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Duralie Coal Mine
Quarterly Compliance Noise Monitoring
October 2017

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Quarterly Compliance Noise Monitoring

October 2017

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1 INTRODUCTION

Duralie Coal Pty Limited (DCPL), a wholly owned subsidiary of Yancoal Australia Limited (Yancoal), has commissioned SLR Consulting Australia Pty Ltd (SLR) to conduct quarterly noise monitoring for the Duralie Coal Mine (DCM) operations guided by the requirements of the *Duralie Coal Mine Noise Management Plan* (NMP), Document No. NMP-R05-A, dated August 2017. This report presents the results and findings from the operator-attended noise surveys conducted between 18 October 2017 and 20 October 2017.

Coal production commenced at Duralie in 2003 using conventional open cut mining methods, operating 24 hours a day. The Duralie Extension Project (DEP) was approved under Project Approval (08_0203) on 10 November 2011, with a maximum Run-of-Mine (ROM) coal mining rate of 3 million tonnes per annum (Mtpa). Sized Duralie ROM coal is loaded and railed to the Stratford Coal Mine (SCM) for coal washing before being transported on the North Coast Railway to the port of Newcastle.

The objectives of the noise monitoring programme for this operating period were as follows:

- Conduct three rounds of external operator-attended noise measurements at the five nominated locations listed in Project Approval, representative of receivers located in the north, west and south directions from the DCM. The monitoring locations are NM1, NM2, NM4, NM5 and the additional monitoring location WR1 representative of Wards River Village.

The three rounds comprise a single round within each of the day, evening and night-time periods as defined in the NSW Industrial Noise Policy (EPA 2000).

- Rail Noise Monitoring – Perform one round of external operator-attended noise measurements at the three nominated locations listed in Section 7.6 of the NMP, being: TN1 (Craven), TN2 (Wards River Village North) and TN3 (Wards River Village South).
- Quantify all sources of noise within each of the attended noise surveys, including measured and/or estimated contribution and maximum level of individual noise sources.
- Assess the noise emissions from the DCM and determine compliance with respect to the limits contained in the NMP.

1.1 Acoustic Terminology

The following report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A**.

2 DCM NOISE LIMITS

2.1 EPL Noise Limits

The site specific noise limits of sub-section L4.1 of Section L4 *Noise Limits* of the EPA's Environment Protection Licence (EPL), EPL 11701 dated 20 August 2014, for the five nominated attended noise monitoring locations, are summarised in **Table 1**.

Table 1 EPL Noise Limits for the Nominated Attended Noise Monitoring Locations [dBA re 20 µPa]

Locality	LAeq(15minute) Criteria			LA1(1minute) Criterion
	Day	Evening	Night	Night
NM1 Woodley	35	35	35	45
NM2 Zulumovski North	35	35	35	45
NM4 Fisher-Webster	35	35	37	45
NM5 Moylan	35	35	35	45
WR1 Wards River Village	35	35	35	45

Additional conditions relating to the noise monitoring location and applicable meteorological conditions are outlined in sub-sections L4.2 (a) and L4.8 of EPL 11701 and are summarised below.

L4.2 (a) with the L_{eq} (15-minute) noise limits in condition 4.1, the noise measurement equipment must be located:

Approximately on the property boundary, where any dwelling is situated 30 metres or less from the property boundary closest to the premises; or

Within 30 metres of a dwelling façade, but not closer than 3 m, where any dwelling on the property is situated more than 30 metres from the boundary closest to the premises.

Noise from the premises is to be measured at a distance within 30 metres of the locations identified in L4.1 to determine compliance with this condition.

L4.8 The noise limits set out in condition in L4.1 apply under all meteorological conditions except for the following:

- a) wind speeds greater than 3 metres/second at 10 metres above ground level; or*
- b) Temperature Inversion conditions up to 3 degrees Celsius/100m and wind speeds greater than 2 metres/second at 10 metres above the ground level; or*
- c) Temperature inversion conditions greater than 3 degrees Celsius/100m.*

2.2 Project Approval Noise Limits

The Project approval conditions relating to the noise limits are as follows:

NOISE

Noise Criteria

- Except for the land referred to in Table 1, the Proponent shall ensure that the noise generated by the project does not exceed the criteria in Table 2 at any residence on privately-owned land or on more than 25 percent of any privately-owned land.

Table 2: Noise criteria dB(A)

Location	Day	Evening	Night	
	$L_{Aeq}(15 \text{ minute})$	$L_{Aeq}(15 \text{ minute})$	$L_{Aeq}(15 \text{ minute})$	$L_{A1}(1 \text{ minute})$
172 - Lyall	35	39	40	45
126 - Hamann Pixalu PL	35	35	39	45
123 - Oleksiuk & Carmody				
173 - Trigg & Holland	35	36	37	45
116 - Weismantel				
127 - Fisher-Webster	35	35	37	45
131(1) - Relton				
180 (1) - Thompson	35	36	36	45
95 - Smith & Ransley	35	35	36	45
144 - Wielgosinski				
169 - Williams	35	36	35	45
177 - Thompson				
All other privately-owned land	35	35	35	45

Notes:

- To identify the locations referred to in Table 2, see the figure in Appendix 3; and
- Noise generated by the project is to be measured in accordance with the relevant procedures and exemptions (including certain meteorological conditions) of the NSW Industrial Noise Policy.

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

Noise Acquisition Criteria

- If the noise generated by the project exceeds the criteria in Table 3 at any residence on privately-owned land or on more than 25 percent of any privately-owned land, then upon receiving a written request for acquisition from the landowner, the Proponent shall acquire the land in accordance with the procedures in Conditions 5 - 6 of Schedule 4.

Table 3: Noise acquisition criteria dB(A) $L_{Aeq}(15 \text{ min})$

Location	Day	Evening	Night
All privately-owned land	40	40	40

Notes:

- Noise generated by the project is to be measured in accordance with the relevant procedures and exemptions (including certain meteorological conditions) of the NSW Industrial Noise Policy; and
- For this condition to apply, the exceedences of the criteria must be systemic.

Rail Noise

5. By the end of December 2011, or as otherwise agreed by the Director-General, the Proponent shall only use locomotives that are approved to operate on the NSW rail network in accordance with the noise limits in the ARTC's EPL (No. 3142).

Operating Conditions

6. The Proponent shall:
 - (a) implement best practice noise management, including all reasonable and feasible noise mitigation measures to minimise the operational, low frequency and rail noise generated by the project; and
 - (b) regularly assess the real-time noise monitoring and meteorological forecasting data and relocate, modify, and/or stop operations on site to ensure compliance with the relevant conditions of this approval, to the satisfaction of the Director-General.

2.3 Rail Noise Limits

The site specific rail noise limits of Clause L2.2 of the DCM NMP Section 4.2.2 are:

It is the objective of this license to progressively reduce noise levels to the goals of 65dB(A)Leq, (daytime from 7am – 10pm), 60dB(A)Leq (night-time from 10pm – 7am) and 85dB(A) (24hr) max pass-by noise, at one metre from the façade of affected residential properties through the implementation of the Pollution Reduction Programs.

Additionally, Section 7.6 of the DCM NMP specifies:

Rail Noise monitoring and reporting against the other rail noise performance criteria described in Section 4 will be undertaken for general information purposes only (i.e. they are not DCM compliance requirements).

Furthermore, Schedule 3 Condition 4(e) of the DCPL Extension Project Approval states:

On privately owned land between the Stratford and Duralie mines where the maximum pass-by rail traffic noise from the Project exceeds 85dB(A), the Proponent shall implement additional noise mitigation measures (such as double glazing, insulation, and/or air conditioning) at the residence in consultation with the owner. These measures must be reasonable and feasible.

2.4 Low Frequency Noise

The "Duralie Modification Noise and Blasting Assessment" (prepared by SLR Consulting Australia dated 9 July 2014) included a low frequency analysis of C and A weighted intrusive noise levels in accordance with INP requirements which indicated that there is no dominant low-frequency content relating to noise emissions from the DCM. A full L_{Ceq} minus L_{Aeq} spectrum low frequency analysis was not conducted on the noise compliance measurements in this round of DCM noise monitoring as DCM noise contribution was not deemed to be the dominant noise source at any noise monitoring location and shall not be addressed further in this report.

3 OPERATIONAL NOISE MONITORING METHODOLOGY

3.1 General Requirements

All acoustic instrumentation employed throughout the monitoring programme has been designed to comply with the requirements of AS IEC 61672.1 – 2004 *Electroacoustics—Sound level meters – Specifications*, AS IEC 61672.2-2004, AS IEC 61672.3-2004 and carried current NATA or manufacturer calibration certificates. Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding ± 0.5 dBA.

3.2 Methodology – Operator-attended Noise Monitoring Locations

Noise monitoring was conducted guided by the requirements of the NMP.

Operator-attended noise measurements were conducted during the day, evening and night-time periods for a minimum of 15 minutes per period at each of the five nominated noise monitoring locations. The details of the operator-attended mine noise monitoring locations are contained within **Table 2** and shown in **Figure 1**. During the operator attended noise measurements, the character and relative contribution of ambient noise sources and mine contributions were determined.

Table 2 DCM Operational Noise Monitoring Locations

Monitoring Location	Receiver Type	Resident / Owner	Monitoring Location - MGA Zone 56	
			Easting (m)	Northing (m)
NM1	Residence	Woodley ¹	400644	6421907
NM2 ²	Residence	Zulumovski North	399042	6430384
NM4	Residence	Fisher-Webster	396790	6428961
NM5	Residence	Moylan	396770	6428945
WR1	Residence	Ward Street - Representative of Wards River Village	399556	6434229

Note 1: Woodley property has recently been purchased by the Thompson family but will retain the title of 'Woodley' until a License revision.

Note 2: Yancoal owned property.

The details of the operator-attended rail noise monitoring locations are contained within **Table 3** and shown in **Figure 1**.

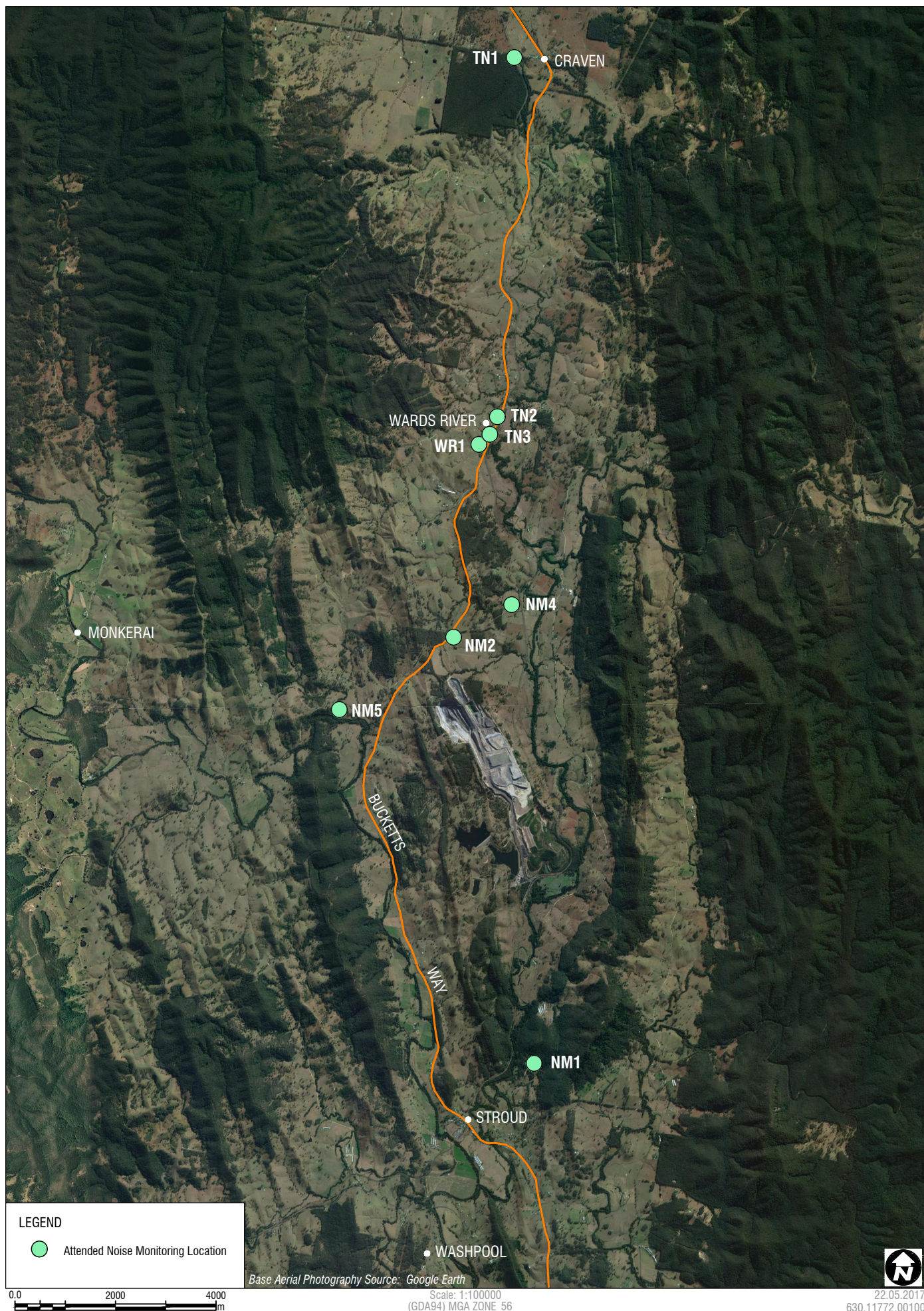
Table 3 Rail Noise Monitoring Locations

Monitoring Location	Receiver Type	Address	Monitoring Location - MGA Zone 56	
			Easting (m)	Northing (m)
TN1	Residence	Craven	400252	6441916
TN2	Residence	Wards River Village North	399914	6434771
TN3	Residence	Wards River Village South	399765	6434421

The objective of the DCM operational operator-attended noise monitoring was to measure the maximum (L_{Amax}) and the $L_{Aeq}(15\text{minute})$ noise level contributions at the nearest potentially affected receptors to determine the noise contribution of mining activities associated with Duralie Coal Mine operations over a 15 minute measurement period. In addition, the operator quantifies and characterises the overall levels of ambient noise in the area (i.e. L_{Amax} , $LA1$, $LA10$, $LA90$, and L_{Aeq}) over the 15 minute measurement interval. The objective of the rail noise monitoring was to determine maximum rail pass-by noise levels from the Duralie Shuttle.

All operator-attended noise measurements were conducted using a one-third octave integrating Brüel & Kjær Type 2250L sound level meter (s/n 3004638).

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4 RESULTS

4.1 Operator-attended Monitoring – DCM Operational Activity

Operator-attended noise measurements were conducted during the day, evening and night periods commencing on Wednesday 18 October 2017. Results of the operator-attended noise surveys at NM1, NM2, NM4 and NM5 and at the additional monitoring location WR1 are provided in **Table 4** to **Table 8**, respectively.

A summary of the results for the operator-attended noise monitoring are displayed graphically in **Appendix B**. Charts of the noise surveys show L_{Amax}, L_{Aeq}, and L_{Aeq}(20Hz-1.25kHz) in one (1) second intervals throughout the monitoring survey.

Ambient noise levels presented include all noise sources such as transport (roads, rail and aircraft), fauna (insects, frogs, birds, and bats), farm animals, the natural environment (wind in trees), domestic noises, other industrial operations as well as Duralie Coal Mine noise emissions.

Weather data during the monitoring period has been obtained from the weather station located on the Duralie Coal Mine site. Where this data was not available meteorological conditions have been estimated based on observed conditions during the monitoring period.

The tables provide the following information:

- Date and start time, operator and equipment details.
- Monitoring location.
- Wind velocity (m/s) and temperature (°C) at the measurement location.
- Typical maximum (L_{Amax}) and contributed L_{Aeq}(15minute) noise levels.

4.1.1 Operator-attended Noise Survey Results – Monitoring Location NM1

Results of the operator-attended noise surveys at NM1 are provided in **Table 4**. Monitoring location NM1 represents residential receptors located to the south of the site. Due to access restrictions noise monitoring was conducted at the entrance to the property.

Table 4 Operator Attended Noise Survey Results – NM1

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L _{Amax}	L _{A1}	L _{A10}	L _{A90}	L _{Aeq}	
Day	19/10/17 12:49 30°C 1 m/s NNW	86	64	44	30	57	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Road traffic 32-86 Insects 32-49 Aeroplane 41 Birdsong 34-51
Evening	19/10/17 21:46 17°C 1 m/s N	40	39	38	36	37	<i>Site related noise events:</i> Duralie Coal Mine: Audible Dumping to 30 Engine noise 25-28 L_{Aeq}(15minute) contribution 26 dBA <i>Other noise events:</i> Road traffic 34-40 Insects 32-37
Night	19/10/17 22:02 16°C 1 m/s NE	41	40	39	36	38	<i>Site related noise events:</i> Duralie Coal Mine: Audible Dumping to 31 Engine noise 25-28 L_{Aeq}(15minute) contribution 27 dBA L_{Amax} contribution 31 dBA <i>Other noise events:</i> Road traffic 34-41 Insects 32-38

DCM overburden haulage and dumping operations were audible during the evening and night-time operator-attended noise surveys at this location.

Noise sources at this location generally included natural noise sources such as birdsong, insects, and wind, as well as transport related noise such as aircraft flyover noise, rail movements and road traffic noise.

4.1.2 Operator-attended Noise Survey Results – Monitoring Location NM2

Results of the operator-attended noise surveys at NM2 are provided in **Table 5**. Monitoring location NM2 represents residential receptors located to the north of the site.

Table 5 Attended Noise Survey Results – NM2

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L _{Amax}	L _{A1}	L _{A10}	L _{A90}	L _{Aeq}	
Day	19/10/17 11:46 25°C 2 m/s N	73	56	49	39	48	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Road traffic 38-73 Birdsong 41-50 Wind in trees 34-48 Aeroplane 42 Insects 35-39
Evening	19/10/17 20:50 17°C 2 m/s NE	55	48	44	38	42	<i>Site related noise events:</i> Duralie Coal Mine: Barely audible Occasional faint engine noise L_{Aeq}(15minute) contribution <28 dBA <i>Other noise events:</i> Road traffic 45-55 Insects 38-46 Dog barking 37 Wind in trees
Night	18/10/17 22:36 18°C 3 m/s NNE	57	52	45	36	42	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Insects 37-43 Wind in trees 36-48 Road traffic 45-57

DCM operations were only barely audible during the operator-attended noise survey conducted during the evening at this location comprising of intermittent haul truck activity. The DCM L_{Aeq}(15minute) noise contribution was estimated to be less than 28 dBA, during the evening operator-attended noise survey. DCM operations were inaudible during the day and night-time operator-attended noise surveys.

The ambient noise environment at the monitoring location during all operator-attended noise surveys was dominated by road traffic noise as well as natural noise sources such as birdsong and insects.

4.1.3 Operator-attended Noise Survey Results – Monitoring Location NM4

Results of the operator-attended noise surveys at NM4 are provided in **Table 6**. NM4 represents residential receptors located to the north of the site.

Table 6 Attended Noise Survey Results – NM4

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L _{Amax}	L _{A1}	L _{A10}	L _{A90}	L _{Aeq}	
Day	19/10/17 11:24 25°C 3 m/s NNW	67	57	51	38	48	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Aeroplane 65 Road traffic 45-67 Insects 32-34 Birdsong 43-60 Wind in trees 34-47
Evening	19/10/17 20:31 17°C 2 m/s NE	76	53	42	37	47	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Insects/frogs 38-52 Wind in trees 39- 43 Road traffic 37-76
Night	18/10/17 22:05 19°C 2 m/s NE	51	48	44	39	42	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Insects 37-45 Road traffic 48-51 Livestock 37-42 Wind in trees 34-41 Aeroplane 39-48

DCM operations were inaudible during all operator-attended noise surveys at this location.

The ambient noise environment at the monitoring location during all operator-attended noise surveys generally consisted of natural noise sources such as wind, insects and birdsong as well as local and distant road traffic.

4.1.4 Operator-attended Noise Survey Results – Monitoring Location NM5

Results of the operator-attended noise surveys at NM5 are provided in **Table 7**. Monitoring location NM5 represents residential receptors located to the west of the site.

Table 7 Attended Noise Survey Results – NM5

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L _{Amax}	L _{A1}	L _{A10}	L _{A90}	L _{Aeq}	
Day	19/10/17 12:13 25°C 2 m/s NNW	58	50	44	34	42	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Road traffic 30-44 Aeroplane 44 Birdsong 43-58 Insects 37-41
Evening	19/10/17 21:13: 17°C 1 m/s NE	52	47	37	31	36	<i>Site related noise events:</i> Duralie Coal Mine: Audible Engine noise 27-32 Dumping 37 L_{Aeq}(15minute) contribution 30 dBA <i>Other noise events:</i> Aeroplane 52 Insects 32-38 Road traffic 30-37 Dog barking 42-45
Night	20/10/17 02:31 16°C Calm	42	35	30	23	28	<i>Site related noise events:</i> Duralie Coal Mine: Barely Audible Engine noise <20 Dumping 23 Dozer tracks 23 L_{Aeq}(15minute) contribution <20 dBA L_{Amax} contribution 23 dBA <i>Other noise events:</i> Road traffic 30-37 Birdsong 28 Insects/frogs 24 Dog barking 34-42 Bats 27

DCM operations were audible during the evening and night period noise surveys at this location. The DCM source identified included engine/mechanical noise, dumping and dozer track slap.

The ambient noise environment at the monitoring location during the daytime period was dominated by natural noise sources and road traffic noise.

The ambient noise environment at the monitoring location during the evening period was dominated by an aeroplane as well as natural noise sources and road traffic noise.

The ambient noise environment at the monitoring location during the night period was dominated by insects and road traffic.

The DCM L_{Aeq}(15minute) noise contribution was estimated to be 30 dBA and less than 20 dBA during the evening and night period, respectively.

During the night-time noise monitoring survey dumping as well as track slap from a dozer resulted in a L_{Amax} noise level of 23 dBA.

4.1.5 Operator-attended Noise Survey Results – Monitoring Location WR1

Results of the operator-attended noise surveys at WR1 are provided in **Table 8**. This location is representative of residential receptors located in Ward Street, Wards River.

Table 8 Attended Noise Survey Results – WR1

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L _{Amax}	L _{A1}	L _{A10}	L _{A90}	L _{Aeq}	
Day	19/10/17 10:58 24°C 2 m/s N	67	52	47	37	44	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Residents 45-67 Road traffic 48-58 Insects 38 Aeroplane 45 Birdsong 38-48 Wind in trees 34-42
Evening	18/10/17 21:35 19°C 2 m/s NE	50	44	42	38	40	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Road traffic 45-50 Insects 38-42 Wind in trees 30
Night	18/10/17 23:01 18°C 2 m/s NNE	51	44	40	37	39	<i>Site related noise events:</i> Duralie Coal Mine: Inaudible <i>Other noise events:</i> Road traffic 47-51 Wind in trees 32-36 Aeroplane 38-42 Bats 34

DCM operations were inaudible during all operator-attended noise surveys at this location. The ambient noise environment at the monitoring location during all operator-attended noise surveys was dominated by road traffic. Other sources included insects, livestock and aircraft flyovers.

4.2 Operator-attended Monitoring – Rail Noise Survey

Duralie Shuttle rail pass-by noise levels are presented in **Table 9**.

Table 9 Operator-attended Rail Noise Monitoring Results

Monitoring Location	Date and Time	L _{Amax} - (dBA)	
		Horn Included	Horn Excluded
TN1	19/10/2017 20:15	94	81
TN2	19/10/2017 10:44	78	76
TN3	20/10/2017 13:23	78	78

Maximum Duralie Shuttle rail pass-by noise levels were below 85 dBA at all monitoring locations, excluding the sounding of horns on approach to level crossings. Maximum noise levels including the sounding of horns exceeded 85 dBA at TN1.

5 PERFORMANCE ASSESSMENT

5.1 Operations

Results of the operator-attended noise measurements compared with the relevant noise criteria contained in the Project Approval and EPL 11701 are given in **Table 10**.

Table 10 Performance Assessment – Operations

Location	Estimated DCM LAeq(15minute) Contribution dBA			Noise Criteria LAeq(15minute) dBA			Compliance		
	Day	Eve	Night	Day	Eve	Night	Day	Eve	Night
NM1	I/A ¹	26	27	35	35	35	Yes	Yes	Yes
NM2 ²	I/A ¹	<28	I/A ¹	35	35	35	Yes	Yes	Yes
NM4	I/A ¹	I/A ¹	I/A ¹	35	35	37	Yes	Yes	Yes
NM5	I/A ¹	30	<20	35	35	35	Yes	Yes	Yes
WR1	I/A ¹	I/A ¹	I/A ¹	35	35	35	Yes	Yes	Yes

1. I/A = Inaudible.

2. Yancoal owned property.

Results presented in **Table 10** indicate that compliance with the relevant criteria was achieved at all operator-attended noise monitoring locations at all time periods.

5.2 Sleep Disturbance

Results of the night period sleep disturbance measurements compared with the relevant noise criteria contained in the Project Approval and EPL 11701 are given in **Table 11**.

Table 11 Performance Assessment – Sleep Disturbance

Location	DCM LA1(1minute) Contribution	Noise Criteria LA1(1minute)	Compliance
NM1	31	45	Yes
NM2 ²	I/A ¹	45	Yes
NM4	I/A ¹	45	Yes
NM5	23	45	Yes
WR1	I/A ¹	45	Yes

1. I/A = Inaudible.

2. Yancoal owned property

Table 11 indicates that compliance with the relevant sleep disturbance noise criteria was achieved at all noise monitoring locations during the night-time noise monitoring period.

5.3 Rail Noise

Maximum Duralie Shuttle rail pass-by noise levels were below 85 dBA at all monitoring locations, excluding the sounding of horns on approach to level crossings.

6 CONCLUSION

SLR was engaged by *Duralie Coal Pty Limited* (DCPL) to conduct quarterly noise monitoring for the Duralie Coal Mine (DCM) guided by the requirements of the *Duralie Coal Mine Noise Management Plan* (NMP), Document No. NMP-R04-A, dated June 2015.

Operator-attended noise monitoring was conducted at five locations between 18 October 2017 and 20 October 2017 in order to determine the noise performance of the DCM operations, has resulted in the following per period assessment of compliance:

- Compliance with the relevant noise criteria was achieved at all noise monitoring locations during the day period.
- Compliance with the relevant noise criteria was achieved at all noise monitoring locations during the evening period.
- Compliance with the relevant noise criteria was achieved at all noise monitoring locations during the night period.

Based on the measured DCM noise contribution compliance with the relevant sleep disturbance noise criteria was achieved at all noise monitoring locations during the night-time noise monitoring period.

Maximum Duralie Shuttle rail pass-by noise levels were below 85 dBA at all monitoring locations, excluding the sounding of horns on approach to level crossings.

ACOUSTIC TERMINOLOGY

1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 “A” Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an “A-weighting” filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A weighting. Sound Levels measured without any weighting are referred to as “linear”, and the units are expressed as dB(lin) or dB.

3 Sound Power Level

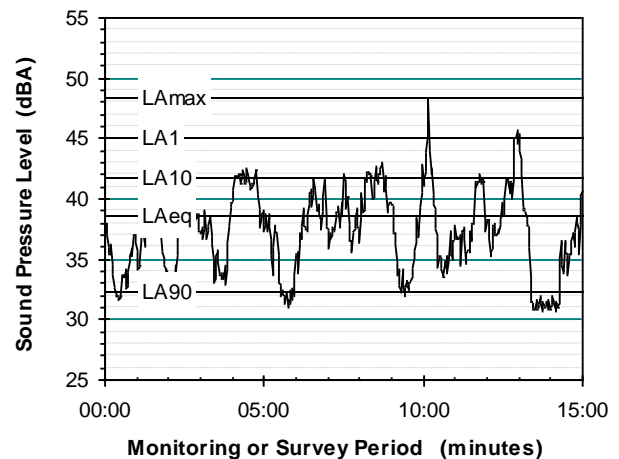
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit $1 \text{E-}12 \text{ W}$.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating the statistical indices.



Of particular relevance, are:

- LA1 The noise level exceeded for 1% of the 15 minute interval.
- LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.
- LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
- LAeq Is the A-weighted equivalent continuous noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.
- LAE The “Sound Exposure Level” which is used to indicate the total acoustic energy of an individual noise event. This parameter is used in the calculation of LAeq values from individual noise events.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

ACOUSTIC TERMINOLOGY

This method produces a level representing the “repeatable minimum” LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (LAeq, LA10 etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

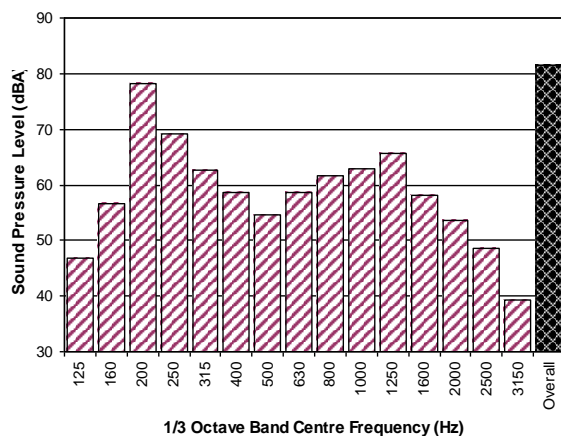
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of “peak” velocity or “rms” velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as “peak particle velocity”, or PPV. The latter incorporate “root mean squared” averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula $20 \log (V/V_0)$, where V_0 is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are used by some organisations.

9 Human Perception of Vibration

People are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual’s perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as “normal” in a car, bus or train is considerably higher than what is perceived as “normal” in a shop, office or dwelling.

10 Overpressure

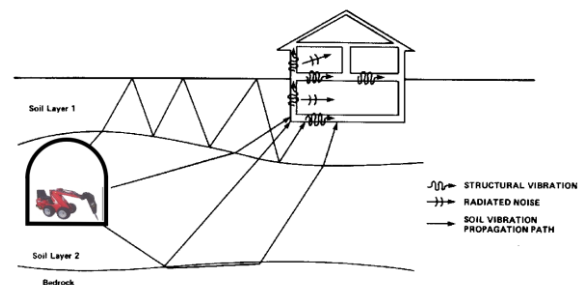
The term “over-pressure” is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed “regenerated noise”, “structure borne noise”, or sometimes “ground-borne noise”. Regenerated noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of regenerated noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and regenerated noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term “regenerated noise” is also used to describe other types of noise that are emitted from the primary source as a different form of energy. One example would be a fan with a silencer, where the fan is the energy source and primary noise source. The silencer may effectively reduce the fan noise, but some additional noise may be created by the aerodynamic effect of the silencer in the airstream. This “secondary” noise may be referred to as regenerated noise.

OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B1 – Day Period – NM1 Operator Attended Noise Survey Results

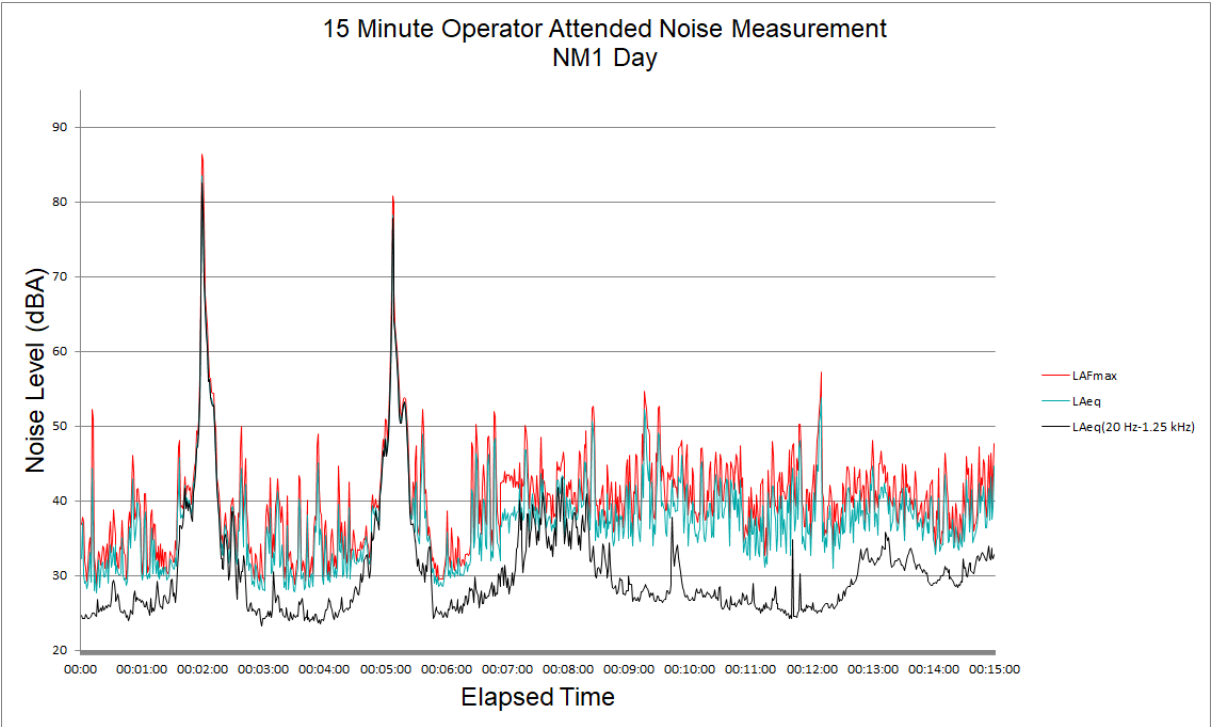
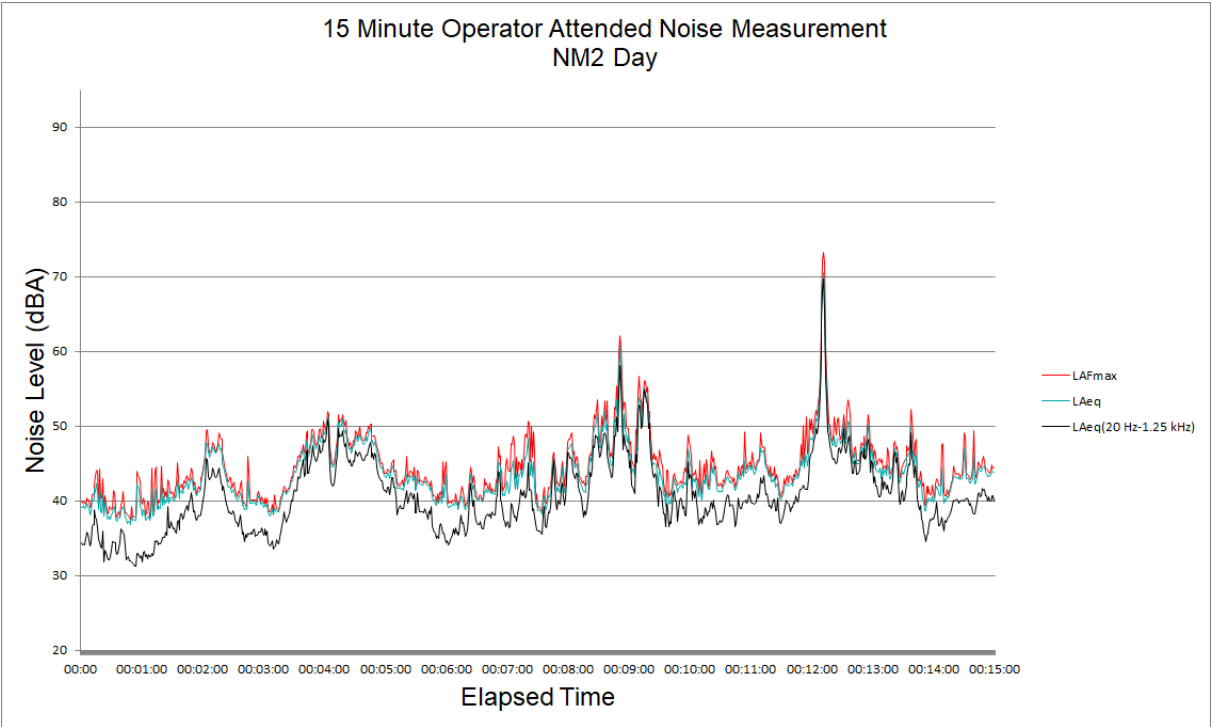


Figure B2 – Day Period – NM2 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B3 – Day Period – NM4 Operator Attended Noise Survey Results

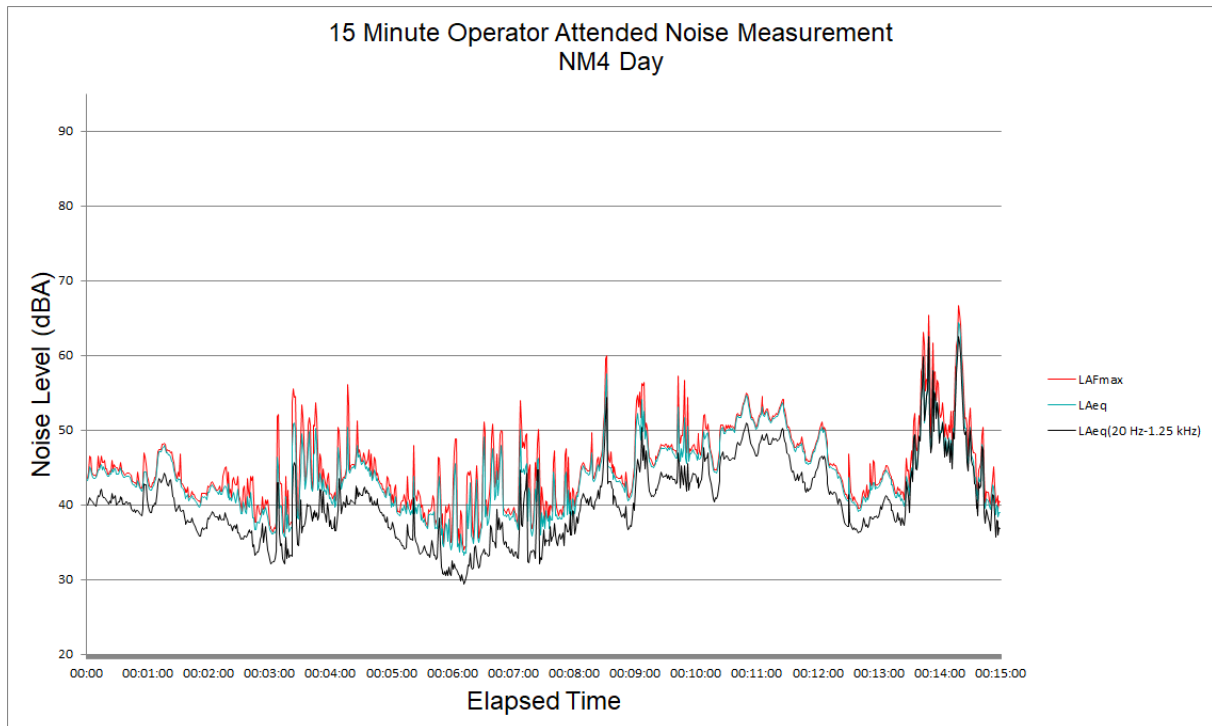
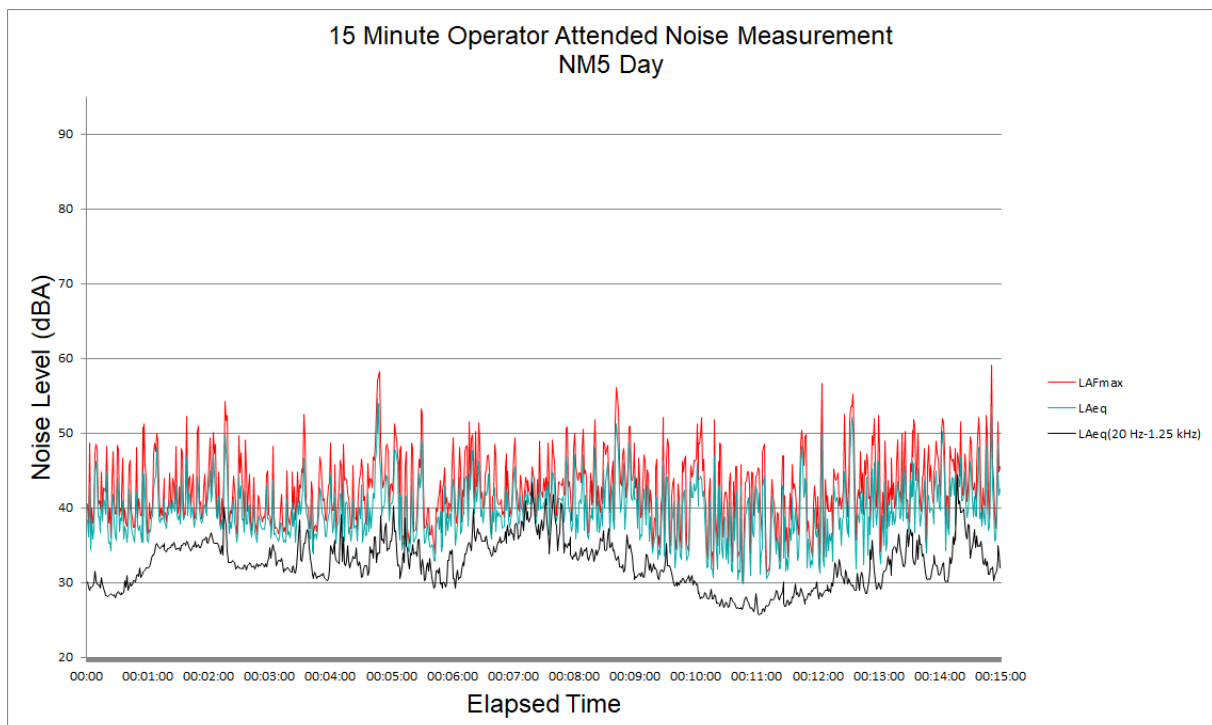


Figure B4 – Day Period – NM5 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B5 – Day Period – WR1 Operator Attended Noise Survey Results

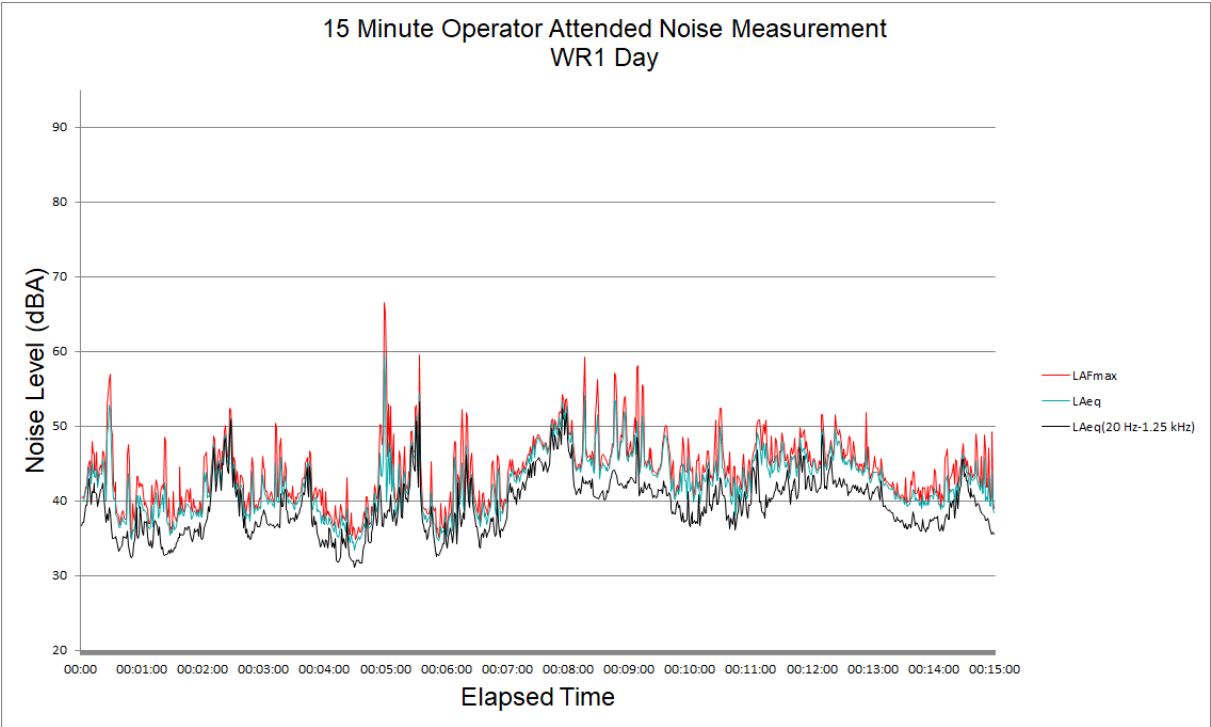
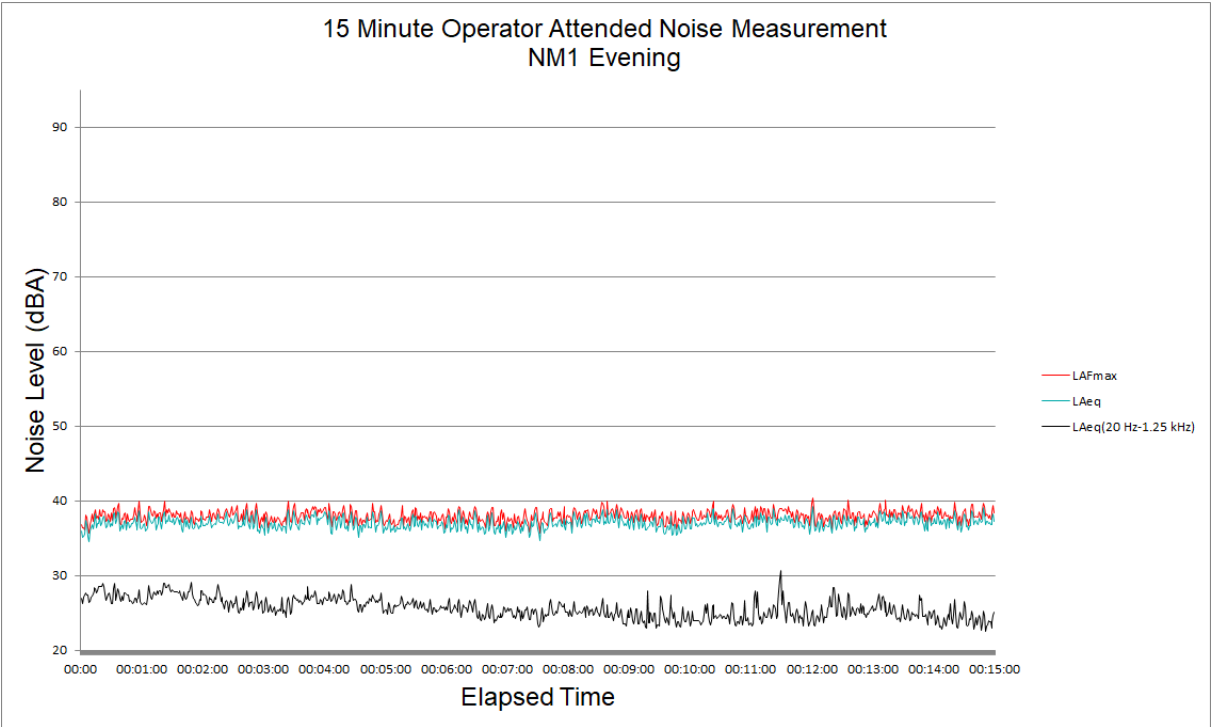


Figure B6 – Evening Period – NM1 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B7 – Evening Period – NM2 Operator Attended Noise Survey Results

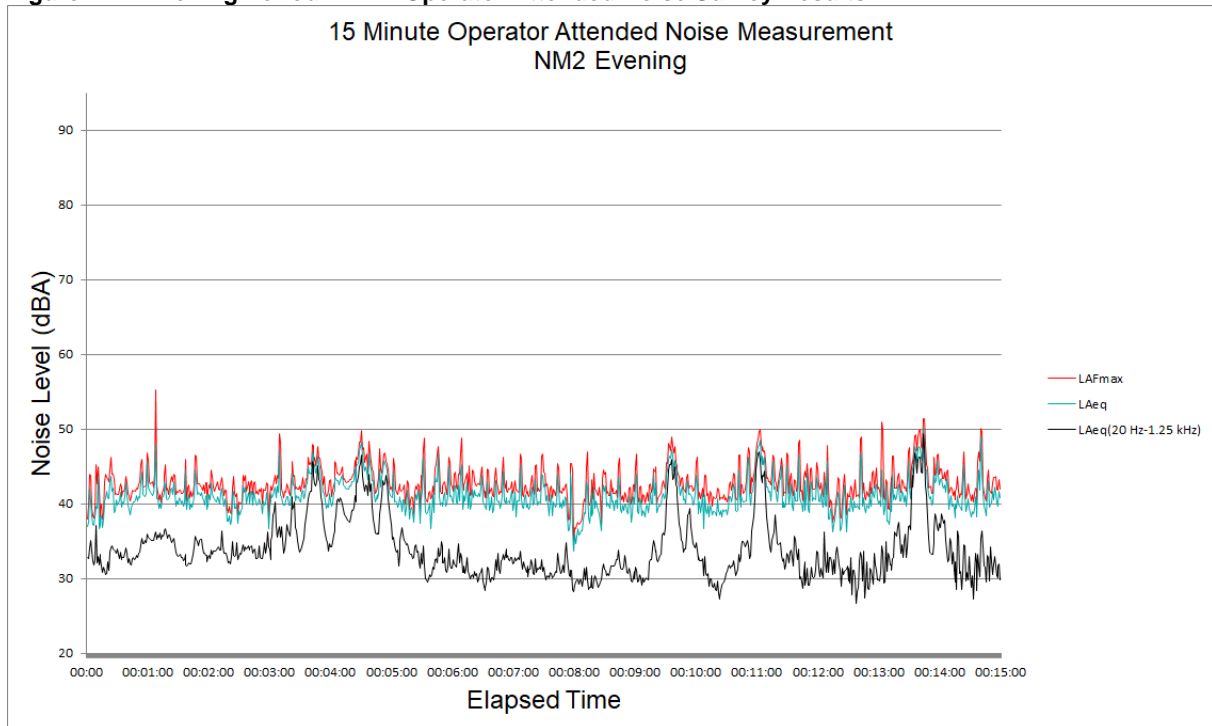
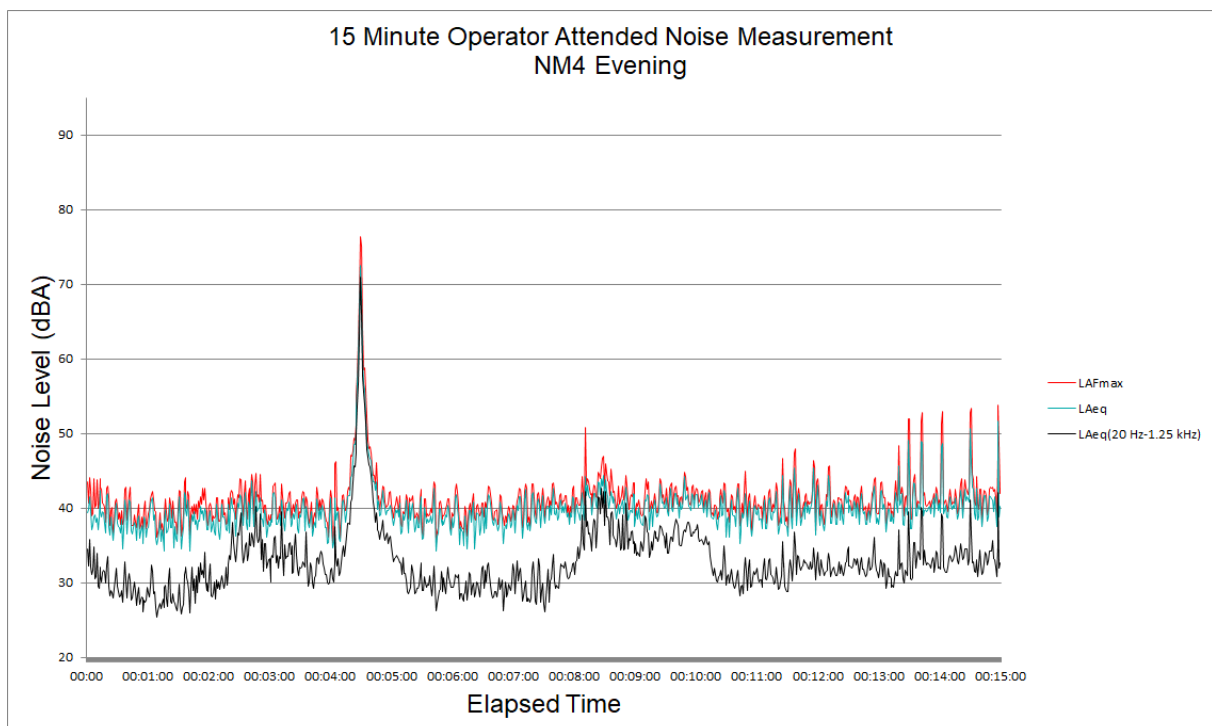


Figure B8 – Evening Period – NM4 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B9 – Evening Period – NM5 Operator Attended Noise Survey Results

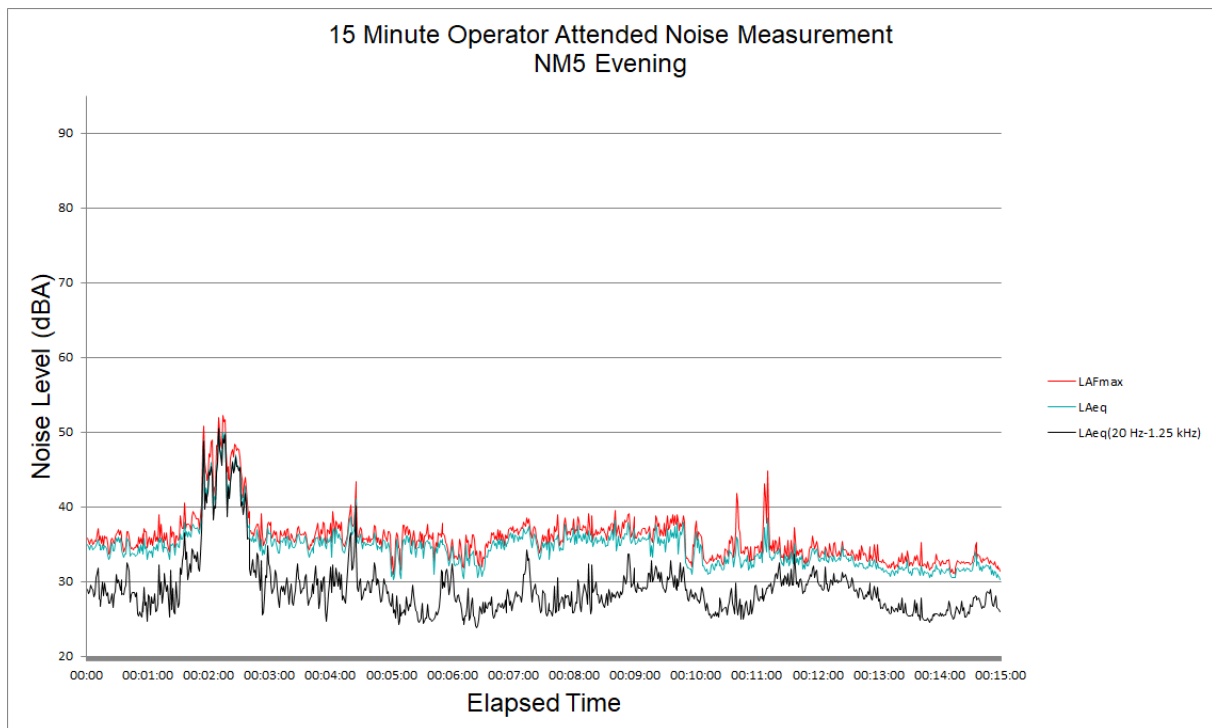
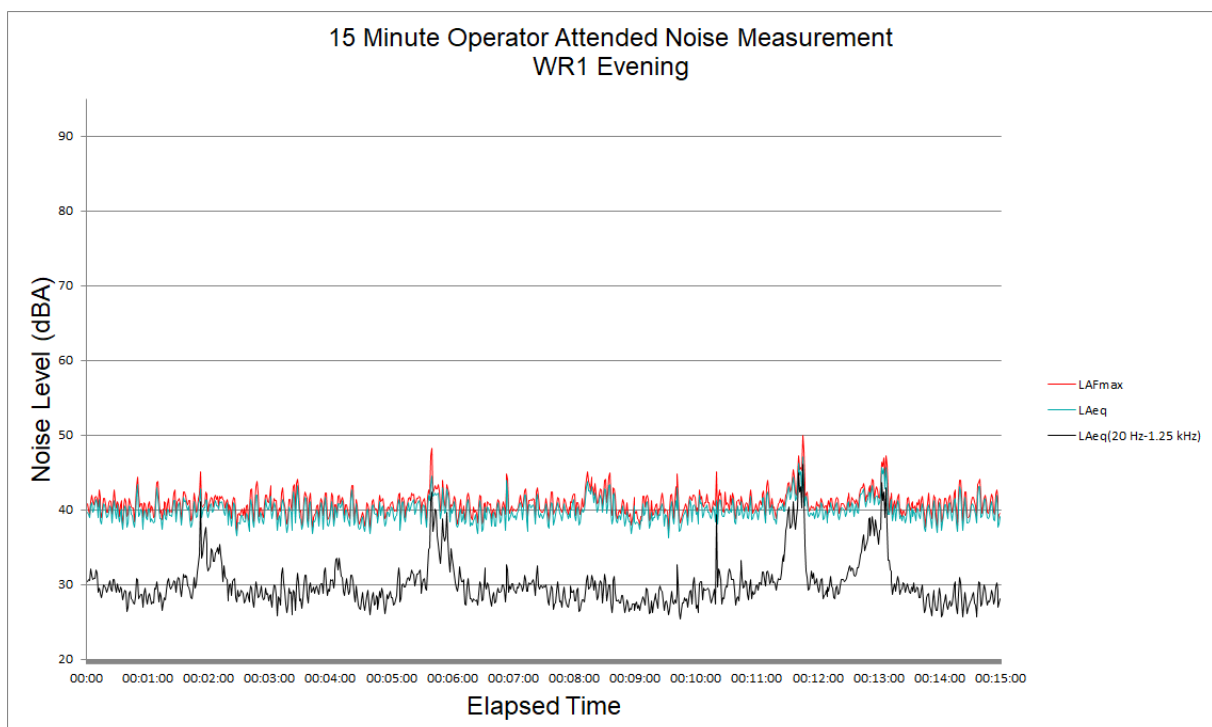


Figure B10 – Evening Period – WR1 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B11 – Night Period – NM1 Operator Attended Noise Survey Results

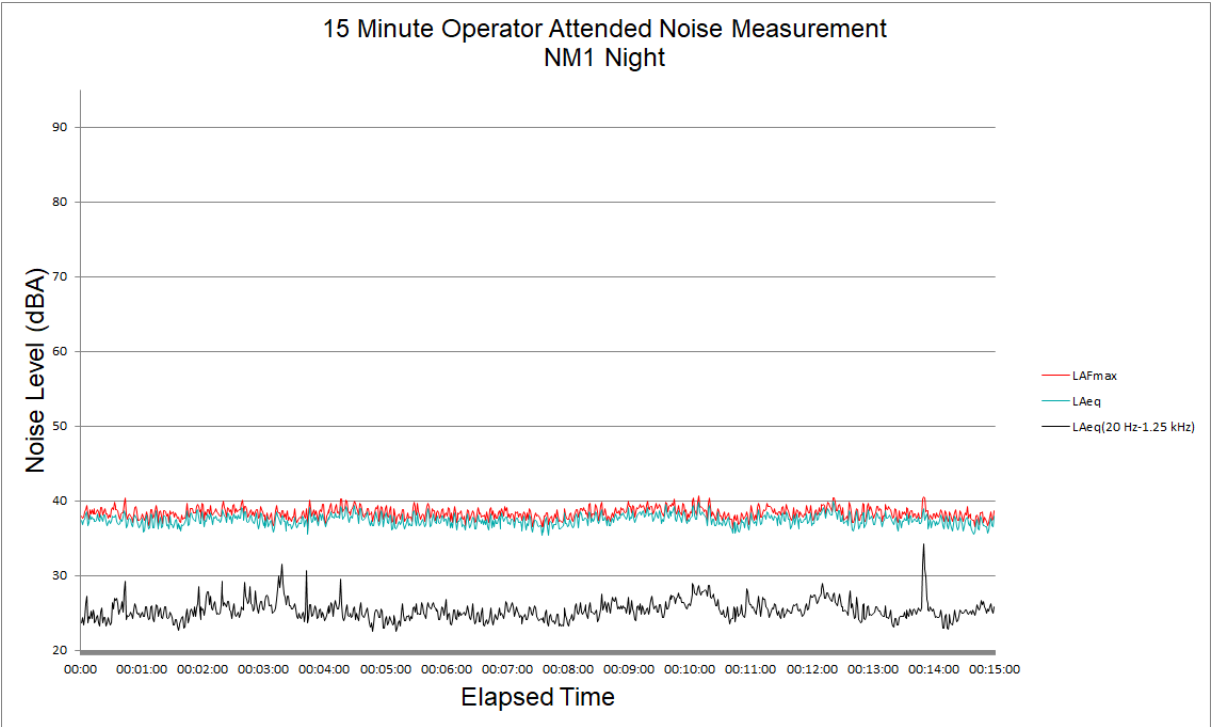
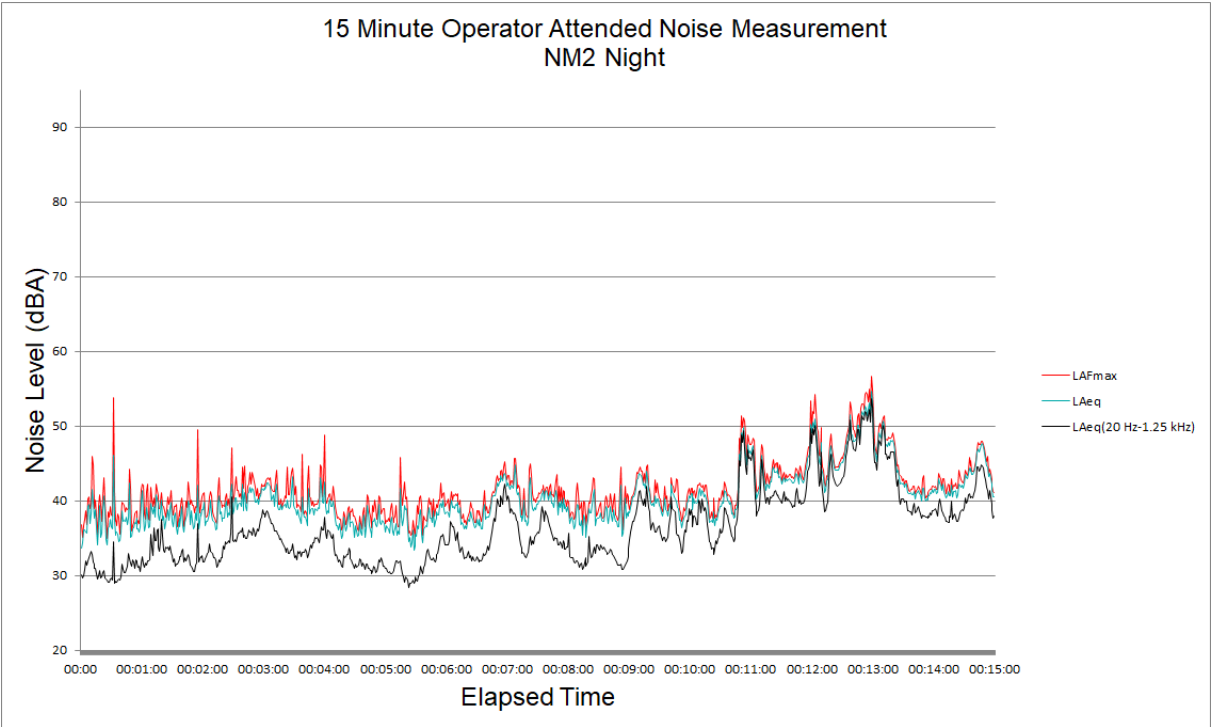


Figure B12 – Night Period – NM2 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B 13 – Night Period – NM4 Operator Attended Noise Survey Results

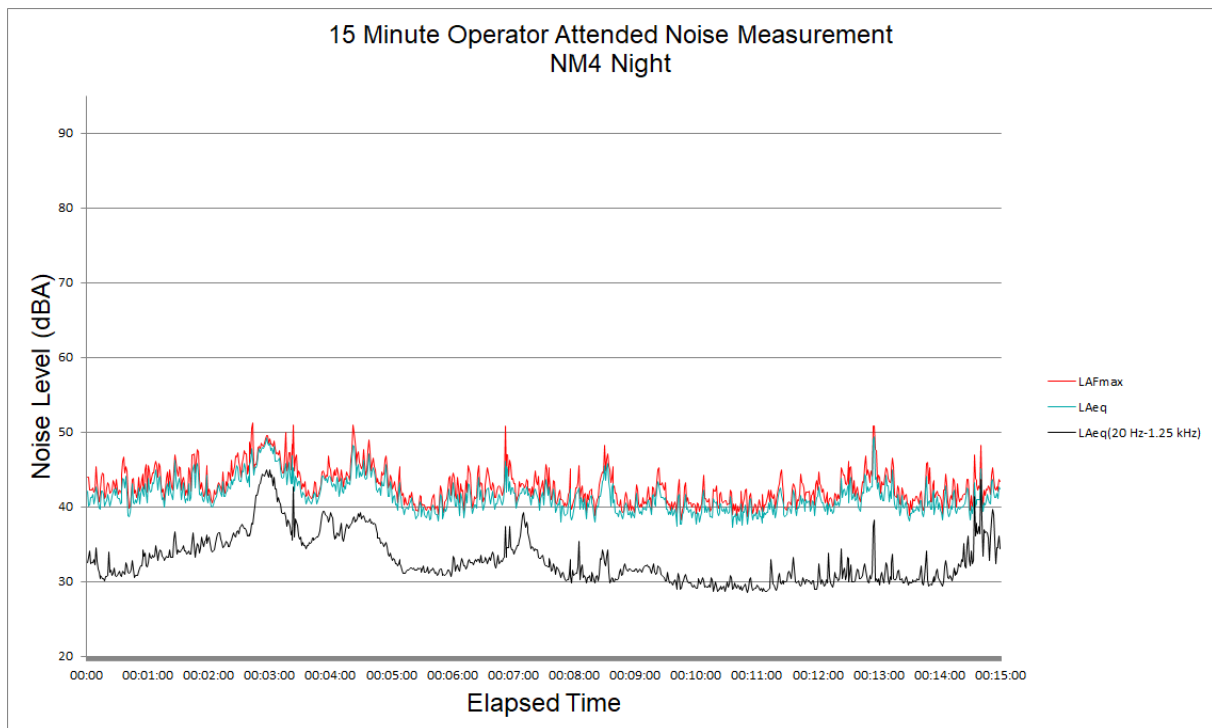
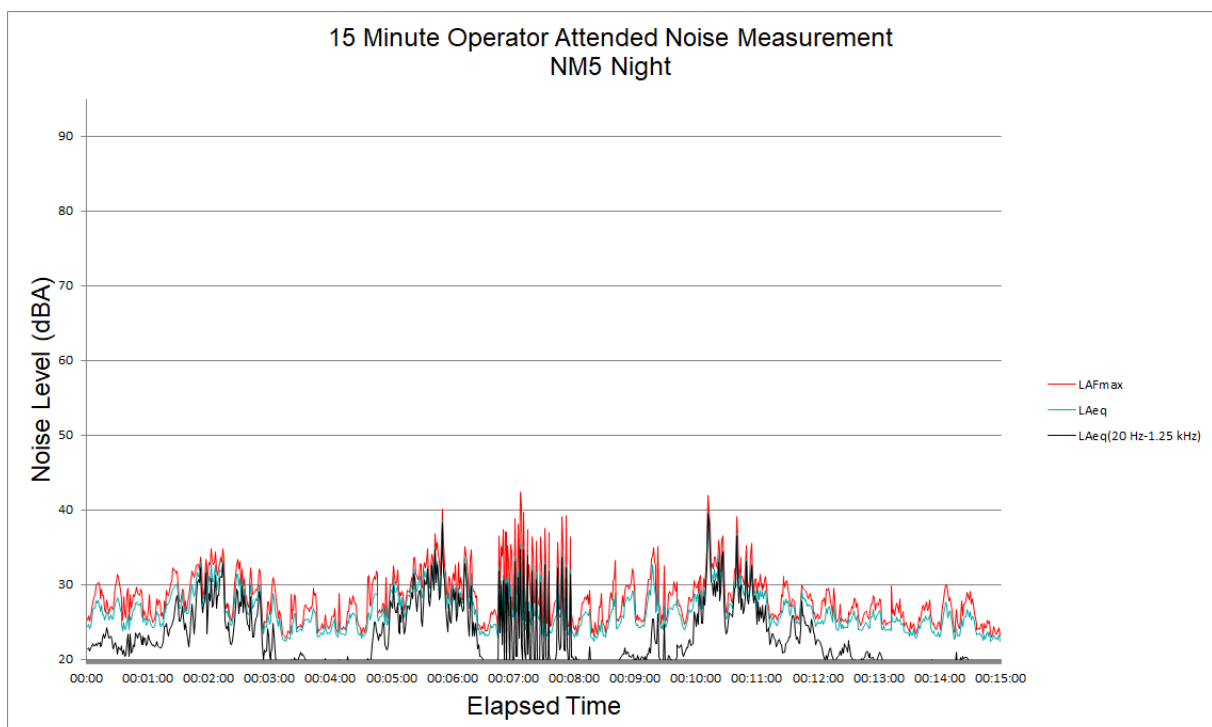


Figure B 14 – Night Period – NM5 Operator Attended Noise Survey Results



OPERATOR ATTENDED NOISE SURVEY CHARTS

Figure B 15 – Night Period – WR1 Operator Attended Noise Survey Results

