemented. These mitigation measures are as follow:

- construction of noise barriers with 4 m high bunding along the southern side of the haul road and the southern perimeter of the ROM pad mine haul route;
- cladding and insulation of the primary crusher and installing noise abatement bunding to the north and south of the crusher;
- filling of the ROM bin prior to night shift to minimise the use of the front-end loader at the ROM pad during the night period;
- modification of the filtration shed's piping system; and
- installation of two overlapping bunds at the northern side of the wagon stockpile area to shield Crystal Street residences.

6.1.2 Noise Monitoring Management Plan

The Noise Monitoring and Management Plan (NMMP) established for the site provides noise monitoring and management procedures that are currently used on-site. These include, but are not limited to, the following measures:

- undertake compliance noise monitoring at all assessment locations and ensure that site noise satisfy the limits outlined in the project approval. The monitoring is completed in accordance with all relevant Australian Standards, policies and guidelines;

- take relevant actions to investigate and determine feasible and reasonable mitigation measures if site noise has been identified to exceed the relevant limits;
- results are reported to the Operations Manager and kept on file for a minimum of 4 years;
- provide adequate and timely response to community noise complaints;
- review data and determine management actions to improve noise emissions from site over time;
- ensure actions are taken to prevent noise exceedances as per conditions in the project approval; and
- make noise reports available to EPA as required.

6.1.3 Noise complaints management

Noise complaints from the community are currently managed in accordance with the site's NMMP and recorded as per the site's complaints procedure. It is noted that the NSW Department of Planning and Environment (DP&E) and other relevant agencies are notified of complaints from the community should one be received.

A review of the community noise complaint register for RASP Mine showed that only one noise complaint was received from a member of the community between January 2014 and October 2016 (to date). The noise complaint was received on 10 July 2016, although no details were available on the time or nature of the noise that resulted in the complaint. This demonstrates a strong history of noise performance at offsite locations and is consistent with attended noise monitoring results collected in the most recent two years of monitoring (2015 and 2016).

6.2 Feasible and reasonable mitigation measures

6.2.1 CBP operations

As noted earlier, a preliminary noise modelling exercise identified that the proposed CBP would require noise mitigation for the site to achieve their current project approval criteria. A number of management and mitigation measures were considered in this assessment, however some were deemed not to be feasible and/or reasonable. These are provided in Table 6.1.

Table 6.1 Consideration of possible feasible and reasonable management and mitigation measures for CBP

Type of noise measure	Measure	Feasible	Reasonable	Justification
At source	CBP concrete enclosure	Yes	Yes	Batching and slumping were identified as potentially high ranked contributors to offsite noise. This measure has been adopted in the model and will be implemented by BHOP.
At source	Use of a small size front-end loader	Yes	Yes	The front-end loader was identified as potentially a high ranked contributor to offsite noise and therefore a smaller size front-end loader (eg Volvo L50F) with a sound power level of the 102 dB(A) will be used. This measure has been adopted in the model and will be implemented by BHOP. The use of a smaller front-end loader was considered to be infeasible because it would not be adequate for the task.
At source	Attenuation of front-end loader	Yes	No	A smaller front-end loader (eg Volvo L50F) with a sound power level of the 102 dB(A) will be used. It was identified as potentially a high ranked contributor to offsite noise. This measure is considered unreasonable given the infrequent occurrence of F class temperature inversion during the winter months in Broken Hill and hence the low probability of sustained noise exceedances. Further, the cost (eg $100,000s per plant) associated with sound attenuation kits versus the total dB reduction achievable (eg 3 to 4 dB) is unreasonable.
At path	6 m high noise barriers to the north-west and south-west of the CBP area	Yes	Yes	This measure has been adopted in the model and will be implemented by BHOP.
At receivers	Architectural treatment of affected dwellings (eg improved glazing, acoustic insulation and mechanical ventilation/ air-conditioning)	Yes	No	This measure is considered unreasonable given the low probability of sustained noise exceedances.

These measures resulted in predicted site noise satisfying criteria at all offsite locations, including during night-time F class temperature inversions.

6.2.2 Additional noise management measures to consider during construction

A number of management and mitigation measures were considered in the assessment of construction noise, however some were deemed not to be feasible and/or reasonable. These are provided in Table 6.2.

Table 6.2 Consideration of possible feasible and reasonable management and mitigation measures for construction

Type of noise measure	Measure	Feasible	Reasonable	Justification
At source	Attenuation of dozer and trucks	Yes	No	Trucks and dozers were identified as potentially high ranked contributors to offsite noise. This measure is considered unreasonable given the duration and temporary nature of the proposed works and cost (eg $100,000s per plant) associated with sound attenuation kits versus the total dB reduction achievable (eg 3 to 4 dB).
At path	Permanent noise barriers (eg 3 m high) near TSF2 construction activities	No	No	This measure is not considered feasible given limited space is available between proposed activity areas and receivers. Further, it is considered unreasonable given the duration and temporary nature of the proposed works and cost (eg $500 per square meter area of barrier).
At receivers	Permanent noise barriers at affected residential property (between site and most affected facade)	Yes	No	This measure is considered unreasonable given the duration and temporary nature of the proposed works and cost (eg $500 per square meter area of barrier).
At receivers	Architectural treatment of affected dwellings (eg improved glazing, acoustic insulation and mechanical ventilation/ air-conditioning)	Yes	No	This measure is considered unreasonable given the duration and temporary nature of the proposed works and cost (eg $50,000 per dwelling).

Further, numerous practical recommendations to assist in mitigating construction noise emissions are provided in Australian Standard *AS 2436-2010 – Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites*. The recommendations provided in this standard include operational strategies, source noise control strategies, noise barrier controls, and community consultation. Examples of noise management strategies that could be implemented during the proposed construction include the following:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise;
- regular identification of noisy activities and adoption of improvement techniques;
- use of broadband audible reverse alarms on vehicles used on site;
- minimising the movement of materials and plant and unnecessary metal-on-metal contact;
- scheduling respite periods for intensive works;

- all plant will be driven in a conservative manner (no over-revving);
- machinery will not be permitted to 'warm-up' before the nominated working hours;
- where possible, machinery will be located/orientated to direct noise away from the closest sensitive receivers;
- where practicable adopt mobile barriers/screens or utilise the location of earth/rock stockpiles to shield neighbouring receivers;
- the quietest suitable machinery reasonably available will be selected for each work activity;
- where possible machinery will have efficient low noise muffler design and be well-maintained;
- the offset distance between noisy items of plant/machinery and nearby sensitive receivers will be maximised;
- queuing of vehicles is not to occur adjacent to residential receivers. Where queuing is required, for example due to safety reasons, an area entry position will be selected that is well removed from receivers. Where this is not feasible, engines are to be switched off to reduce their overall noise impacts on receivers;
- where practicable, ensure the coincidence of noisy plant/machinery working simultaneously in close proximity to sensitive receivers is avoided;
- scheduling activities to minimise impacts by avoiding conflicts with other scheduled events;
- scheduling noisy activities to coincide with high levels of neighbourhood noise so that noise from the activities is partially masked and not as intrusive;
- planning deliveries and access to the site to occur quietly and efficiently; and
- optimising the number of deliveries to the site by amalgamating loads where possible.

It is recommended that specific detailed noise management and mitigation measures be reviewed once the construction activities for each task are clearly defined and contractors for the work have been selected or engaged.

7 Conclusion

EMM has completed a cumulative noise assessment for the proposed construction and operational activities at RASP Mine. An assessment of future operational noise was completed for the proposed CBP operations combined with existing approved operations.

Cumulative construction noise levels from existing approved operations and proposed CBP and TSF2 construction works are predicted to satisfy the ICNG noise management levels during standard hours at most assessment locations. The exceptions are locations A12, A13 and A14 where cumulative construction noise levels are predicted to be marginally (1 dB) above the NMLs (at A13) and moderately (3 to 4 dB) above the NMLs (at A12 and A14) during construction works associated with the extension of TSF2. These excursions above criteria are expected to be limited and only span a period of approximately three months for Embankment 2 and two months for Embankment 3 and Embankment 1.

Future site $L_{Aeq(15\text{-}min)}$ noise levels following the completion of the construction works are predicted to satisfy the criteria at all assessment locations, including during night-time F class temperature inversion conditions. Cumulative noise is not anticipated to cause an impact at any of the assessment locations.

Predicted L_{Amax} noise levels from the proposed CBP operation are not predicted to cause sleep disturbance impact at any of the assessment locations during worst case night-time meteorological conditions.

It is recommended that noise management measures currently used at RASP Mine be continued. In addition, standard construction noise management measures including operational strategies, source noise control strategies, noise barrier controls, and community consultation are implemented for the duration of the construction works, in particular during the extension of the TSF2.

Appendix A

Project approval (PA 07_0018)

(e) include a program for the staged implementation of the measures identified in (d) above in the event that dust emissions are higher than predicted or the public health monitoring suggests further action is required to reduce blood lead levels in the environment surrounding the site; and
(f) include a detailed communication strategy, that outlines how the relevant dust and blood level monitoring data would be reported on the Proponent's website along with any relevant public education material.

Updated Human Health Risk Assessment

14. Within one year of the commencement of operation of the project, and every five years thereafter, unless otherwise agreed by the Secretary, the Proponent shall update the human health risk assessment prepared for the project and presented in the EA to the satisfaction of the Secretary. The updated risk assessment shall:
(a) be prepared by a suitably-qualified expert whose appointment has been endorsed by the Secretary;
(b) take into account monitoring data collected under this approval, and such other information as may be relevant to the assessment; and
(c) be submitted to the Secretary, EPA and the Western Area Health Service within one month of its completion.

NOISE AND VIBRATION

Construction Noise Restrictions

15. Construction activities associated with the project shall only be undertaken between 7:00am and 7:00pm on any day.

Note to Condition 15:
- *Construction activities include, but are not limited to, all construction work, front-end loader on the ROM pad, rock breaking and primary crushing in the process area, conveyors in the process area, flat-bed road truck haulage from the process area to the rail load-out area, locomotives at the rail load-out area and forklift at the rail load-out area.*

Operational Noise Restrictions

16. Operational activities associated with the project are permitted to occur at any time, subject to compliance with the noise limits specified in this approval, and subject to the following restrictions:
(a) deleted;
(b) shunting of concentrate wagons shall only occur between 7:00am and 6:00pm on any day; and
(c) production rock blasting shall only occur between 6:45am and 7:15pm on any day.

Noise Limits

17. The Proponent shall ensure that the noise generated by the project does not exceed the criteria in Table 7.

Table 7: Operational Noise Criteria

Location	[a] Day (dB(A))	[b] Evening (dB(A))	[c] Night (dB(A))
A1 – Piper Street North	38	37	35
A2 – Piper Street Central	38	37	35
A3 – Eyre Street North	44	41	39
A4 – Eyre Street Central	44	41	39
A5 – Eyre Street South	44	41	39
A6 – Bonanza and Gypsum Streets	48	41	39
A7 – Carbon Street	35	35	35
A8 – South Road	48	39	39
A9 – Crystal Street	46	39	39
A10 – Barnet and Blende Streets	42	41	35
A11 – Crystal Street	46	39	39
A12 – Crystal Street	46	39	39
A13 – Eyre Street North 2	38	35	35
A14 – Piper Street North	35	35	35

Notes to Condition 17:

- *Receiver locations are as identified in the noise assessments presented in the EA and PPR;*
- *Noise limits are to be measured in accordance with the NSW Industrial Noise Policy (EPA, 2000);*
- *[a] Day is defined as 7:00am to 6:00pm Mondays to Saturdays and 8:00am to 6:00pm on Sundays and public holidays;*
- *[b] Evening is defined as 6:00pm to 10:00pm on any day; and*
- *[c] Night is defined as 10:00pm to 7:00 am Mondays to Saturdays and 10:00pm to 8:00am on Sundays and public holidays.*

Blasting Limits

18. The Proponent shall ensure that basting on the site does not cause exceedances of the criteria in Tables 8 and 9.

Table 8: Blasting Criteria (excluding Block 7)

Location	Airblast Overpressure (dB(Lin Peak))	Ground Vibration (mm/s)	[a] Allowable Exceedance
Residence on privately owned land	115	5	[b] 5% of the total number of blasts over a 12-month period
	120	10	0%
Public Infrastructure	-	100	0%

Table 9: Blasting Criteria (Block 7)

Location	Airblast Overpressure (dB(Lin Peak))	Ground Vibration (mm/s)	[a] Allowable Exceedance
Residence on privately owned land	115	[c] 3 (interim)	5% of the total number of blasts over a 12-month period
	120	10	0%
Broken Hill Bowling Club, Italio (Bocce) Club, Heritage Items within CML7	-	50	0%
Perilya Southern Operations	-	100	0%
[d] Public Infrastructure	-	100	0%

These criteria do not apply if the Proponent has a written agreement with the relevant owner to exceed these criteria, and has advised the Department in writing of the terms of this agreement.

Notes to Tables 8 and 9:

- *[a] The allowable exceedance must be calculated separately for development blasts and production blasts;*
- *[b] The 5% allowable exceedance does not apply to production blasts until the Proponent has successfully completed a Pollution Reduction Program aimed at achieving this goal, as required by the EPA under the Proponent's EPL (No. 12559), or as otherwise agreed with the EPA;*
- *[c] The interim criteria applies unless and until such time that the Proponent has written consent from the Secretary to apply site specific criteria in accordance with condition 19 of this approval; and*
- *[d] The Proponent must close South Road to pedestrians if blasts are expected to exceed a peak particle velocity ground vibration of 65 mm/s at the road reserve surface, while the blast firing occurs.*

19. The Proponent may establish site specific ground vibration criteria for residential receivers that may be affected by blasting operations in Block 7, to the satisfaction of the Secretary. These criteria must:
    (a) be prepared by a suitably qualified mining engineer;
    (b) be prepared in consultation with the EPA;
    (c) protect the amenity of all residences on privately owned land; and
    (d) be based on blast monitoring data for the Block 7 mining area.

Blast Frequency

19A. The Proponent may carry out a maximum of:
    (a) 1 production blast a day and 6 production blasts a week, averaged over a calendar year; and
    (b) 6 development blasts a day and 42 development blasts a week, averaged over a calendar year.

Appendix B

Single octave sound power levels

Table 7.1 Plant and equipment sound power levels

	Single octave sound power level spectrum, dB(A)									Total, dB(A)
Item	**31.5 Hz**	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**	
Dozer	102	107	114	103	103	106	100	93	87	116
Excavator	58	69	90	93	95	100	98	89	79	104
Haul truck	72	95	100	103	107	105	105	100	93	112
Roller	63	74	95	98	100	105	103	94	84	109
Watercart	72	95	100	103	107	105	105	100	93	112
Aggregate truck	-	89	95	90	89	93	97	92	85	102
Agitator truck	67	85	89	90	96	99	97	92	84	103
Agitator (slumping)	-	55	54	80	92	106	108	108	107	113
Agitator (batching)	66	83	96	98	100	105	103	101	96	109
Cement truck	-	89	95	90	89	93	97	92	85	102
Conveyor	48	59	63	65	72	69	65	60	50	75
Conveyor drive	28	28	52	71	81	90	89	89	70	94
Front-end loader	60	88	94	95	97	100	99	93	84	105

Appendix C

Meteorological data analysis results

Table 7.2 Percentage of occurrence of wind for each season and period for 2014, 2015 and 2016

Wind direction (degrees)	Season	Period	Percentage of occurrence (%)		
			2014	2015	2016[1]
360	Summer	Day	2	2	2
22.5	Summer	Day	2	2	2
45	Summer	Day	3	2	2
67.5	Summer	Day	3	2	1
90	Summer	Day	3	2	2
112.5	Summer	Day	3	2	2
135	Summer	Day	3	2	2
157.5	Summer	Day	3	2	2
180	Summer	Day	3	2	2
202.5	Summer	Day	2	2	2
225	Summer	Day	2	2	2
247.5	Summer	Day	2	2	2
270	Summer	Day	2	2	2
292.5	Summer	Day	2	2	1
315	Summer	Day	2	2	1
337.5	Summer	Day	2	2	2
360	Summer	Evening	3	6	5
22.5	Summer	Evening	4	7	5
45	Summer	Evening	5	7	5
67.5	Summer	Evening	5	7	5
90	Summer	Evening	5	8	5
112.5	Summer	Evening	5	8	4
135	Summer	Evening	6	7	5
157.5	Summer	Evening	6	7	4
180	Summer	Evening	6	5	4
202.5	Summer	Evening	6	4	4
225	Summer	Evening	5	4	4
247.5	Summer	Evening	4	3	3
270	Summer	Evening	3	3	4
292.5	Summer	Evening	2	2	5
315	Summer	Evening	3	3	6
337.5	Summer	Evening	3	4	5
360	Summer	Night	6	7	4
22.5	Summer	Night	7	8	3
45	Summer	Night	6	9	4
67.5	Summer	Night	7	9	4
90	Summer	Night	7	10	4
112.5	Summer	Night	7	10	5
135	Summer	Night	8	9	6
157.5	Summer	Night	9	9	8
180	Summer	Night	9	9	8
202.5	Summer	Night	8	9	8

Table 7.2 Percentage of occurrence of wind for each season and period for 2014, 2015 and 2016

Wind direction (degrees)	Season	Period	Percentage of occurrence (%)		
			2014	2015	2016[1]
225	Summer	Night	8	8	9
247.5	Summer	Night	8	7	8
270	Summer	Night	6	5	8
292.5	Summer	Night	4	4	6
315	Summer	Night	4	4	5
337.5	Summer	Night	4	5	5
360	Autumn	Day	7	5	5
22.5	Autumn	Day	6	5	5
45	Autumn	Day	6	5	5
67.5	Autumn	Day	5	5	5
90	Autumn	Day	5	4	5
112.5	Autumn	Day	4	4	5
135	Autumn	Day	4	4	5
157.5	Autumn	Day	4	4	5
180	Autumn	Day	4	4	5
202.5	Autumn	Day	4	4	5
225	Autumn	Day	5	4	5
247.5	Autumn	Day	5	4	5
270	Autumn	Day	5	4	4
292.5	Autumn	Day	5	4	4
315	Autumn	Day	6	4	4
337.5	Autumn	Day	6	4	5
360	Autumn	Evening	13	8	11
22.5	Autumn	Evening	13	8	12
45	Autumn	Evening	12	9	11
67.5	Autumn	Evening	10	10	10
90	Autumn	Evening	9	10	10
112.5	Autumn	Evening	9	11	10
135	Autumn	Evening	9	12	12
157.5	Autumn	Evening	9	13	12
180	Autumn	Evening	9	13	13
202.5	Autumn	Evening	8	11	13
225	Autumn	Evening	7	11	11
247.5	Autumn	Evening	7	10	9
270	Autumn	Evening	9	8	10
292.5	Autumn	Evening	10	7	10
315	Autumn	Evening	11	6	10
337.5	Autumn	Evening	13	7	10
360	Autumn	Night	10	9	11
22.5	Autumn	Night	10	9	12
45	Autumn	Night	10	9	12
67.5	Autumn	Night	10	9	12

Table 7.2 Percentage of occurrence of wind for each season and period for 2014, 2015 and 2016

Wind direction (degrees)	Season	Period	Percentage of occurrence (%)		
			2014	2015	2016[1]
90	Autumn	Night	10	9	12
112.5	Autumn	Night	8	9	10
135	Autumn	Night	8	12	10
157.5	Autumn	Night	10	14	13
180	Autumn	Night	11	17	14
202.5	Autumn	Night	11	18	13
225	Autumn	Night	10	19	13
247.5	Autumn	Night	10	18	12
270	Autumn	Night	9	15	10
292.5	Autumn	Night	7	11	8
315	Autumn	Night	7	9	8
337.5	Autumn	Night	9	9	11
360	Winter	Day	5	5	8
22.5	Winter	Day	5	6	8
45	Winter	Day	4	6	7
67.5	Winter	Day	5	7	7
90	Winter	Day	5	8	6
112.5	Winter	Day	5	9	5
135	Winter	Day	5	9	5
157.5	Winter	Day	5	9	5
180	Winter	Day	6	10	4
202.5	Winter	Day	6	11	4
225	Winter	Day	6	9	5
247.5	Winter	Day	5	8	5
270	Winter	Day	5	6	6
292.5	Winter	Day	5	5	6
315	Winter	Day	4	5	6
337.5	Winter	Day	4	4	7
360	Winter	Evening	10	11	12
22.5	Winter	Evening	10	12	12
45	Winter	Evening	10	13	12
67.5	Winter	Evening	10	14	11
90	Winter	Evening	10	15	9
112.5	Winter	Evening	12	15	9
135	Winter	Evening	11	15	10
157.5	Winter	Evening	10	16	10
180	Winter	Evening	10	14	10
202.5	Winter	Evening	10	12	9
225	Winter	Evening	10	11	7
247.5	Winter	Evening	9	10	8
270	Winter	Evening	8	10	9
292.5	Winter	Evening	9	10	12

Table 7.2 Percentage of occurrence of wind for each season and period for 2014, 2015 and 2016

Wind direction (degrees)	Season	Period	Percentage of occurrence (%)		
			2014	2015	2016[1]
315	Winter	Evening	9	11	13
337.5	Winter	Evening	9	11	12
360	Winter	Night	11	14	15
22.5	Winter	Night	10	14	15
45	Winter	Night	10	15	15
67.5	Winter	Night	10	15	15
90	Winter	Night	10	14	13
112.5	Winter	Night	10	13	9
135	Winter	Night	10	10	7
157.5	Winter	Night	11	10	6
180	Winter	Night	13	11	7
202.5	Winter	Night	14	11	8
225	Winter	Night	14	10	9
247.5	Winter	Night	14	11	9
270	Winter	Night	13	11	10
292.5	Winter	Night	11	11	10
315	Winter	Night	9	11	13
337.5	Winter	Night	10	13	14
360	Spring	Day	2	4	9
22.5	Spring	Day	3	4	10
45	Spring	Day	3	4	9
67.5	Spring	Day	3	4	7
90	Spring	Day	4	4	6
112.5	Spring	Day	4	4	5
135	Spring	Day	4	4	6
157.5	Spring	Day	4	4	6
180	Spring	Day	4	4	5
202.5	Spring	Day	4	4	5
225	Spring	Day	3	3	5
247.5	Spring	Day	3	3	5
270	Spring	Day	3	3	5
292.5	Spring	Day	2	3	6
315	Spring	Day	2	3	8
337.5	Spring	Day	2	4	8
360	Spring	Evening	11	4	18
22.5	Spring	Evening	10	6	16
45	Spring	Evening	9	5	13
67.5	Spring	Evening	9	7	12
90	Spring	Evening	7	10	9
112.5	Spring	Evening	6	11	9
135	Spring	Evening	8	12	8
157.5	Spring	Evening	8	12	7

Table 7.2 Percentage of occurrence of wind for each season and period for 2014, 2015 and 2016

Wind direction (degrees)	Season	Period	Percentage of occurrence (%)		
			2014	2015	2016[1]
180	Spring	Evening	9	11	7
202.5	Spring	Evening	9	10	7
225	Spring	Evening	8	9	7
247.5	Spring	Evening	10	7	9
270	Spring	Evening	10	6	13
292.5	Spring	Evening	10	6	15
315	Spring	Evening	10	5	15
337.5	Spring	Evening	10	5	18
360	Spring	Night	6	7	21
22.5	Spring	Night	7	7	21
45	Spring	Night	7	8	20
67.5	Spring	Night	9	8	18
90	Spring	Night	9	8	18
112.5	Spring	Night	8	7	12
135	Spring	Night	9	7	5
157.5	Spring	Night	12	9	3
180	Spring	Night	13	9	6
202.5	Spring	Night	13	9	8
225	Spring	Night	12	9	9
247.5	Spring	Night	11	8	10
270	Spring	Night	8	7	10
292.5	Spring	Night	6	5	10
315	Spring	Night	6	5	10
337.5	Spring	Night	6	7	17

Notes: 1. Includes data up to 19 September 2016.

Table 7.3 Percentage of occurrence of stability class for the winter months of 2014, 2015 and 2016

Stability class	Percentage of occurrence (%)		
	2014	2015	2016
A	4	0	4
B	3	0	3
C	10	0	8
D	43	22	45
E	25	78	23
F	7	0	7
G	9	0	10

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