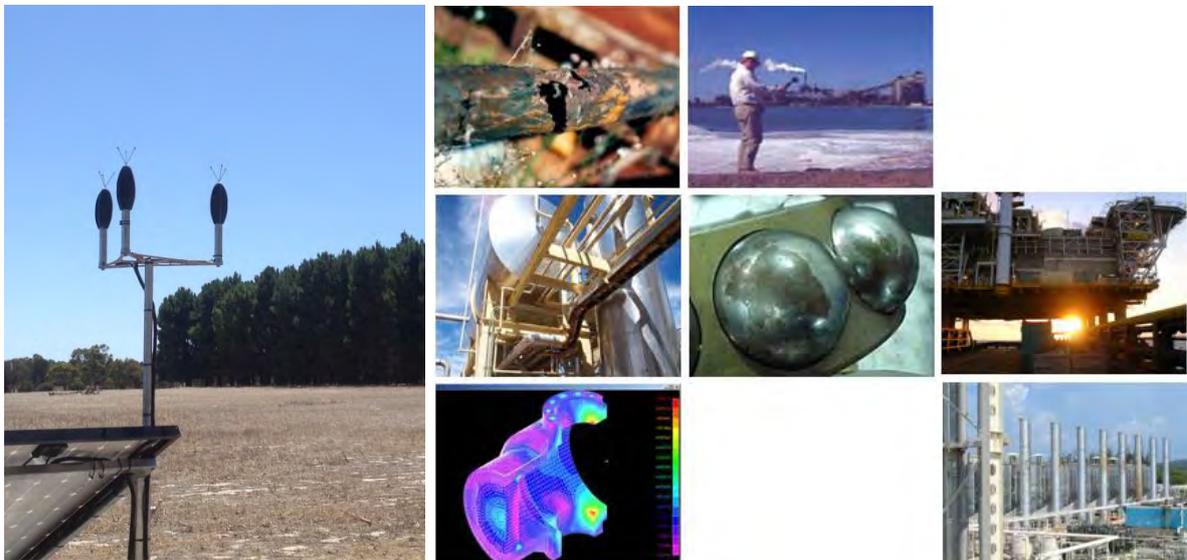


**KEYSBROOK MINERAL SANDS MINE
ENVIRONMENTAL NOISE
COMPLIANCE REPORT Q9 2018
23 OCTOBER 2017 TO 22 JANUARY 2018**



KEYSBROOK LEUCOXENE PTY LTD

1401854-9-100-Rev4-23.Feb.2018

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EXECUTIVE SUMMARY

MZI Resources Limited (MZI), through its subsidiary Keysbrook Leucoxene Proprietary Limited (KLPL), operate a mineral sands mine and primary processing plant within an area of rural land near the townships of Keysbrook and North Dandalup. The South West Main freight railway and South West Highway are approximately 1.0 km and 1.8 km respectively east of the project area. Keysbrook mine operations commenced on 22 October 2015. The mine operates continuously, 24 hours per day, 7 days per week.

This report has been prepared pursuant to Condition 14-5 of Ministerial Statement 810 (MS810), which requires the submission of a quarterly report, prepared by an independent acoustic expert to include the following –

- a. review noise monitoring methodology and results for the quarter;
- b. an assessment of the extent to which noise emissions from the proposal comply with the Noise Regulations;
- c. details of any management or other measures that the proponent has implemented, or proposes to implement, to abate emissions, and to prevent non-compliance with the Noise Regulations, and the effectiveness of any measures that have been implemented.

This report covers the ninth quarter of mining operations (Q9), from 23 October 2017 to 22 January 2018 inclusive.

To inform management of noise emissions from the operations, KLPL undertake noise monitoring consistent with the principles of the approved 2011 *Noise Monitoring Plan*. A revised Noise Monitoring Plan was submitted to the Department of Water and Environmental Regulation on 14 September 2017. The plan was revised to reflect the progression of the mine and improved understanding of the local noise environment.

During Q9, premises to the north-east and south of the active mining area were the closest without an agreement that provides relief from the requirements of Condition 14-1 of MS810. SVT has undertaken an assessment of noise levels focussed at noise monitors representative of these residences and also completed analysis of data from noise monitors representative of other residences around the mine operations.

Within the Q9 period the Mine Field Unit 2 (MFU2) was in operation. Night mining occurred in the south-eastern lot 300 throughout the period. Excavated ore was transported to MFU2 for initial processing.

Five monitors were deployed for the reporting period. Four of these monitors were at locations selected to record noise levels representative, as far as reasonably practicable, of operational noise received at noise sensitive premises nearest to operations. The fifth monitor, the BarnOwl, was located closer to the mining operation to utilise its directional functionality, which assists in differentiating operational noise from other local noise sources.

Given the volume of noise data, a high level screening was first undertaken to focus assessment on periods and locations where operational noise was more likely to be elevated due to meteorological conditions. This approach is consistent with that utilised for a Noise Study submitted in June 2017 as part of an inquiry into the regulation and management of noise under Section 46 of the *Environmental Protection Act 1986*. Each period identified by the high level screening was then subjected to a detailed assessment. This detailed analysis included significant post-processing of

data with procedures to exclude or minimise as far as practicable, the contribution to measured noise levels from relatively easily identifiable extraneous noise sources, such as trains and some forms of wildlife.

Of the 92 nights in the reporting period, sixteen nights, considered amongst the worst case for noise propagation in specific directions from the operations, were identified for detailed assessment. An elevated likelihood of exceedance of assigned noise levels was identified for parts of seven of these nights. The following points summarise the detailed assessment at each noise monitoring location.

- South-west of the Wet Concentrator Plant, in the direction of NSOD1, detailed analysis of two nights concluded a low risk of exceedance at residences in the direction of this monitor.
- East of the mining area, in the direction of NMT3, an elevated likelihood of exceedance occurred on three of the nights analysed in detail. An elevated likelihood of exceedance was concluded at up to three residences in the same direction as this monitor.
- South of the mining area, in the direction of NMT4, an elevated likelihood of exceedance occurred on two of the nights analysed in detail. The movement of mining closer to this monitor is considered, under certain conditions, to have contributed to elevated levels of noise identified at NMT4. An elevated likelihood of exceedance was concluded at up to two residences in the same direction as this monitor.
- North of the mining area, in the direction of NMT5, an elevated likelihood of exceedance occurred on two of the nights analysed in detail. An elevated likelihood of exceedance was concluded at one resident in the same direction as this monitor.

It was an adjustment due to the assessed presence of tonality that increased the assessed noise level over the assigned level on all nights determined to have an elevated likelihood of exceedance. Tonality was assessed as a desktop exercise using the quantitative process from the regulations without observation of audibility onsite.

Considering the screening process and the assessed levels, it is possible that an elevated likelihood of exceedance may have occurred at some of these residences around the active mining area on other occasions within the reporting period.

SVT understands that KLPL maintained its adaptive management approach for noise emissions during Q9. Operational activity was planned daily, based on weather forecasts. The level and location of mining activities was adjusted on occasions based on real time noise observations and data to manage noise.

KLPL's programme of noise abatement continued during the quarter. Measures implemented during the quarter included:

- continued discussions and development with mining equipment suppliers, investigating the timing, practicalities and benefits of customised noise attenuation on the mobile mining fleet.
- the BarnOwl underwent a biennial NATA calibration check and was relocated closer to the active mining operation to enable greater utilisation of the directional capability of the instrument in differentiating operational noise from other environmental noise sources.

In addition to its noise monitoring and management, KLPL has pursued the negotiation and execution of amenity agreements with neighbouring landowners to address concerns of the possibility of impacts from operational noise emissions. SVT is advised that two amenity agreements, pertaining to residences near to the operations, have been executed subsequent to the end of the quarter.

SVT has made several recommendations in this report:

- 1 Investigate the source of the 'motor' at constant idle, which was clearly heard during the detailed assessments of the NMT3 logger on 26 October and 27 October. *(MZI have subsequently indicated that this is 'attributed to inspection doors being inadvertent left open on the housing of a tails pump, which was promptly rectified, and steps taken to minimise the risk of re-occurrence').*
- 2 Review the noise management procedures for night time mining operations to ensure adequacy for avoiding noise impact at residents. This review could include:
 - a. Revised validation of the adaptive noise management system.
 - b. Attended noise monitoring to ensure that measured levels at monitors are representative of mining operations.
 - c. Review of noise monitor alert settings and limits, as well as the management process for responding to alerts.

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1. INTRODUCTION

MZI Resources Limited (MZI), through its subsidiary Keysbrook Leucoxene Proprietary Limited (KLPL), operate a mineral sands mine and primary processing plant within an area of rural land near the townships of Keysbrook and North Dandalup. The South West Main freight railway and South West Highway are approximately 1.0 km and 1.8 km to the east of the project area. Keysbrook mine operations commenced on 22 October 2015. The mine operates continuously, 24 hours per day, 7 days per week.

Operations occur on private freehold land, which is predominantly used for pastoral grazing and small rural lots. Appendix Figure A-1 presents an aerial view of the mine area and surrounds, including the closest residences.

SVT have been commissioned by KLPL to prepare a report that maintains the continuum of rationale and comprehensive data analysis demonstrated in previous quarterly reports.

This report has been prepared pursuant to Condition 14-5 of Ministerial Statement 810 (MS810), which requires the submission of a quarterly report, prepared by an independent acoustic expert to include the following: –

- a. review noise monitoring methodology and results for the quarter;
- b. an assessment of the extent to which noise emissions from the proposal comply with the Noise Regulations;
- c. details of any management or other measures that the proponent has implemented, or proposes to implement, to abate emissions, and to prevent non-compliance with the Noise Regulations, and the effectiveness of any measures that have been implemented.

To inform management of noise emissions from the operations, KLPL undertake noise monitoring consistent with the principles of the approved 2011 *Noise Monitoring Plan*. A revised Noise Monitoring Plan was submitted to the Department of Water and Environmental Regulation on 14 September 2017. The plan was revised to reflect the progression of the mine and improved understanding of the local noise environment.

This report covers the ninth quarter of mining operations (Q9), from 23 October 2017 to 22 January 2018 (inclusive).

During Q9, residences in the direction of noise monitors at NMT3 and NMT4 (north-east and south of the active mining operations) were closest to the mining operations and at greatest risk of receiving elevated noise levels. Assessment of noise data from these monitors has been the main focus. In addition, analysis of data from noise monitors representative of other residences nearby to the operations has also been undertaken.

1.1 Relevant Documents

Regulatory Documents

- [1] *Environment Protection Act 1986*
- [2] Environmental Protection (Noise) Regulations 1997
- [3] Ministerial Statement 810, 19 October 2009, Statement That a Proposal May Be Implemented Pursuant to the Provisions of the *Environmental Protection Act 1986*.

Noise Monitoring Plans

- [4] Noise Monitoring Plan, August 2011, 511442-11b, Lloyd George Acoustics
- [5] Noise Monitoring Plan, September 2017, 511442-11b, Keysbrook Leucoxene Pty Ltd

Previous Quarterly Reports

A list of the quarterly reports presenting the analysis and assessment results since the start of operations are listed in Table 1-1.

Table 1-1: Summary of Keysbrook Mineral Sands Mine quarterly noise monitoring compliance reports

Operations Period	Date Range	Report Reference
Q1 2016	22 October 2015 to the 22 January 2016	SVT Report 1370900-5-100-Rev2-18.Feb.2016
Q2 2016	23 January 2016 to 22 April 2016	SVT Report 1401854-1-100-Rev4-3.Jun.2016
Q3 2016	23 April 2016 to 22 July 2016	SVT Report 1401854-2-100-Rev3-19.Aug.2016
Q4 2016	23 July 2016 to 22 October 2016	SVT Report 1401854-3-100-Rev4-18.Nov.2016
Q5 2017	23 October 2016 to 22 January 2017	SVT Report 1401854-4-100-Rev4-31.Jan.2017
Q6 2017	23 January 2017 to 22 April 2017	SVT Report 1401854-5-100-Rev3-16.May.2017
Q7 2017	23 April 2017 to 22 July 2017	SVT Report 1401854-7-100-Rev2-25.Aug.2017
Q8 2017	23 July to 22 October 2017	SVT Report 1401854-8-100-Rev3-1.Dec.2017
Q9 2018	23 October 2017 to 22 January 2018	This Report

2. REGULATIONS AND LICENCE CONDITIONS

2.1 Assigned Levels

Noise management in Western Australia is implemented through the Environmental Protection (Noise) Regulations 1997 (the *Regulations*), which operate under the *Environmental Protection Act 1986*. The *Regulations* specify maximum noise levels (assigned levels) which are the highest noise levels that can be received at noise sensitive (residential), commercial and industrial premises.

Appendix A presents an aerial view of the approved project area and surrounding land, and includes the closest Noise Sensitive Receptors (NSR).

Appendix B provides more detail on the regulations and information on the determination of the assigned levels.

Table 2-1 presents the L_{A10} site specific assigned levels for the nearest noise sensitive premises. The L_{A10} assigned level is quoted in the table as this is considered the most stringent for operations as the noise emissions are relatively constant. The L_{A1} and L_{AMAX} assigned levels also apply to the Keysbrook site, although based on extensive attended and un-attended noise monitoring, these levels are rarely approached.

Table 2-1: Assigned noise levels (L_{A10}) in dB(A)

Address	Influencing Factor in dB	Assigned Noise levels (L_{A10}) in dB(A)		
		Week day ¹	Evening and Sunday ²	Night ³
All NSRs	0	45	40	35

The *Regulations* allow for an assessment period of between 15 minutes and 4 hours (period normally determined by the regulator). A longer period, such as three to four hours, is more appropriate for assessing noise emissions on the basis that, given the nature of operations, levels can vary from hour to hour and a longer assessment period will be more representative of the long term L_{A10} noise levels.

For assessment of the unattended logged noise data in post processing, where it is possible to assess noise on a 4 hour basis, without the period being compromised by effects such as weather, fauna or external anthropogenic related noise, a 4 hour period is used. If a 4 hour assessment is not possible because of these effects, a 3 hour period is considered.

¹ Week day: 0700 to 1900 hours Monday to Saturday.

² Evening and Sunday: 1900 to 2200 hours all days, and 0900 to 1900 hours Sunday and public holidays.

³ Night: 2200 hours on any day to 0700 hours Monday to Sunday and 0900 hours Sunday and public holidays.

2.2 Noise Monitor Placement

Table 2-2 lists the noise monitors in place, along with the system availability, during the reporting period. Table 2-3 contains the coordinates for each monitor. A map showing the location of noise monitors is presented in Appendix Figure A-1.

Table 2-2: Noise monitors in place during the investigative noise monitoring period.

Name	Location	System availability
NSOD1	South-West	100%
BarnOwl1	South-West (with NSOD1)	97%
NMT3	East	100%
NMT4	South-East	100%
NMT5	North-East	100%

KLPL relocated the BarnOwl closer to the active mining operation on 24 October, following a biennial NATA calibration check. The BarnOwl experienced some technical issues following the calibration check, which resulted in the slightly reduced availability.

Table 2-3: Noise monitor coordinates.

Logger	Easting	Northing	Latitude	Longitude
BarnOwl	401719 m E	6405543 m S	-32.4833°	115.9541°
NSOD1	398375 m E	6405418 m S	-32.4833°	115.9186°
NMT3	403489 m E	6408054 m S	-32.4607°	115.9729°
NMT4	402712 m E	6405461 m S	-32.4835°	115.9649°
NMT5	402139 m E	6410032 m S	-32.4436°	115.9552°

2.3 Adjustments for Characteristic of Noise

Measured noise levels at the receiver are required to be adjusted if the noise exhibits intrusive or dominant characteristics, i.e. if the noise is impulsive, tonal, or modulating. If the noise is assessed as having tonal, modulating or impulsive characteristics, the measured noise levels are adjusted by the amounts given in Table 2-4. The adjusted noise levels must comply with the assigned noise levels. *Regulation 9* sets out objective tests to assess whether the noise is taken to be free of these characteristics. These adjustments are cumulative to a maximum of 15 dB.

Table 2-4: Adjustments for intrusive or dominant noise characteristics

Situation	Adjustment to Measured Level
Where tonality is present	+5 dB
Where modulation is present	+5 dB
Where impulsiveness is present	+10 dB

2.4 Assessment of Tonality

Regulation 9(1) defines an assessment method for tonality:

tonality means the presence in the noise emission of tonal characteristics where the difference between —

- (a) the A-weighted sound pressure level in any one-third octave band; and
- (b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

SVT notes the importance of recognising that for noise emissions to be considered as exhibiting tonality, "tonal characteristics" must be present in the noise emission. That is, the tonal noise must **be able to be identified as tonal by a listener**. This requires that the "tonal noise" must first be subjectively audible at the assessment location and that it contains a prominent frequency and is characterised by a definite pitch. If the tonal noise is audible, the objective test is then applied to determine if the tonal characteristics meet the definition of tonality and whether an adjustment needs to be applied.

With recordings of the measured sound, the limitations on playback equipment and the relative levels of sound mean that the subjective test for tonality cannot always be confidently conducted as a desktop only exercise. Therefore, to assess tonality in full, attended noise monitoring is typically required, along with the capture of one third octave spectral data. The analysis of the monitoring data does provide a trigger for further investigation of potential tonality through attended monitoring.

As indicated above, it is not practicable to fully assess the presence of audible tonal characteristics using noise monitoring data. Instead, in analysing the data for this report, SVT has applied an objective test, and professional judgement, to assess tonality.

3. SUMMARY OF ACTIVITIES IN Q9

3.1 Mine Operations for the Quarter

Mining occurred in the south-eastern sector of the approved mine footprint, on Lot 300, during the quarter. Excavated ore was transported northwards to Mine Field Unit 2 (MFU2) for initial screening before being pumped as a slurry to the Wet Concentrator Plant.

The Wet Concentrator Plant continued to operate on a 24/7 basis during the reporting period, with downtime for scheduled maintenance.

3.2 Noise Management Measures Undertaken by KLPL

In addition to the adaptive noise management procedures explained in section 4.4, the following noise mitigation and management measures were implemented by KLPL during the Q9 reporting period:

- KLPL has continued discussions with mining equipment suppliers, investigating the timing, practicalities and benefits of customised noise attenuation on the mobile mining fleet. Attenuation measures implemented include:
 - High performance noise attenuating muffler on Caterpillar haul truck (116);
 - Engine bay attenuation and new high performance muffler replaced on Caterpillar 980 Loader (WL3); and
 - Acoustic matting was erected around the Process Water Booster Pump (320-PP-111) and Slurry Booster Pump No.1 (320-PP-113). This was completed on 13 February 2018, subsequent to the Q9 reporting period.
 - A submersible pump has been sourced to replace the surface mounted pump at the Southern Production Bore. Delivery and installation is expected to occur during the next report period.
- As part of the ongoing site noise emission management procedures, dynamic sound power testing was conducted on various vehicles within the mobile fleet on 14 December.
- KLPL had the BarnOwl undergo a biennial NATA calibration check and relocated the monitor closer to the active mining operation on 24 October. The relocation was to enable greater utilisation of the directional capability of the instrument in differentiating operational noise from other environmental noise sources.
- KLPL has pursued the negotiation and execution of amenity agreements with neighbouring landowners to address concerns of the possibility of impacts from operational noise emissions. Subsequent to the end of the quarter, two amenity agreements pertaining to residences near to the operations were executed.

4. LOGGING NOISE DATA ANALYSIS

4.1 Logging System Technical Details

4.1.1 Equipment and Calibration

Noise monitors (omni-directional) and field calibrators are owned/leased, operated and maintained by KLPL. The equipment meets the requirements specified in Schedule 4 of the Environmental Protection (Noise) Regulations 1997.

KLPL advises that the noise monitoring systems have been regularly calibrated at intervals compliant **with regulatory requirements and manufacturer's recommendations.**

Laboratory calibration of B&K 2250/2270 sound level meters (omni-directional) and field calibrators meets the relevant provisions set out in Schedule 4 of the Environmental Protection (Noise) Regulations 1997.

Laboratory calibration of the BarnOwl is as per manufacturer recommendations.

4.1.2 Noise Monitors

The monitors are specifically located with the intention to assess noise levels at noise sensitive premises nearest to operations (or at locations which receive noise which is, as far as reasonably practicable, representative of the noise received at the nearest premises).

The systems meet the requirements set out in section 4.1.1. The monitors are connected to the B&K Sentinel system, facilitating 24/7 and real-time access to the recorded data. NSOD1, NMT3, NMT4 and NMT5 were configured to capture a 60 second audio clip at the time of the highest noise level within every 5 minute period. In addition, NMT3, NMT4 and the BarnOwl were configured to capture a 60 second audio clip at the time of the highest noise level within every hour period.

Details on the BarnOwl directional system are presented in Appendix D.

4.1.3 Meteorological Data

KLPL provided the weather data used throughout the analysis, which was recorded at various locations on site. The data sources are summarised in Table 4-1.

Table 4-1: Sources of meteorological data

Source of Meteorological Data	Location	Height
BAM dust monitor	23/10/17 to 09/11/17: Located east from Wescott Rd	-3 m
	09/11/17 Onwards: Located at a residence on the eastern side of the site	
BarnOwl monitor	Located at the BarnOwl	-2 m
KLPAWS	Located centrally, near to the site's administration buildings	10 m

The weather data is logged and averaged over 15 minute samples, and time stamped for the start of the logged period.

Due to the topographical influences, wind conditions including direction and velocity, often vary significantly across the 5km east west extent of the project area.

4.2 Monitoring Data Analysis Methodology

4.2.1 Un-Attended Noise Monitoring

In order to focus the assessment effort on periods more likely to exhibit elevated operational noise levels, a high level screening of the 92 nights of noise data in the reporting period was first conducted. The screening was designed to identify periods where meteorological conditions were most likely to give rise to elevated operational noise levels recorded at the monitor. Noise data for each period identified through screening was assessed in detail. The following outlines the screening process:

- The screening criteria used is shown in Table 4-2. The weather station(s) most applicable to the noise monitor location has been used. Where two weather stations are listed, the criteria was applied to either station (i.e. not both).
- Screening assessments were completed on 1 hour data samples.
- The number of high risk 1 hour periods occurring between 10pm and 5am indicated the possibility of elevated levels of operational noise for each night. (Typically, from 4am-5am natural and external anthropogenic noise contributions become significant.)

Table 4-2: High noise risk screening criteria

Noise Monitor	Weather Station	Wind Speed	Wind Direction	Rain
NSOD1	BAM (Up to 9 Nov)	<0.5 m/s (any direction); or <1.3 m/s (specified direction)	0 deg to 90 deg	Less than 0.5mm
	KLPAWS	< 0.6 m/s (any direction); or < 1.3 m/s (specified direction)		
NMT3	BAM (up to 9 Nov)	<0.4 m/s (any direction); or <1.5 m/s (specified direction)	180 deg to 270 deg	
	KLPAWS	<0.7 m/s (any direction); or <2 m/s (specified direction)		
NMT4	BarnOwl (1 Nov onwards)	<0.6 m/s (any direction); or <1.3 m/s (specified direction)	270 deg to 110 deg	
	KLPAWS	<0.7 m/s (any direction); or <2 m/s (specified direction)	270 deg to 90 deg	
NMT5	BAM (Up to 9 Nov)	<0.4 m/s (any direction); or <1.2 m/s (specified direction)	135 deg to 225 deg	
	KLPAWS	<0.6 m/s (any direction); or <1.7 m/s (specified direction)		

Note: Weather for the BarnOwl station was unavailable until 1 Nov, due to technical issues following its removal for a two year NATA laboratory calibration. The BAM dust monitor and weather station was moved from west of Westcott Rd to a residence east of the active mining area on 9 November 2017. KLPL have advised that the new location has been observed to record generally lower wind speeds and is considered less representative of conditions in the areas around the noise monitors, than the previous location. From 9 November 2017 the KLPAWS weather station was used as the primary data source to assess meteorological conditions at NSOD1, NMT3 and NMT5.

Screening criteria has been optimised for the location of mining operations, which is why the criteria differ from those used in previous quarterly reports.

The results of screening were compared with noise monitor summary logs provided by KLPL. The logs were a summary of KLPL's daily in-house analysis of noise data, which include an assessment of noise risk for each night. KLPL's **analysis includes review of spectral content**, logged noise levels, recorded audio and weather data. The summary of each night included an assessment of the noise risk, and the significance of extraneous noise.

In choosing nights to analyse further, the following was considered:

- A higher number of nights for analysis were selected at monitors closest to mining operations;
- **SVT's screening based on meteorological conditions**; and,
- KLPL provided noise analysis logs.

It is noted that SVT's scope included detailed analysis of an agreed set number of nights.

Detailed analysis was undertaken on the nights identified in the pre-screening, and followed the procedure illustrated in Figure 4-1.

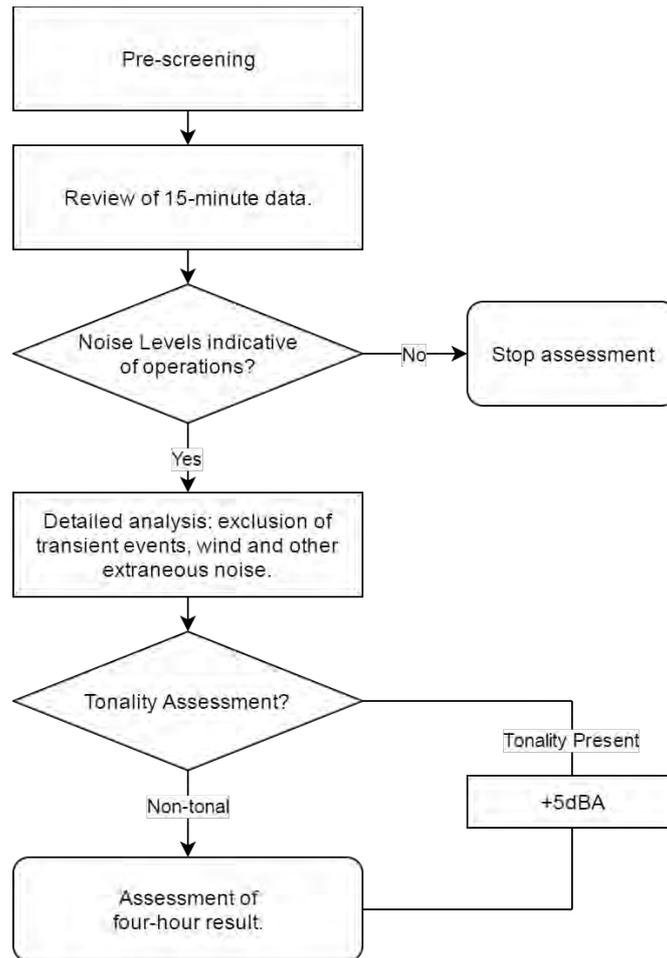


Figure 4-1: Detailed assessment methodology

The detailed assessments were undertaken using the following methodology:

- If an initial review of the data indicated a consistent, dominant presence of wind or extraneous noise (that was unable to be excluded using frequency filtering), no further analysis was completed. If the information was indicative of potentially audible mining noise close to or above the assigned limit, further analysis was undertaken.
- Further analysis involved reviewing one-second logged data for a four-hour period. The period selected captured the highest mining noise contribution over the night time period between 22:00 and 05:00, and where extraneous noise contribution was minimal. Extraneous noise sources such as wind, trains, cars or animals were then excluded based upon any non-typical data in the trace of $L_{eq,1s}$ against time (i.e. transient and other extraneous noise sources). The audio samples and recorded spectra were used to increase confidence in identifying the dominant noise source.

- In the analysis of logged spectral data, values outside the range of 25Hz to 1.6 kHz were not included⁴. This was in order to exclude the majority of high frequency noise attributed to frogs and insects.
- The remaining data was separated into 30-minute intervals over the four-hour period. The L_{Aeq} for each 30-minute interval was tested for tonality and a +5dBA adjustment applied if the objective test outlined in section 2.4 was met and the frequency could be attributed to operations.
- The assessment of noise emissions was based on the L_{10} (considering the residual data after exclusion of extraneous noise, often then constituting a period shorter than four hours) including any tonality adjustments.

The $L_{10,4h}$ is also provided in the results for additional information. The $L_{10,4h}$ is determined as the noise level that is exceeded for 24 minutes of the residual data (i.e. 10% of four hours), rather than 10% of the residual time.

4.2.2 NSR Adjustments

Table 4-3 summarises adjustments to be applied to results obtained at noise monitors to estimate noise received at representative noise sensitive premises. These adjustments reflect the distance between the logger and the nearest residence. The adjustment factors were derived from noise modelling of a typical night mining scenario in block 880 which is representative of the area of mining late in the Q9 reporting period. The adjustments are equivalent to the difference in prediction between the noise monitor location and the receiver location.

Receivers that are the subject of an agreement or owned by KLPL have not been assessed. Agreements were reached with some of the receivers listed during the reporting period – the assessment has taken this into account by not assessing noise at these receivers after the agreement date.

Table 4-3: Noise sensitive receptor adjustments applicable to noise monitor results

Noise Monitor	Representative Receiver	Adjustment (dBA)
NSOD1	Receiver 215	-4.4
	Receiver 220	-3.8
NMT3	Receiver 275	-5.5
	Receiver 276	-4.6
	Receiver 288	-5.6
NMT4	Receiver 208	-3.3
	Receiver 209	-3.7
	Receiver 221	-6.4
NMT5	Receiver 318	0.0
	Receiver 353	-5.2

⁴ The Regulatory definition of one-third octave band is the range of 25 Hz to 20 kHz inclusive. Therefore, 25Hz was selected for the low end of the frequency range for inclusion. It was identified that insect/frog noise frequently influences 1/3 octave bands 2 kHz and above, so 1.6 kHz was chosen as the upper frequency limit.

4.2.3 Limitations of Monitoring Data Analysis

Limitations of the Keysbrook noise monitoring analysis include:

- Inability to assess the audible presence of tonal characteristics in un-attended monitoring (see section 2.4);
- Inability to exclude all extraneous noise sources (i.e. birds, wind in trees, traffic, trains);
- Difficulty in accurately determining the contribution of mine site noise to the overall noise levels;
- For the noise monitors on the Sentinel system, audio is provided in short samples (as opposed to continuous audio)⁵; and
- At times, recorded weather data does not correlate with expected noise monitoring observations. This is likely due to inconsistent, time and space varying local weather conditions, particularly with regards to temperature and wind gradients (changing with height) and local influences.

4.3 Analysis Results and Compliance Assessment

SVT has undertaken detailed analysis of a screened sample of nights of noise logging data from 23 October 2017 to 22 January 2018 inclusive. Table 4-4 summarises the results at the noise monitors. Appendix C contains a detailed table with the results for each night analysed.

Table 4-4: Summary of screening and detailed analysis

Logger	No. of High Risk Nights Identified in Screening	No. Nights Analysed	Highest L _{A10} (25Hz–1.6kHz)	Number of periods > 30 dBA L _{A10} (25Hz–1.6kHz)
NSOD1	1	2	27.5	0
NMT3	10	5	39.3	5
NMT4	13	6	36.4	4
NMT5	9	3	31.6	2

Table 4-5 presents an assessment of compliance for each of the nights analysed accounting for tonality adjustments and adjustments for distance (refer sections 2.3 and 4.2.2). Nights where a result was not obtainable due to constant extraneous noise (wind or fauna) are omitted from this table. Further detail is provided in the tables in Appendix C.

⁵ The sentinel system provides short compressed audio recordings to reduce data transfer over the cellular network.

Table 4-5: Assessment of analysed data

Monitor	Date & Assessment Period	Raw LA10 ⁶ [dBA]	LA10 (25Hz-1.6kHz) [dBA]	Tonality	Highest NSR LA10 level after adjustments ⁷	No. of NSRs with elevated likelihood of exceedance
NSOD1	26/10/2017 10:58:29 PM to 03:00:00 AM	27.8	24.7	YES 50Hz 160Hz	25.9	-
NSOD1	09/11/2017 10:00:00 PM to 02:00:00 AM	30.0	27.5	No	23.7	-
NMT3	24/10/2017 11:00:00 PM to 03:00:00 AM	37.0	36.4	YES 100Hz	36.8	3
NMT3	26/10/2017 12:00:00 AM to 04:00:00 AM	40.1	39.3	YES 100Hz	39.7	3
NMT3	27/10/2017 11:00:00 PM to 03:00:00 AM	39.5	39.2	YES 80Hz 100Hz	39.6	3
NMT3	26/12/2017 11:00:00 PM to 03:00:00 AM	36.9	34.4	YES 80Hz	34.8	-
NMT3	11/01/2018 10:00:00 PM to 02:00:00 AM	35.8	31.8	No	27.2	-
NMT4	24/10/2017 11:00:00 PM to 03:00:00 AM	34.4	33.4	YES 50Hz 100Hz 200Hz	35.1	1
NMT4	25/10/2017 12:00:00 AM to 04:00:00 AM	39.2	36.4	YES 160Hz	38.1	2
NMT4	26/10/2017 10:00:00 PM to 02:00:00 AM	35.0	33.2	YES 200Hz	34.9	-
NMT4	11/12/2017 12:00:00 AM to 04:00:00 AM	35.8	31.0	YES 100Hz	32.7	-
NMT4	26/12/2017 11:00:00 PM to 03:00:00 AM	33.9	22.8	No	19.5	-
NMT4	11/01/2018 11:00:00 PM to 03:00:00 AM	36.0	23.5	No	20.2	-
NMT5	24/10/2017 10:00:00 PM to 02:00:00 AM	32.6	30.9	YES 100Hz 160Hz	35.9	1
NMT5	26/10/2017 11:00:00 PM to 03:00:00 AM	35.2	31.6	YES 40Hz 63Hz 160Hz	36.6	1
NMT5	26/12/2017 10:00:00 PM to 02:00:00 AM	31.6	29.5	YES 80Hz 160Hz	34.5	-

A summary of the assessment for NSRs associated with each monitor is listed below.

NSOD1

- Levels below the assigned level were found on the two nights analysed.

⁶ Raw L₁₀ is the L₁₀ level prior to excluding data and frequency filtering.

⁷ Refer Table 2-4 and Table 4-3

- Based on the screening sample size and the assessment levels determined, the risk that a high probability of exceedance occurred on other occasions in the reporting period is low.

NMT3

- A total of 10 nights were identified in the screening process as high risk, with five of the highest risk nights selected for further detailed analysis.
- An elevated likelihood of exceedance was identified at representative receivers for this monitor on three of the nights analysed. Tonality was found to be present on all of these nights where the adjustment applied has pushed the measured level above the assigned levels.
- The assessment concluded that on the nights of the 26 October and 27 October a 'motor' at constant idle can be heard for extended periods during the night. The 'motor' was a dominant sound source and may have significantly contributed to levels in the 80Hz and 100Hz 1/3 octave bands.
- While data screening identified the nights with the greatest risk of operational noise propagation towards the monitor for further analysis, based on the screening sample size and the assessment levels determined, it is possible that an elevated likelihood of exceedance may have occurred on other occasions in the reporting period.

NMT4

- A total of 13 nights were identified in the screening process as high risk, with six of the highest risk nights selected for further detailed analysis.
- An elevated likelihood of exceedance was identified at representative receivers for this monitor on two of the nights analysed. Tonality was found to be present on all of these nights where the adjustment applied has pushed the measured level above the assigned levels.
- The assessment concluded that wind generated extraneous noise was present throughout the night of the 25 October. SVT has excluded as much of this as possible, noting that some contribution may remain in the analysis. A sensitivity test indicates that the remnant wind noise that was unable to be filtered from the data set may have up to 1 dB influence.
- The assessment concluded that extraneous bird noise was present for significant periods during the 24 October and 26 October. SVT has excluded as much of this extraneous noise as possible, noting that some contribution may remain in the residual data for analysis.
- Two of the nights identified in screening as high risk, and analysed in further detail, were found to have significant extraneous influence from trains and cars throughout the night. Upon exclusion, the Special L₁₀ (25Hz to 2kHz) was found to be below 25 dBA for these nights.
- While data screening identified the nights with the greatest risk of operational noise propagation towards the monitor for further analysis, based on the screening sample size and the assessment levels determined, it is possible that an elevated likelihood of exceedance may have occurred on other occasions in the reporting period.

NMT5

- A total of nine nights were identified in the screening process as high risk, with three of the highest risk nights selected for further detailed analysis.

- An elevated likelihood of exceedance was identified at representative receivers for this monitor on two of the nights analysed. Tonality was found to be present on all of these nights where the adjustment applied has pushed the measured level above the assigned levels.
- The assessment concluded that on the three nights analysed animal noise was present at various points during the assessment period. SVT has excluded as much of this as possible, noting that some contribution may remain in the residual data for analysis.
- While data screening identified the nights with the greatest risk of operational noise propagation towards the monitor for further analysis, based on the screening sample size and the assessment levels determined, it is possible that an elevated likelihood of exceedance may have occurred on other occasions in the reporting period.

4.4 Adaptive Noise Management

KLPL have advised that during the quarter, they have maintained daily predictive noise assessments based on weather forecasts to determine the extent and location of mining activity. Operational activities were occasionally modified in response to noise alerts triggered by the noise monitors and field observations by KLPL staff (predominantly the Shift Supervisor).

The scale and activity of the night-time mobile mining fleet remained constrained, and adjusted daily, during the reporting period to manage noise risk.

5. RECOMMENDATIONS

Some recommendations specific to the Q9 findings are made below.

- 1 Investigate the source of the 'motor' at constant idle, which was clearly heard during the detailed assessments of the NMT3 logger on 26 October and 27 October. *(MZI have subsequently indicated that this is 'attributed to inspection doors being inadvertent left open on the housing of a tails pump, which was promptly rectified, and steps taken to minimise the risk of re-occurrence')*
- 2 Review the noise management procedures for night time mining operations to ensure adequacy for avoiding noise emissions that exceed the assigned level at residents. This review could include:
 - a. Revised validation of the adaptive noise management system.
 - b. Attended noise monitoring to ensure that measured levels at monitors are representative of mining operations.
 - c. Review of noise monitor alert settings and limits, as well as the management process for responding to alerts.

6. CONCLUSION

SVT has undertaken detailed analysis of noise data for a sample of nights from 23 October 2017 to 22 January 2018. The sample set was determined through a screening process that aimed to identify periods where weather conditions were most conducive to noise propagation. Sixteen nights were analysed in detail. Noise monitoring data was captured from five monitors in four monitoring locations, in various directions from operations.

Residences in the direction of noise monitors at NMT3, NMT4 and NMT5 (east, south and north of the active mining operations) are closest to the mining operations and at greatest risk of receiving elevated noise levels. An elevated likelihood of exceedance of assigned noise levels was identified for parts of eight nights. The following points summarise the assessment at each noise monitoring location.

- South-west of the WCP in the direction of NSOD1, detailed analysis of two nights concluded a low risk of exceedance at residences in the direction of this monitor. The monitor NSOD1 remains closest to the WCP but relatively distant from the mining activities.
- East of the mining area in the direction of NMT3, an elevated likelihood of exceedance occurred on three of the nights analysed in detail. This monitor is relatively close to the MFU and mining operations. An elevated likelihood of exceedance was concluded at up to three residences in the same direction as this monitor.
- South of the mining area in the direction of NMT4, an elevated likelihood of exceedance occurred on two of the nights analysed in detail. The progression of mining closer to this monitor is considered, under certain conditions, to have contributed to elevated levels of noise identified at NMT4. An elevated likelihood of exceedance was concluded at up to two residences in the same direction as this monitor.
- In the direction of NMT5 an elevated likelihood of exceedance occurred on two of the nights analysed in detail. An elevated likelihood of exceedance was concluded at one resident in the same direction as this monitor.

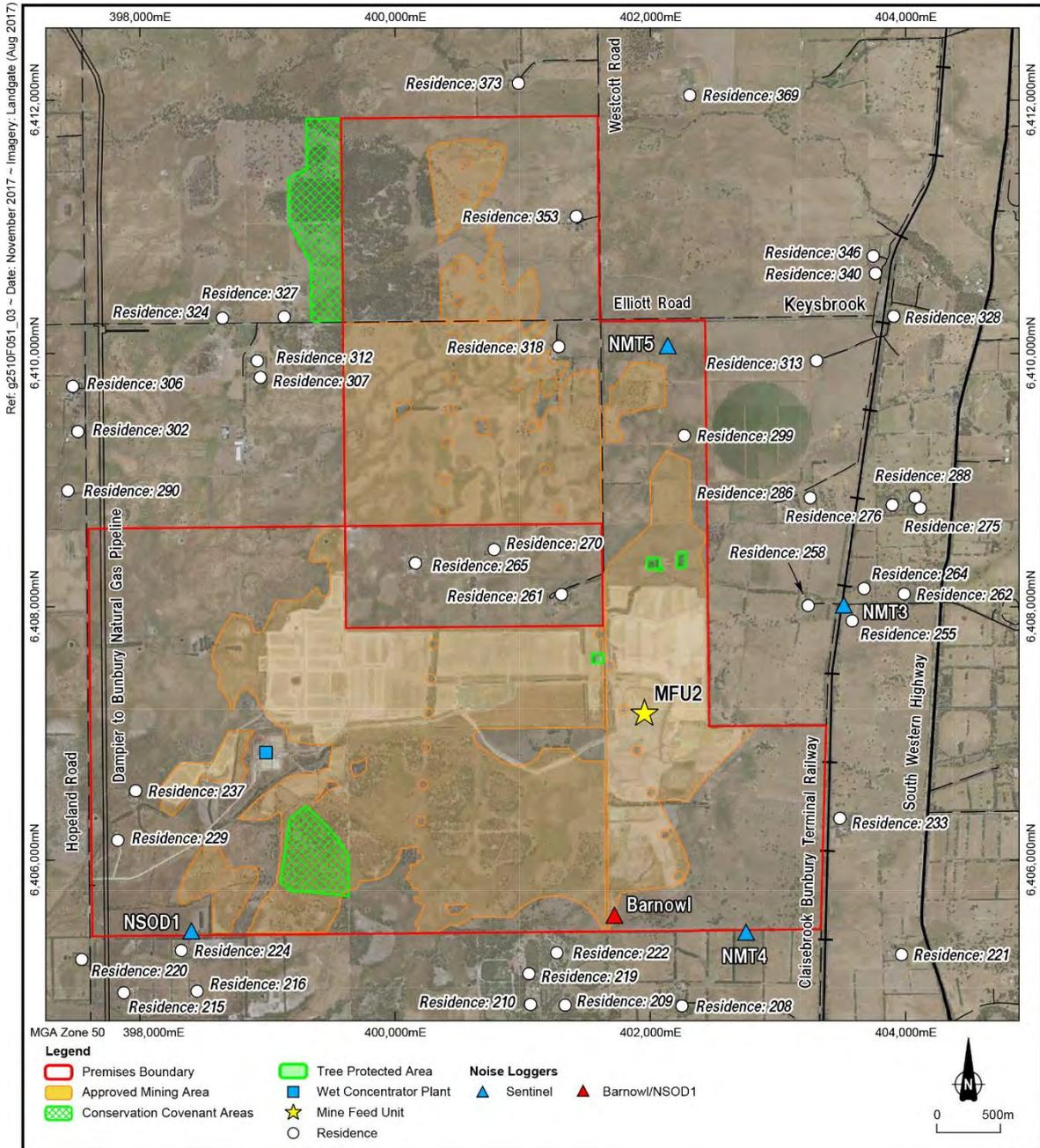
The adjustment due to the presence of tonality has increased the assessed noise level to exceed the assigned level on all nights with an elevated likelihood of exceedance.

Considering the screening process and the assessed levels, it is possible that an elevated likelihood of exceedance occurred at some of these residences around the active mining area on other occasions within the reporting period.

SVT understands that KLPL maintained its adaptive management approach for noise emissions during Q9. Operational activity was planned daily, based on weather forecasts. The level and location of mining activities was adjusted or suspended on occasions based on real time noise observations and data to manage noise.

SVT has made several recommendations in this report aimed at reviewing the noise emissions of parts of the operation and reviewing the noise management tools and processes.

APPENDIX A KEYSBROOK NOISE MONITORING NETWORK



Appendix Figure A-1: Aerial view of the Keysbrook mine site, surrounding area and location of noise monitors in the Q9 reporting period.

APPENDIX B SUMMARY OF NOISE REGULATIONS

Management of industrial noise in Western Australia is implemented through the WA *Environmental Protection (Noise) Regulations 1997* which operate under the *Environmental Protection Act 1986*. The *Regulations* specify maximum noise levels (Assigned Noise Levels) which are the highest noise levels that can be received at noise-sensitive (residential), commercial and industrial premises.

For noise sensitive premises (i.e. residences), an **"influencing factor"** is incorporated into the assigned noise levels. The influencing factor depends on land use zonings within circles of 100 metres and 450 metres radius from the noise receiver, including:

- the proportion of industrial land use zonings;
- the proportion of commercial zonings; and
- the presence of major roads.

The presence of major roads or industrial developments (or zoning for those developments) can result in influencing factors in a range from 0 to 20dB.

The regulations categorises "land on which a mining operation is carried on" as industrial premises for the purposes of calculating the influencing factor.

For noise sensitive residences, the time of day also affects the assigned levels.

The regulations define three types of assigned noise level:

- L_{Amax} Assigned Noise Level means a noise level which is not to be exceeded at any time;
- L_{A1} Assigned Noise Level which is not to be exceeded for more than 1% of the time; and
- L_{A10} Assigned Noise Level which is not to be exceeded for more than 10% of the time.

Appendix Table B-1 below presents the generic Assigned Noise Levels for noise sensitive premises defined in the regulations.

Appendix Table B-1: Assigned noise levels

Type of premises receiving noise	Time of day	Assigned Noise Levels dBA		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sundays and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 - 0700 hours on any day Monday to Saturday & 2200 - 0900 hours Sunday and public holidays	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80

APPENDIX C DETAILED ASSESSMENT TABLES

Appendix Table C-1: Results at noise monitors for nights analysed in detail

Logger	Date & Assessment Period	L ₁₀ Raw (Before Processing)	Assessment Duration	L _{Aeq} dBA	L ₁₀ dBA	L ₁₀ (25-2kHz) dBA	L ₉₀ dBA	L ₉₀ (25-2kHz) dBA	Tonal?	Comments	Weather Data
NSOD1	26/10/2017 10:58:29 PM to 03:00:00 AM	27.8	03:26:53	26.7	22.4	26.2	24.7	22.7	YES 50Hz 160Hz	Very little operations noise audible throughout the night. Fixed plant operations are faintly audible around 1:30AM. Tonality of 50Hz and 160Hz may be the result of fixed plant activities. Majority of noise is extraneous bird, cow and insect noise. Cars and planes can also be heard.	22:00 NE, 0 to 0.5 m/s 23:00 N, 0.3 to 1.4 m/s 00:00 NE, 0.8 to 1.4 m/s 01:00 NE, 0.3 to 1.6 m/s 02:00 NE, 0.1 to 0.8 m/s 03:00 NE, 0.6 to 1.4 m/s 04:00 E, 0.5 to 1 m/s
NSOD1	09/11/2017 10:00:00 PM to 02:00:00 AM	30.0	02:56:57	26.4	24.7	28.6	27.5	23.4	No	Operations audible for certain periods of the night. Fixed plant is audible from 10:30PM to 11PM. Fixed plant becomes more audible from 12:30AM onwards, however it is dominated by extraneous bird, cow, car, train and plane noise. Bird noise becomes more prevalent from 12:30AM onwards. No tonality is present within the spectrum.	22:00 SE, 0 to 0.7 m/s 23:00 S, 0.7 to 1.2 m/s 00:00 S, 0.9 to 1.6 m/s 01:00 SE, 1.3 to 1.9 m/s 02:00 S, 0.6 to 1.2 m/s 03:00 SW, 0 to 1.3 m/s 04:00 S, 0 to 0.7 m/s
NMT3	24/10/2017 11:00:00 PM to 03:00:00 AM	37.0	03:21:17	32.9	32.5	36.6	36.4	25.7	YES 100Hz	Operations audible throughout the night in the form of loader engine revs and haul truck differential whine. Tonality at 100 Hz likely due to mobile equipment. Extraneous insect noise was consistent throughout the assessment period, however not a dominant source. Audible engine revs were present from 11 PM until soon after 1 AM. Haul truck whine most prominent between 12 AM and 1 AM. Lull in audible operations noise between 1 AM and 2:30AM. From 2:30 AM onwards a constant motor idle is audible, may be attributed to MFU activities.	22:00 NE, 0.5 to 1.1 m/s 23:00 N, 0.9 to 1.2 m/s 00:00 N, 1.2 to 1.8 m/s 01:00 NE, 0 to 1.2 m/s 02:00 NE, 0.5 to 1.6 m/s 03:00 N, 0.7 to 2.2 m/s 04:00 N, 1.1 to 1.8 m/s

Logger	Date & Assessment Period	L ₁₀ Raw (Before Processing)	Assessment Duration	L _{Aeq} dBA	L ₁₀ dBA	L ₁₀ (25-2kHz) dBA	L ₉₀ dBA	L ₉₀ (25-2kHz) dBA	Tonal?	Comments	Weather Data
NMT3	26/10/2017 12:00:00 AM to 04:00:00 AM	40.1	03:37:07	36.4	36.2	39.3	39.3	29.0	YES 100Hz	Operations audible throughout the assessment period, in the form of excavator bucket noise and haul truck whine. A constant motor idle was present for extended periods of time, this may be attributed to MFU activities. Tonality of 100 Hz is likely due to mobile equipment and constant motor idle. Insects and frogs contributed some extraneous during the assessment period. Haul truck whine and bucket scrape audibility was fairly consistent during the night. Constant motor idle was audible between 1 AM and 1:45 AM, and from 2:20 AM onwards.	22:00 NE, 0 to 0.5 m/s 23:00 N, 0.3 to 1.4 m/s 00:00 NE, 0.8 to 1.4 m/s 01:00 NE, 0.3 to 1.6 m/s 02:00 NE, 0.1 to 0.8 m/s 03:00 NE, 0.6 to 1.4 m/s 04:00 E, 0.5 to 1 m/s
NMT3	27/10/2017 11:00:00 PM to 03:00:00 AM	39.5	02:57:35	37.0	36.8	39.3	39.2	33.4	YES 80Hz 100Hz	Operations audible for the majority of night, except for periods of extraneous wind noise during the start and end of the assessment period. Some wind influence was not able to be removed from the analysis between 11PM and 12:20AM. A sensitivity test determined that this has little affect the overalls levels for the night. Operations audible in the form of MFU loader engine revs, haul trucks whine, bucket scrapes and constant idle motor noise, which may be attributed to MFU activities. Tonality of 100 Hz is likely due to mobile equipment and constant idling engine. Extraneous insect noise was also present for periods of the night. Loader, haul truck whine and bucket scrapes were audible from 11 PM to 1 AM. During 1AM to 2AM Haul truck whine and bucket scrapes are audible. From 2 AM onwards, in times of low wind, haul truck whine and constant idle motor noise are audible.	22:00 SW, 0.5 to 1.6 m/s 23:00 SW, 1.8 to 4.1 m/s 00:00 SW, 1 to 1.7 m/s 01:00 SW, 1 to 1.8 m/s 02:00 SW, 1.7 to 3.4 m/s 03:00 W, 1.2 to 3.2 m/s 04:00 W, 1.8 to 4.7 m/s
NMT3	26/12/2017 11:00:00 PM to 03:00:00 AM	36.9	02:22:31	31.4	30.3	35.0	34.4	26.8	YES 80Hz	Operations audible throughout the night in the form of haul truck whine, bucket scrapes, MFU loader and constant revs motor noise, which could be attributed to MFU activities. Tonality of 80 Hz is likely due to mobile equipment and constant idling motor. Extraneous insect noise was significant post-midnight. Traffic on SW Highway more frequent than usual. Extraneous traffic noise removed in processing. Small periods of winds post 2AM were also removed in processing. Motor running at constant revs audible from 11PM to 1:30AM. Haul truck whine most audible from 11 PM to 1AM, and post 2AM. Bucket scrapes and MFU loader audible in the first half of the night.	22:00 E, 0 to 0.1 m/s 00:00 SE, 0.2 to 0.5 m/s 01:00 S, 0.2 to 1.1 m/s 02:00 SE, 0.4 to 0.9 m/s 03:00 SE, 0 to 1.3 m/s 04:00 SE, 0.6 to 1.2 m/s

Logger	Date & Assessment Period	L ₁₀ Raw (Before Processing)	Assessment Duration	L _{Aeq} dBA	L ₁₀ dBA	L ₁₀ (25-2kHz) dBA	L ₉₀ dBA	L ₉₀ (25-2kHz) dBA	Tonal?	Comments	Weather Data
NMT3	11/01/2018 10:00:00 PM to 02:00:00 AM	35.8	02:32:58	29.3	28.4	32.4	31.8	22.9	No	Operations audible from 10 PM to 12:30 AM. Post 12:30 AM LAeq drops to low 20s, and operations are only occasionally audible. Operations noise consists of haul truck whine and loader noise. Greater than normal number of trains and cars on SW Highway during the night. Extraneous noise from traffic and trains removed in processing.	22:00 S, 0.7 to 1.2 m/s 23:00 SE, 0 to 1.2 m/s 00:00 SE, 0 to 0.9 m/s 01:00 SE, 0.3 to 0.7 m/s 02:00 SE, 0.7 to 0.7 m/s 03:00 E, 0 to 0.9 m/s
NMT4	24/10/2017 11:00:00 PM to 03:00:00 AM	34.4	03:03:37	31.8	31.4	33.6	33.4	29.1	YES 50Hz 100Hz 200Hz	Operations audible and dominant throughout the assessment period, with the exclusion of 1:30AM to 2AM. Operations noise consists mostly of haul truck activity from 11PM to 1.30AM. Haul trucks whine, bucket scrapes and idling motor noise can be heard from 2AM onwards. Tonality of 50Hz appears to be an artefact of the spectrum, while tonality at 200Hz is likely the result of mobile equipment. Extraneous cattle noise is also present from 11:15Am until 1:15AM, this was unable to be filtered from operations noise. A sensitivity test determined that the cattle noise had little effect on overall levels throughout the night. Extraneous bird noise present from 1AM onwards, with bird contribution being greatest from 2AM onwards. Extraneous bird noise was not dominant and should have little effect on results.	22:00 NE, 0.5 to 1.1 m/s 23:00 N, 0.9 to 1.2 m/s 00:00 N, 1.2 to 1.8 m/s 01:00 NE, 0 to 1.2 m/s 02:00 NE, 0.5 to 1.6 m/s 03:00 N, 0.7 to 2.2 m/s 04:00 N, 1.1 to 1.8 m/s
NMT4	25/10/2017 12:00:00 AM to 04:00:00 AM	39.2	02:19:39	34.1	36.6	36.4	30.0	29.3	YES 160Hz	Operations noise was consistent throughout the night. Haul trucks, bucket scrapes and MFU loader were audible. Tonality of 160Hz is likely due to mobile equipment. Some extraneous wind contribution at the start of the period, this was removed. Operations becomes most audible post 1AM with excavator, loader and haul clearly audible. There is also some extraneous wind influence during this period, particularly between 2AM and 4AM. Much of the extraneous wind was removed in post processing. However, some of this was unable to be removed from analysis. Operations is the dominant sound source during this period, and a sensitivity test indicates that wind noise remaining in analysis may have had a 1 dBA influence on overall L10. Small extraneous bird contribution from 3:30AM onwards, the bird noise is not a dominant source and is unlikely to contribute significantly to overall levels.	22:00 N, 1.3 to 1.9 m/s 23:00 N, 1.5 to 2 m/s 00:00 W, 0.9 to 3.1 m/s 01:00 NE, 1 to 2.6 m/s 02:00 N, 1.6 to 4 m/s 03:00 NW, 0.7 to 3.5 m/s 04:00 NW, 0.7 to 1.8 m/s

Logger	Date & Assessment Period	L ₁₀ Raw (Before Processing)	Assessment Duration	L _{Aeq} dBA	L ₁₀ dBA	L ₁₀ (25-2kHz) dBA	L ₉₀ dBA	L ₉₀ (25-2kHz) dBA	Tonal?	Comments	Weather Data
NMT4	26/10/2017 10:00:00 PM to 02:00:00 AM	35.0	02:40:57	30.3	29.8	33.4	33.2	25.8	YES 200Hz	Variable audibility from operations during the night. Operations audible in the form of haul trucks and excavator. Tonality of 200Hz likely due to mobile equipment. Extraneous bird noise from 12:30AM onwards. Haul truck and excavator most audible from 10PM to 10:30PM and 11:30PM to 1AM. However, MFU activity is still somewhat audible outside these times.	22:00 NE, 0 to 0.5 m/s 23:00 N, 0.3 to 1.4 m/s 00:00 NE, 0.8 to 1.4 m/s 01:00 NE, 0.3 to 1.6 m/s 02:00 NE, 0.1 to 0.8 m/s 03:00 NE, 0.6 to 1.4 m/s 04:00 E, 0.5 to 1 m/s
NMT4	11/12/2017 12:00:00 AM to 04:00:00 AM	35.8	01:32:10	29.4	31.4	31.0	26.7	25.3	YES 100Hz	Levels above 30dBA for the majority of the night. Few extraneous noise sources, elevated levels likely the result of operations. Operations most audible up to 1:15AM. Mining contributions are the results of haul trucks and MFU loader. Tonality of 100Hz likely due to mobile equipment.	22:00 N, 1.1 to 1.9 m/s 23:00 NW, 1.2 to 2.1 m/s 00:00 SE, 0.4 to 1.5 m/s 01:00 S, 0.6 to 1.6 m/s 02:00 SE, 0 to 1.7 m/s 03:00 E, 0 to 0.9 m/s 04:00 S, 0.4 to 2.0 m/s
NMT4	26/12/2017 11:00:00 PM to 03:00:00 AM	33.9	02:03:59	23.4	20.5	24.8	22.8	22.4	No	Large amounts of extraneous traffic and train noise during the night, and very little cattle or bird activity. Train and traffic noise removed in processing. Operations are faintly audible in periods without extraneous influence, haul trucks can be heard during the night, as well as MFU activities. No tonality is present.	22:00 E, 0 to 0.1 m/s 00:00 SE, 0.2 to 0.5 m/s 01:00 S, 0.2 to 1.1 m/s 02:00 SE, 0.4 to 0.9 m/s 03:00 SE, 0 to 1.3 m/s 04:00 SE, 0.6 to 1.2 m/s
NMT4	11/01/2018 11:00:00 PM to 03:00:00 AM	36.0	02:00:28	23.6	20.7	25.3	23.5	22.3	No	Extraneous train and traffic noise dominated the evening. In quiet periods, operations noise faintly audible during the night. Mining noise consisted of loader in MFU and the occasional haul truck whine. No tonality for the period. Extraneous cattle noise also present during the first half of the night, this was removed in processing along with traffic and train influence.	22:00 N, 1.1 to 1.9 m/s 23:00 NW, 1.2 to 2.1 m/s 00:00 SE, 0.4 to 1.5 m/s 01:00 S, 0.6 to 1.6 m/s 02:00 SE, 0 to 1.7 m/s 03:00 E, 0 to 0.9 m/s 04:00 S, 0.4 to 2.0 m/s

Logger	Date & Assessment Period	L ₁₀ Raw (Before Processing)	Assessment Duration	L _{Aeq} dBA	L ₁₀ dBA	L ₁₀ (25-2kHz) dBA	L ₉₀ dBA	L ₉₀ (25-2kHz) dBA	Tonal?	Comments	Weather Data
NMT5	24/10/2017 10:00:00 PM to 02:00:00 AM	32.6	02:44:58	29.2	28.6	31.3	31.0	25.6	YES 100Hz 160Hz	Noise contributions throughout the assessed period were predominantly from the haul trucks and a distinct tone generated by mobile equipment at 100Hz. There is strong at 100Hz and 160Hz which could be attributed to haul trucks and the MFU loader. A number of extraneous noise sources were present through the period including: trains, cars, birds and dogs. Contributions from birds and dogs tended to be continuous, particularly around 11PM and 2AM. Levels were generally below 30 dBA from 10PM to 12AM, gradually increasing during that time. Levels were above 30 dBA from 12AM to 1:15AM, where gradually decreased from 1:15AM onwards.	22:00 NE, 0.5 to 1.1 m/s 23:00 N, 0.9 to 1.2 m/s 00:00 N, 1.2 to 1.8 m/s 01:00 NE, 0 to 1.2 m/s 02:00 NE, 0.5 to 1.6 m/s 03:00 N, 0.7 to 2.2 m/s 04:00 N, 1.1 to 1.8 m/s
NMT5	26/10/2017 11:00:00 PM to 03:00:00 AM	35.2	02:37:10	29.8	29.0	32.1	31.6	25.5	YES 40Hz 63Hz 160Hz	Operations audible throughout the night. Noise from operations consistent of haul truck whine, excavator bucket scrapes/shakes, MFU loader noise and constant idle motor noise. Tonality of 40Hz is an artefact of the spectrum and unlikely to be audible. Tonality at 63Hz and 160Hz is likely the result of mobile equipment. Extraneous noise was also present throughout the evening, although it was not dominant. Frogs, birds and cattle can be heard on audio recordings. However, it is unlikely that they contribute heavily to overall levels.	22:00 NE, 0 to 0.5 m/s 23:00 N, 0.3 to 1.4 m/s 00:00 NE, 0.8 to 1.4 m/s 01:00 NE, 0.3 to 1.6 m/s 02:00 NE, 0.1 to 0.8 m/s 03:00 NE, 0.6 to 1.4 m/s 04:00 E, 0.5 to 1 m/s
NMT5	26/12/2017 10:00:00 PM to 02:00:00 AM	31.6	03:23:02	28.2	27.4	30.0	29.5	25.6	YES 80Hz 160Hz	Operations noise was present throughout the evening. Mining noise consisted of haul trucks, excavator bucket scrapes. Tonality of 80Hz and 160Hz is likely from mobile equipment. A number of extraneous noise sources were also present during the evening including dogs at 11:20PM and birds at 12:40AM. Insect noise was also present during the night. Extraneous bird and dog noise was not dominant and is unlikely to have greatly affected overall levels.	22:00 E, 0 to 0.1 m/s 00:00 SE, 0.2 to 0.5 m/s 01:00 S, 0.2 to 1.1 m/s 02:00 SE, 0.4 to 0.9 m/s 03:00 SE, 0 to 1.3 m/s 04:00 SE, 0.6 to 1.2 m/s

APPENDIX D BARNOWL

The BarnOwl™ utilises a three microphone array that, under suitable environmental noise conditions, enables the system to approximately determine the direction of the sound source.

An omni-directional noise monitor (NSOD1) has been co-located with the BarnOwl™ since September 2016. Both data sets have been regularly cross-checked with the other, as a quality assurance measure to test for any calibration drift and provide a back-up for interruptions to either system.

Appendix Figure D-1 presents a photo of the BarnOwl system.

The BarnOwl directional system captures and logs the following:

Total	The total sound pressure level from a single microphone.
All Directionally Identified Sources	The total noise level calculated by the directional system algorithm, from all directionally identified sources. It excludes sources with no measurable direction (see list below). The metric is an indicator of the dominance or otherwise of overall background noise.
Angle of Interest	The noise level calculated by the directional system algorithm, including only noise from the direction of the minesite.

When the "Total" level is much larger than the "All Directionally Identified Sources" level, this indicates that the dominant noise is:

- a) outside of the plane of direction finding (such as aircraft overhead);
- b) **the noise is "all encompassing" or dispersed, such as wind generated foliage noise, insect/bird noise, or road traffic noise;**
- c) outside of the frequency range of direction finding (very low or high frequency); or
- d) within 3 m of the microphone array.

In the circumstances for all encompassing noise, some proportion of this noise may be assigned to the Angle of Interest by the algorithm.

While the BarnOwl is sophisticated instrumentation, the nature of environmental noise means it cannot always distinguish between noise sources. Like any sound level meter, the system cannot filter out wind or rain noise.

Once winds exceed a relatively low speed and background noise levels increase, the BarnOwl direction finding analysis algorithm is less reliable (likely due to wind generated noise in trees being "all encompassing").

Use of the BarnOwl data in the analysis and assessment of operations noise emissions has considered the limitations of the system in relation to Schedule 4 of the *Environmental Protection (Noise) Regulations 1997*.



Appendix Figure D-1: The BarnOwl noise monitor