PHASE 2 MULGA EAST IRON ORE PROJECT

Noise Monitoring Program
Technical Report

Prepared for:

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c/o Strategen-JBS&G
Level 1, 50 Subiaco Square Rd
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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Hancock Prospecting Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
675.11414-R03-v2.0	29 September 2020	Matt Bruck / Luke Zoontjens	Steven Walker	Jason Shepherd
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EXECUTIVE SUMMARY

The Mulga East Iron Ore Project (the Project) is located within the Mulga Downs pastoral station in the Pilbara region, approximately 260 kilometre (km) from Port Hedland and 250 km from Newman. The Project may involve open cut mining, on-site ore processing, waste storage, workshops, and transport infrastructure, including; railways, access and service roads and an airport.

SLR Consulting Australia Pty Limited (SLR) was engaged to undertake baseline ambient noise monitoring at two monitoring locations around the Project area before any earthworks / construction activities commence. This monitoring was performed to support an application under the *Environmental Protection Act 1986* (the Act), by obtaining ambient sound level data over an extended period (one year). The data will be used to inform and support the environmental studies, since:

- Obtaining such data is considered appropriate to determine the extent of any potential noise impacts on nearby sensitive receptors and terrestrial fauna, and to support the extent of any noise management measures, hours of operation or engineering treatments proposed.
- In the absence of information to the contrary, noise levels in the area are expected to vary significantly due to seasonal weather and the influence of noise sources such as local fauna.

Between 8 May 2019 to 11 May 2020, SLR sited, installed and commissioned the noise monitoring equipment and performed servicing, maintenance and reporting tasks to meet project objectives.

Ambient sound levels recorded by the monitoring program were determined to be linked to ambient weather conditions, distant traffic and local fauna. The ambient sound levels were within Assigned Noise Levels, assigned under the *Environmental Protection (Noise) Regulations 1997*, where weather conditions did not adversely influence the measured noise levels. During specific weather conditions, such as high wind and/or heavy rain, the ambient noise levels were above the night-time Assigned Noise Levels.

This report summarises the monitoring data measured by the noise monitoring program over the 12-month period from 8 May 2019 to 11 May 2020 inclusive. The baseline noise monitoring dataset collected over this period is considered to be suitable to define baseline noise levels in support of an application for approval under the Act.

Suitable construction and/or operational design targets for noise can be developed from the measured baseline noise levels, conditional on the time period, season or live weather conditions.

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1 Introduction

The Mulga East Iron Ore Project (the Project) is located within the Mulga Downs pastoral station in the Pilbara region, approximately 260 km from Port Hedland and 250 km from Newman. The Project may include:

- A series of open cut mine pit voids, some of which will extend below the in-situ water table.
- An onsite ore processing plant, waste rock landforms, waste storage area or tailing storage facility.
- Mining infrastructure including rail load out facility, workshops, access and service roads.
- An accommodation camp and airport.
- A rail spur approximately 50 km in length from the existing Roy Hill Iron Ore rail line.

SLR were engaged to undertake 12 months of baseline ambient noise monitoring at two monitoring locations around the Project area before any earthworks / construction activities commence. Between 8 May 2019 to 11 May 2020, SLR sited, installed and commissioned the noise monitoring equipment at two locations and performed servicing, maintenance and reporting tasks to meet project objectives.

This Technical Report summarises the monitoring data measured by the noise monitoring program over the 12-month period from May 2019 to May 2020.

1.1 Background and Aims

The Project is to be referred under the *Environmental Protection Act 1986* (the Act) for approval, and this process is expected to involve consideration of the potential for unreasonable noise impact on the surrounding environment.

In this regard, a data gap analysis was undertaken by SLR (reference 675.11414-R02-V2.0, dated 20 May 2019). The analysis identified two issues related to noise as follows:

- Lack of previous baseline noise monitoring in the area.
- Lack of details of rail alignment and operations.

Establishing baseline noise levels is beneficial since:

- Obtaining such data is considered appropriate to determine the extent of any potential noise impacts on nearby sensitive receptors and terrestrial fauna, and therefore defend the extent of any noise management measures, hours of operation or engineering treatments proposed.
- In the absence of information to the contrary, noise levels in the area are expected to vary significantly on timescales of the order of 9 to 12 months due to seasonal weather and fauna (refer discussion in 675.11414-R02-V2.0).

Based on the above, the Desktop Data Gap Analysis report recommended baseline noise monitoring for a duration of no more than 12 months at two locations around the Project area in accordance with Australian Standard AS1055 "*Acoustics - Description and measurement of environmental noise*". The exact locations of such monitoring were not specified given the scale of the Project area and as details around the rail alignment and operations were (and still remain) largely unknown.

Therefore, the aim of this study is to establish baseline noise levels to inform and support the environmental assessment anticipated to be required as part of the relevant environmental and planning approval process for the Project.

1.2 Scope

This report provides:

- Background information on the noise and vibration assessment framework for the construction and operation of mining facilities in Western Australia in **Section 2**.
- A summary of the baseline noise monitoring methodology, including equipment used, monitoring locations, sampling periods, calibration and quality review procedures etc in **Section 3**.
- A summary of the data collected (including the meteorological conditions during the baseline monitoring programme) in **Section 4**.
- Demonstration that all required regulatory standards have been met in **Section 5**.
- The findings of the baseline study for input into the noise impact assessment in **Section 6**.

2 Criteria

2.1 Noise Assessment Framework

The following table outlines the noise and vibration assessment framework for construction and operation of mining facilities in Western Australia.

Table 1 Noise and Vibration Assessment Framework

Aspect	Source	Statutory / Government Policy	Australian / International Standards	Industry best practice
Construction noise effects	Airblast overpressure from blasting	EPNR1997[1]	ANZEC guidelines[2]	EPNR1997
	Construction plant and activities within site		AS2107:2016	
Construction vibration effects	Ground-borne vibration (GBV) from blasting	-	ANZEC guidelines	
	Vibration from construction activities (excavation, compaction etc)	-	AS/ISO 2631.2:2014[3] BS 6472:2008	AS 2670.2:1990[4]
Operational environmental noise	Airborne noise from rail operations	SPP5.4[5]	-	SPP5.4 NSW RING[6]
	Vehicle movements on public roads			SPP5.4
	Mining activities Mechanical ventilation plant On site power generation Blasting	EPNR1997 EPA guidance[7]	AS2107:2016[8]	EPNR1997
Operational vibration effects	Ground-borne vibration (GBV) from mining operations	-	ANZEC guidelines	
	Ground-borne vibration (GBV) from rail operations	-	AS/ISO 2631.2:2014 BS 6472:2008 ISO 14837[9]	AS 2670.2:1990 NSW RING NSW DEC Guidelines[10] ASHRAE 2011[11] FTA guidelines[12]

[1] Western Australia Environmental Protection (Noise) Regulations 1997 ("EPNR1997", "The Regulations") as amended.
[2] Australian and New Zealand Environment Council Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration, 1990.
[3] AS ISO 2631.2:2014 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Vibration in buildings (1 Hz to 80 Hz).
[4] Australian Standard AS 2670.2 1990 *"Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)"*.
[5] Western Australia State Planning Policy 5.4, Road and Rail Transport Noise 2019 ("SPP5.4", "The Policy").
[6] New South Wales Rail Infrastructure Noise Guideline, NSW EPA, May 2013.
[7] Environmental Protection Authority, 2016, Environmental Factor Guideline – Social Surroundings, Environmental Protection Authority, 2015, Environmental Assessment Guideline for Environmental principles, factors and objectives (EAG 8).
[8] Australian/New Zealand Standard 2107:2016 'Recommended design levels and reverberation times for building interiors'.
[9] International Standard ISO 14837-1 2005 "*Mechanical vibration - Ground-borne noise and vibration arising from rail systems - Part 1: General guidance*".
[10] Department of Environment and Conservation NSW, "Assessing Vibration: a technical guideline" (2006) http://www.environment.nsw.gov.au/resources/noise/vibrationguide0643.pdf
[11] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 2011, HVAC Applications – SI Edition, Chapter 47.
[12] Federal Transit Administration 2006, Transit Noise and Vibration Impact Assessment, Report FTA-VA-90-1003-06.

Aspect	Source	Statutory / Government Policy	Australian / International Standards	Industry best practice
	Ground-borne noise (GBN) ('regenerated noise') noise from rail operations	-	-	NSW RING

Selected aspects of **Table 1** are further discussed in the following subsections.

2.1.1 Construction Noise Regulations

Construction noise emissions are regulated by the Western Australia *Environmental Protection (Noise) Regulations 1997* (The Regulations), which operate under the *Environmental Protection Act 1986*. Noise from the construction of mining assets falls under Regulation No. 13, *'Construction Sites'*. Depending on application, the Regulations may require a noise management plan (NMP) to be prepared, specific to the proposed activities.

Regulation 13 states, in part, the following (noting that the following criteria are independent of ambient noise levels in the area, but monitoring helps to inform the relative change in noise levels over time):

"13. Construction Sites

(1) In this regulation —

***ancillary measure** means a measure designated to be an ancillary measure under subregulation (7);*

***construction site** means premises or a public place on which the sole or principal activity is the carrying out of construction work;*

***construction work** means —*

(a) the construction, erection, installation, alteration, repair, maintenance, cleaning, painting, renewal, removal, excavation, dismantling or demolition of, or addition to, any building or structure, or any work in connection with any of these things, that is done at or adjacent to the place where the building or structure is located; or

(b) work on which a hoisting appliance or any scaffold or shoring is used; or

(c) work in driving or extracting piles, sheet piles or trench sheet; or

(d) work in laying any pipe or work in lining pipe that is done at or adjacent to the place where the pipe is laid or to be laid; or

(e) work in sinking or lining or altering, repairing, maintaining, renewing, removing, or dismantling a well or borehole; or

(f) reclamation or site works including road works and earth works; or

(g) the removal or reinstatement of vegetation or topsoil for the purpose of or in relation to a mining operation; or

(h) tunnelling.

[..]

(3) Regulation 7 does not apply to noise emitted from a construction site as a result of construction work carried out other than between the hours specified in subregulation (2) if the occupier of the construction site shows that—

(a) the construction work was carried out in accordance with control of environmental noise practices set out in section 4 of AS 2436-2010 Guide to noise and vibration control on construction, maintenance and demolition sites; and

(b) the equipment used on the premises was the quietest reasonably available; and

(c) the construction work was carried out in accordance with a noise management plan, excluding any ancillary measure, in respect of the construction site —

> (i) *prepared and given to the CEO not later than 7 days before the construction work commenced; and*
>
> (ii) *approved by the CEO; the equipment used to carry out the works is the quietest reasonably available; and*
>
> (d) *at least 24 hours before the construction work commenced, the occupier of the construction site gave written notice of the proposed construction work to the occupiers of all premises at which noise emissions received were likely to fail to comply with the standard prescribed under regulation 7; and*
>
> (e) *it was reasonably necessary for the construction work to be carried out at that time.*
>
> ***[..]***
>
> (6) *A noise management plan prepared under subregulation (3)(c), (4) or (5A) is to include, but is not limited to —*
>
> (a) *details of, and reasons for, construction work on the construction site; and*
>
> (b) *details of, and the duration of, activities on the construction site likely to result in noise emissions that fail to comply with the standard prescribed under regulation 7; and*
>
> (c) *predictions of noise emissions on the construction site; and*
>
> (d) *details of measures to be implemented to control noise (including vibration) emissions; and*
>
> (e) *procedures to be adopted for monitoring noise (including vibration) emissions; and*
>
> (f) *complaint response procedures to be adopted.*
>
> ***[..]"***

From the above, the assigned noise levels do not apply to construction sites where the proponent:

1. Demonstrates that the construction work is carried out in accordance with section 4 of AS 2436-2010.
2. Uses the quietest reasonably available equipment.
3. Prepares and supplies the relevant authority with a Noise Management Plan (NMP) no later than 7 days before the proposed works.
4. Provides notice to potentially affected residents at least 24 hours prior the start of the proposed works.
5. Provides reasonable justification for the works to take place outside standard hours.

Generally, NMPs must include:

1. Details of the construction site.
2. Details of the planned activities and duration.
3. Predictions of noise emissions.
4. Recommended mitigation measures.
5. Noise and/or vibration monitoring requirements.
6. Complaint response and management procedures.

2.1.2 Blasting

Blasting is covered by Regulation 11 (Airblast levels due to blasting), which in part states that:

> (4) *Subject to subregulation (5), no airblast level resulting from blasting on any premises or public place, when received at any other premises between 0700 hours and 1800 hours on any day, may exceed —*
>
> (a) *for an airblast level received at noise sensitive premises —*

(i) when received at a sensitive site — 120 dB LZ peak; or

(ii) when received at a location other than a sensitive site — 125 dB LZ peak; or

(b) for an airblast level received at any other premises — 125 dB LZ peak.

(5) The levels specified in subregulation (4) do not apply in respect of an airblast level when received at premises, or a part of premises, on which the blaster believes on reasonable grounds no person is present at the time of the blast.

(6 Despite subregulation (4), airblast levels for 9 in any 10 consecutive blasts (regardless of the interval between each blast), when received at any other single premises between 0700 hours and 1800 hours on any day, must not exceed —

(a) for airblast levels received at noise sensitive premises —

(i) when received at a sensitive site — 115 dB LZ peak; or

(ii) when received at a location other than a sensitive site — 120 dB LZ peak; or

(b) for airblast levels received at any other premises — 120 dB LZ peak.

[..]

(8) Subject to subregulation (9), no airblast level resulting from blasting on any premises or public place, when received at other premises outside the periods between 0700 hours and 1800 hours on any day, may exceed 90 dB LZ peak except where that blasting is carried out in accordance with the Mines Safety and Inspection Regulations 1995 regulation 8.28(4).

(9) The level specified in subregulation (8) does not apply in respect of an airblast level when received at premises, or a part of premises, on which the blaster believes on reasonable grounds no person is present at the time of the blast.

(10) Where blasting is carried out in accordance with the Mines Safety and Inspection Regulations 1995 regulation 8.28(4) outside the periods between 0700 hours and 1800 hours on any day —

(a) the blasting is taken to be carried out between 0700 hours and 1800 hours; and

(b) subregulations (4), (5), (6) and (7) apply accordingly.

2.1.3 Operational Noise Regulations

Noise emissions from mining operations are covered by the Regulations. Generally, to achieve compliance with the Regulations, the noise levels at nearby residential areas[13] are not to exceed defined limits (Assigned Noise Levels, or simply, assigned levels).

A summary of the applicable noise limits is provided in **Table 2**. From this table it can be seen that the Regulations adopt three noise metrics to quantify the noise limits. The 'L_{A10}' assigned noise level (level exceeded more than 10% of the time) is used to assess noise from continuous operation mining facilities.

The assigned levels are determined from consideration of prevailing background noise levels and 'influencing factors' (IFs) that consider the level of commercial and industrial zoning in the locality. The influencing factor takes into account zoning and road traffic around each noise sensitive receiver of interest, within a 100 m and 450 m radius.

For the Project area, the IF is expected to be zero, so the typical Assigned Noise Level would be L_{A10} 35 dB at night, and up to L_{A10} 45 dB at other times, except Sundays and evenings where it is L_{A10} 40 dB.

[13] The nearest sensitive receivers at present are considered to be more than 10 km away, in a southeasterly direction.

Under the Regulations, if noise emitted from any premises, when received at any other premises, cannot reasonably be free of intrusive characteristics of tonality, modulation and impulsiveness, a series of adjustments are added to the emitted levels (measured or calculated) and the adjusted level must comply with the assigned level. These adjustments are detailed in **Table 3** and are further defined in Regulation 9(1) of the Regulations.

Table 2 Assigned Noise Levels Summary

Part of premises receiver noise	Time of day	Assigned level, dBA		
		L_{A10}	L_{A1}	L_{Amax}
Noise Sensitive premises at locations within 15 m of a building directly associated with a noise sensitive use	7.00 am to 7.00 pm Monday to Saturday ('Day')	45 + IF	55 + IF	65 + IF
	9.00 am to 7.00 pm Sunday and public holidays ('Sundays')	40 + IF	50 + IF	65 + IF
	7.00 pm to 10.00 pm all days ('Evening')	40 + IF	50 + IF	55 + IF
	10.00 pm on any day to 7.00 am Monday to Saturday and 9.00 am Sunday and public holidays ('Night')	35 + IF	45 + IF	55 + IF
Noise Sensitive premises at location further than 15 m from a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	65	75	80
Industrial and utility premises	All hours	65	80	90

Table 3 Definition of Noise Characteristics

Noise characteristic	Definition	Adjustment if present (Note[1])
Tones	Where the difference between the A weighted sound pressure level in any one third octave ban and the arithmetic average of the A weighted sound pressure levels in the two adjacent one third octave bands is greater than 3 dB in terms of $L_{Aeq,T}$ 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_{ASlow} levels.	+5 dB
Modulation	A variation in the emission of noise that – • Is more than 3 dB LAFast or is more than 3 dB LAFast in any one third octave band; • Is present for at least 10% of the representative assessment period; and, • Is regular, cyclic and audible.	+5 dB
Impulsiveness	Present where the difference between the L_{APeak} and L_{Amax} is more than 15 dB when determined for single representative event.	+10 dB

Note 1 where noise emission is not music, these adjustments are cumulative to a maximum of 15 dB.

2.2 Noise and Vibration Impacts on Fauna

2.2.1 Introduction

While noise impacts on people are commonly regulated, there are no state policies or other widely accepted guidelines relating to noise levels or thresholds at which there would be an adverse effect on fauna.

One reason for the lack of guidelines is that noise effects on most wildlife species are poorly understood (Larkin *et al.* 1996[14], Brown 2001[15]; OSB 2003[16]. The lack of understanding of noise effects on wildlife is understandable when the following points are considered:

- Response to noise disturbance cannot be generalised across species or among genera. Studies of one species cannot be extrapolated to other species.
- Hearing characteristics are species-specific. For example, noise impacts on humans are determined using a frequency weighting filter (A-weighting) that corresponds to human hearing characteristics, as determined through laboratory testing. The frequency-dependent hearing characteristics of animals cannot be determined in this way.
- When studying noise effects on animals, it can be difficult to separate noise effects from other sensory disturbing effects (e.g. visual or olfactory cues).
- Experimental research in a laboratory is not always applicable in a natural setting.

As with humans, an animal's response to noise can depend on a variety of factors, including noise level, frequency distribution, duration, number of events, variation over time, rate of onset, noise type, existence and level of ambient noise, time of year, and time of day. The animal's location, age, sex, and past experience may also affect their response to noise.

Despite the difficulties associated with assessing noise impacts on animals, studies have been done that can assist in drawing some general conclusions. Relevant literature has been collated in a number of reviews including AMEC 2005[17]) (noise from mining operations), Dawe and Goosem 2008[18] (road traffic noise impacts, an Australian study), Manci *et al.* 1988[19] (effect of aircraft noise and sonic booms), and US FHA 2004 (road traffic noise impacts).

Some key findings of these reviews are summarised in the following subsections, noting that they are general in nature and not specific to the Project area.

2.2.2 Mammals

Manci *et al.* state that:

[14] Larkin, R.P., D. Margoliash, J.A. Kogan (1996) Recognition of the utterances of terrestrial wildlife: a new approach. The Journal of the Acoustical Society of America, 99(4 pt. 2): 2532.
[15] Brown, L. (2001) Overview of research on the effects of noise on wildlife in Proceedings of the Effects of Noise on Wildlife Conference, Happy Valley-Goose Bay, Labrador.
[16] Ocean Studies Board (OSB) (2003). Ocean Noise and Marine Mammals. National Research Council, Division on Earth and Life Studies. The National Academies Press, Washington, DC.
[17] AMEC Americas Limited (July 2005) Mackenzie Gas Project Effects of Noise on Wildlife prepared for Imperial Oil Resources Ventures Limited.
[18] Dawe, G. and M. Goosem (2008) *Noise Disturbance along Highways: Kuranda Range Road Upgrade Project.* Report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Limited, Cairns (157pp.).
[19] Manci, K.M., D.N. Gladwin, R. Villella, and M.G. Cavendish (1988) Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. U.S. Fish and Wildlife Service. National Ecology Research Center, Ft. Collins, CO. NERC-88/29. 88 pp.

> *"Sound levels above about 90 dB are likely to be adversive to mammals and are associated with a number of behaviours such as retreat from the sound source, freezing, or a strong startle response. Sound levels below about 90 dB usually cause much less adversive behavior. Laboratory studies of domestic mammals have indicated that behavioural responses vary with noise types and levels, and that domestic animals appear to acclimate to some sound disturbances."*

The US FHA review notes that some mammals avoid roads, and that in some cases this avoidance behaviour has been attributed to noise.

2.2.3 Birds

Measurements of absolute auditory sensitivity in a wide variety of bird species show a region of maximum sensitivity between 1 and 5 kHz, with a rapid decrease in sensitivity at higher frequencies. The data suggests that in this frequency range, birds show a level of hearing sensitivity that is similar in most respects to that found for the most sensitive mammals, with avian performance clearly inferior above and below this range of frequencies (Manci *et al.*).

The general conclusion of the US FHA review is that some (although not all) bird species are sensitive to road traffic noise at least during breeding and that the distances over which this effect is seen can vary considerably, from a few meters to more than 3 km away. Reduced bird diversity and density of bird life near to roads, is in some cases associated with average noise levels above L_{Aeq} 50 dB. Dawe and Goosem state that:

> *"Anthropogenic noise can also trigger flight and alert responses in birds and altered behaviour after the noise disturbance, which can lead to reduced breeding success, at noise levels ranging from 65-85 dB(A). Complete habituation to such disturbance does not always occur, even in less noise-sensitive species."*

2.2.4 Reptiles

Sound perception appears to be subordinate in importance to vision or chemoreception in the activities of most reptiles, but studies have shown that certain desert reptiles are sensitive to low-intensity sound (Manci *et al.*). Noise may be of more adaptive significance for nocturnal species because full use cannot be made of vision. Critical environmental sounds are often of relatively low intensity (e.g. the movement of insect prey and predators such as snakes and owls).

Some studies reviewed by Manci *et al.* indicate hearing damage to some lizard species after exposure to steady noise levels above L_{Aeq} 95 dB.

2.2.5 Invertebrates

Manci *et al.* describe several studies on the effects of noise on insects. In some cases, noise has been studied with a view to controlling pest insects such as meal-moths and flour beetles, with some success in reducing hatching from the larval stage. Some studies have shown reduced lifespan in insects exposed to noise, and reduced number of eggs produced by females.

Some insects (including bees) stop moving when exposed to high noise levels. Honey bees ceased moving for up to 20 minutes in response to frequencies between 200 and 2,000 Hz, with intensities varying from 107-119 dB and did not appear to habituate to the sound (Manci *et al.*).

2.2.6 Conclusions

A review of the literature indicates that there are no specific government policies or industry guidelines regarding what noise or vibration levels may be appropriate to minimise impacts to wildlife and fauna, and to preserve the health and biodiversity of ecosystems.

It is clear that noise can have adverse effects on wildlife, with different species being more or less sensitive to noise. As with humans, extremely high noise levels can result in hearing damage or other physiological effects.

On the basis of the literature and noting the difficulties inherent in assessing noise impacts on fauna described, long-term adverse impacts on fauna are unlikely to arise from short duration, high noise events. These events may however result in a short-term startle response. The threshold of hearing damage is likely to be species and frequency dependent, and as with humans, damage may be cumulative over time.

At lower noise levels, the literature provides many studies that outline various mechanisms by which various species may potentially be affected by noise, such as physical damage to hearing, increased energy expenditure or physical injury while responding to noise, interference with normal animal activities and impaired communication. Ongoing impacts of these effects might include habitat loss through avoidance, reduced reproductive success and increased mortality.

Whilst there are no robust guidelines directly addressing what levels would be appropriate, the establishment of existing baseline noise levels around the Project area helps indicate where the sound environment may be modified as a result of the Project.

3 Monitoring Method

3.1 Monitoring Locations

In consultation with Strategen-JBS&G, SLR deployed two temporary environmental noise monitoring stations. The noise monitors were deployed in accordance with AS1055 at a height of 1.5 m above ground, with power supplied from a connected solar panel and weather protected heavy duty battery. The noise monitors have a typical background A-weighted noise floor of L_{pA} 16 dB. The noise monitors were protected from disturbance through the use of temporary fencing.

One noise monitor (Mulga A) was positioned in the central section of the Project area, whilst the other noise monitor (Mulga B) was positioned in the eastern section. **Table 4** and **Figure 1** provide further details on the noise monitoring locations.

Figure 1 Indicative Locations of Noise Monitors


East Campsite
Noise Monitor A
Noise Monitor B
Auski Tourist Village
0
30 km

Table 4 Noise Monitor Location Information

Parameter	Mulga A	Mulga B
Photo (at June 11, 2020)		
ID	MULGA_A	MULGA_B
Make / Model	01DB DUO	01DB DUO
Serial number	12649	12669
Location (refer **Figure 1**)	656,948 m E; 7,554,623 m S	673,722 m E; 7,548,569 m S
Location Description	75 m east of T-junction near Mulga East camp, 400 m due south of camp	Near eastern boundary of tenement at elevated position on hill. Turnoff is adjacent to a turn left sign facing eastbound traffic.
System (external third party) calibration date	11 January 2019 Next due 11 January 2021	21 November 2018 Next due 21 November 2020

3.2 Description of Measurements

The noise monitoring was conducted in accordance with Australian Standard AS1055, using a 15-minute time sampling interval.

3.2.1 Calibration

The noise monitors were calibrated using a NATA accredited calibrator upon installation (May 2019) and confirmed in June 2020 to be within 0.5 dB of initial calibration in line with AS 1055 requirements. The units were set to undertake internal electrical calibration on a monthly basis and they did not report any faults during the reporting period.

3.2.2 Noise Descriptors Measured

Third octave band L_{Aeq} and L_{Zeq} results were obtained with alignment to averaged weather results available in 15-minute samples. These results were then reviewed in terms of their statistical occurrence.

3.2.3 QA/QC Procedure

Traceability of the results is maintained through the calibration details logged in each noise monitor, and GPS information confirming the units were not relocated during the survey period.

3.3 Uncertainty of Measurement

The expected level of system measurement uncertainty (as estimated according to the ISO Guide to Measurement Uncertainty) is outlined in **Table 5**.

Table 5 Estimated Measurement Uncertainty by System

Parameter	System	U_{95} (Note [1])	Student's t-factor
Airborne noise L_{Aeq}, L_{A10}, L_{A1}	01dB DUO	0.8 dB	2.00

Note [1] The U_{95} is the expanded uncertainty of measurement for a 95% confidence interval. It represents the estimated range in which the true value lies for 95 out of 100 repeated events.

4 Summary of Monitoring Data

4.1 Coverage

Table 6 presents the number of days with data in each monitoring period. Data was captured continuously through to mid-November, after which data coverage is sporadic or missing until the end of May 2020.

Table 6 Summary of Noise Data Coverage Per Month

Month	Days of coverage		Comment
	Mulga A	Mulga B	
May, 2019	23	23	Deployed on 8 May
June, 2019	30	30	-
July, 2019	31	31	-
August, 2019	31	31	-
September, 2019	30	30	-
October, 2019	31	31	-
November, 2019	30	18	Lost power to Mulga B on 18 November, suspected due to solar panel regulator failure in extreme temperature and solar loading
December, 2019	31	0	Mulga B still unpowered
January, 2020	15	0	Lost power to Mulga A on 15 January due to high air temperatures damaging solar panel. Mulga B still unpowered
Feb-March, 2020	8	7	Intermittent / reduced operation with battery changes.
Apr-May, 2020	3	0	
Total for period	**263**	**201**	-

4.2 Summary of Results

The noise monitoring data collected at the two locations are summarised in the following subsections. The monthly results are presented graphically in **Appendix B**.

4.2.1 Meteorological Data

A graphical summary of the meteorological data sourced from the automatic weather station (AWS) operated by the Bureau of Meteorology (BoM) at Karijini North (station 05098) is provided in **Appendix C**. Note Karijini North replaced Wittenoom AWS (station 05026) when it was closed in 2019.

4.2.2 Minimum 15-Minute Period Levels

Table 7 presents the minimum daytime (7.00 am–7.00 pm), evening (7.00 pm–10.00 pm) and night-time (10.00 pm–7.00 am) period $L_{Aeq,15min}$ noise levels recorded by the two noise monitors for the entire monitoring period.

Table 7 Summary of Day, Evening and Night L_{amin} Noise Levels

Month	Minima, day		Minima, evening		Minima, night	
	Mulga A	Mulga B	Mulga A	Mulga B	Mulga A	Mulga B
May, 2019	27	21	27	17	24	16
June, 2019	24	20	25	18	24	16
July, 2019	25	20	24	17	23	16
August, 2019	24	20	26	18	23	16
September, 2019	22	18	27	16	24	16
October, 2019	21	17	27	20	22	16
November, 2019	22	17	27	18	23	16
December, 2019	24	-	30	-	21	-
January, 2020	30	-	33	-	27	-
Feb-Mar, 2020	24	22	33	31	34	26
Apr-May, 2020	21	-	34	18	27	-

4.2.3 Typical Background 15-Minute Period Levels

Table 8 presents the typical background daytime (7.00 am–7.00 pm), evening (7.00 pm–10.00 pm) and night-time (10.00 pm–7.00 am) period $L_{Aeq,15min}$ noise levels over the monitoring period. From this table, the background levels at Mulga A are higher and this is largely attributed due to the camp, which is located around 450 m away.

Table 8 Summary of Day, Evening and Night 90th Percentile $L_{Aeq,15min}$ Noise Levels

Month	L90, day		L90, evening		L90, night	
	Mulga A	Mulga B	Mulga A	Mulga B	Mulga A	Mulga B
May, 2019	30	24	27	17	27	17
June, 2019	28	23	26	18	26	17
July, 2019	27	23	25	17	25	17
August, 2019	28	23	27	18	26	17
September, 2019	27	22	28	17	26	16
October, 2019	25	20	28	22	25	16
November, 2019	26	21	28	19	25	16
December, 2019	26	-	32	-	27	-
January, 2020	33	-	35	-	32	-
Feb-Mar, 2020	26	26	34	35	32	32
Apr-May, 2020	26	-	27	-	-	-

4.2.4 Median 15-Minute Period Levels

Table 9 presents the average daytime (7.00 am–7.00 pm), evening (7.00 pm–10.00 pm) and night-time (10.00 pm–7.00 am) period L_{Aeq} noise levels over the monitoring period.

Table 9 Summary of Day, Evening and Night Median L_{aeq} Noise Levels

Month	Median, day		Median, evening		Median, night	
	Mulga A	Mulga B	Mulga A	Mulga B	Mulga A	Mulga B
May, 2019	36	33	30	20	29	21
June, 2019	36	36	29	22	24	22
July, 2019	35	34	28	34	25	20
August, 2019	36	36	28	23	24	22
September, 2019	36	34	28	22	22	20
October, 2019	35	34	28	29	21	21
November, 2019	37	36	29	29	23	20
December, 2019	37	-	30	-	24	-
January, 2020	39	14	35	-	30	-
Feb-Mar, 2020	31	37	36	46	24	34
Apr-May, 2020	28	-	-	-	21	-

4.2.5 10th Percentile 15-Minute Period Levels

Table 10 presents the average daytime (7.00 am–7.00 pm), evening (7.00 pm–10.00 pm) and night-time (10.00 pm–7.00 am) period 10th percentile $L_{Aeq,15min}$ noise levels over the monitoring period.

Table 10 Summary of Day, Evening and Night L_{A10} Noise Levels

Month	L10, day		L10, evening		L10, night	
	Mulga A	Mulga B	Mulga A	Mulga B	Mulga A	Mulga B
May, 2019	42	41	33	24	32	26
June, 2019	43	46	31	28	33	28
July, 2019	41	43	33	25	31	26
August, 2019	43	46	33	30	31	27
September, 2019	43	45	35	30	31	25
October, 2019	44	47	39	37	32	31
November, 2019	43	46	36	33	31	27
December, 2019	45	-	45	-	38	-
January, 2020	46	42	44	-	43	-
Feb-Mar, 2020	44	56	41	57	43	46
Apr-May, 2020	42	42	-	-	37	19

4.2.6 Maximum 15-Minute Period Levels

Table 11 presents the maximum daytime (7.00 am–7.00 pm), evening (7.00 pm–10.00 pm) and night-time (10.00 pm–7.00 am) period $L_{Aeq,15min}$ noise levels recorded by the two noise monitors for the entire monitoring period.

Table 11 Summary of Day, Evening and Night Max $L_{aeq,15min}$ Noise Levels

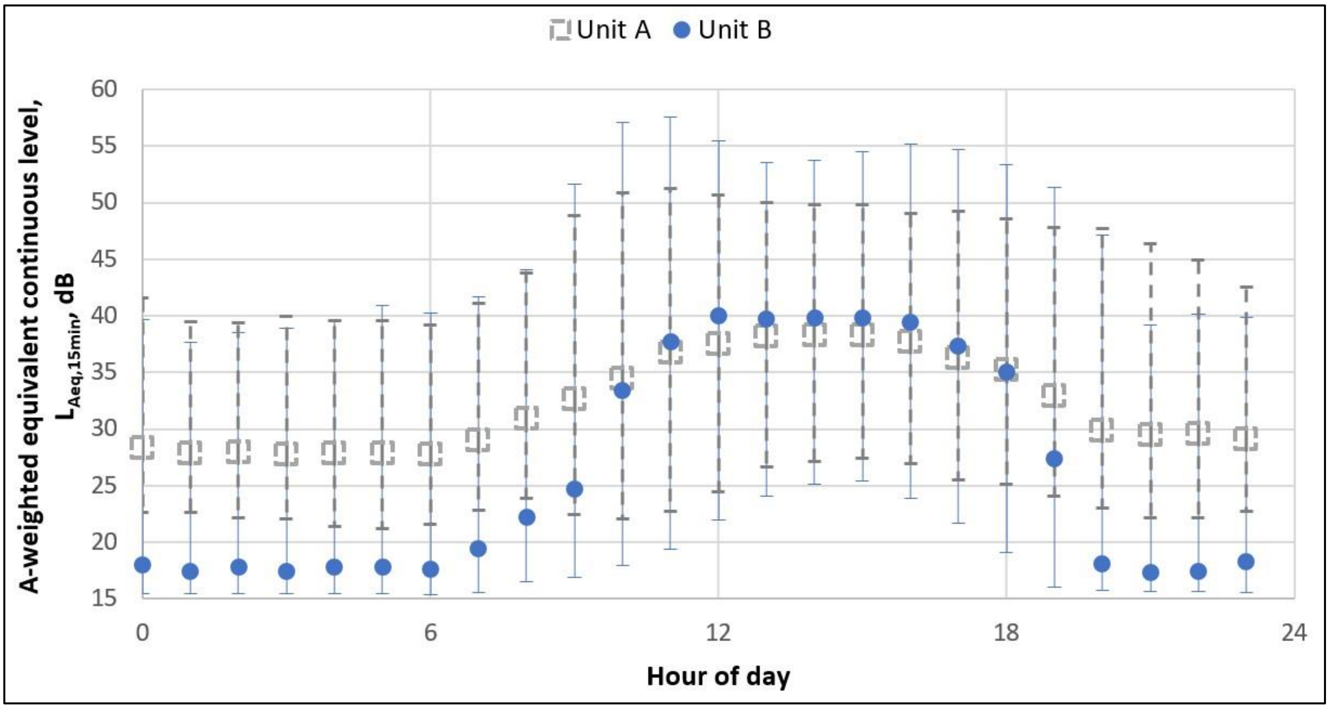
Month	Maxima, day		Maxima, evening		Maxima, night	
	Mulga A	Mulga B	Mulga A	Mulga B	Mulga A	Mulga B
May, 2019	47	45	35	28	35	30
June, 2019	49	49	34	32	35	32
July, 2019	47	48	37	29	33	31
August, 2019	50	49	37	34	35	33
September, 2019	52	50	40	34	35	31
October, 2019	52	52	42	40	38	39
November, 2019	51	50	41	36	36	35
December, 2019	51	-	48	-	46	-
January, 2020	51	59	46	-	48	-
Feb-Mar, 2020	55	62	42	58	46	52
Apr-May, 2020	48	49	42	36	40	33

4.3 Effects

4.3.1 Diurnal

Figure 2 presents the median 15-minute L_{Aeq} result versus hour of the day at each location. Error bars indicate the 5^{th} and 95^{th} percentile results.

Figure 2 Median $L_{aeq,15min}$ Versus Hour of Day



From this figure it can be seen that typical ambient levels increase to around $L_{Aeq,15min}$ 35 dB to 40 dB between 11.00 am and 6.00 pm, then at Mulga B they reduce to at or below the measurement floor of L_{Aeq} 16 dB between the hours of 8.00 pm and 6.00 am.

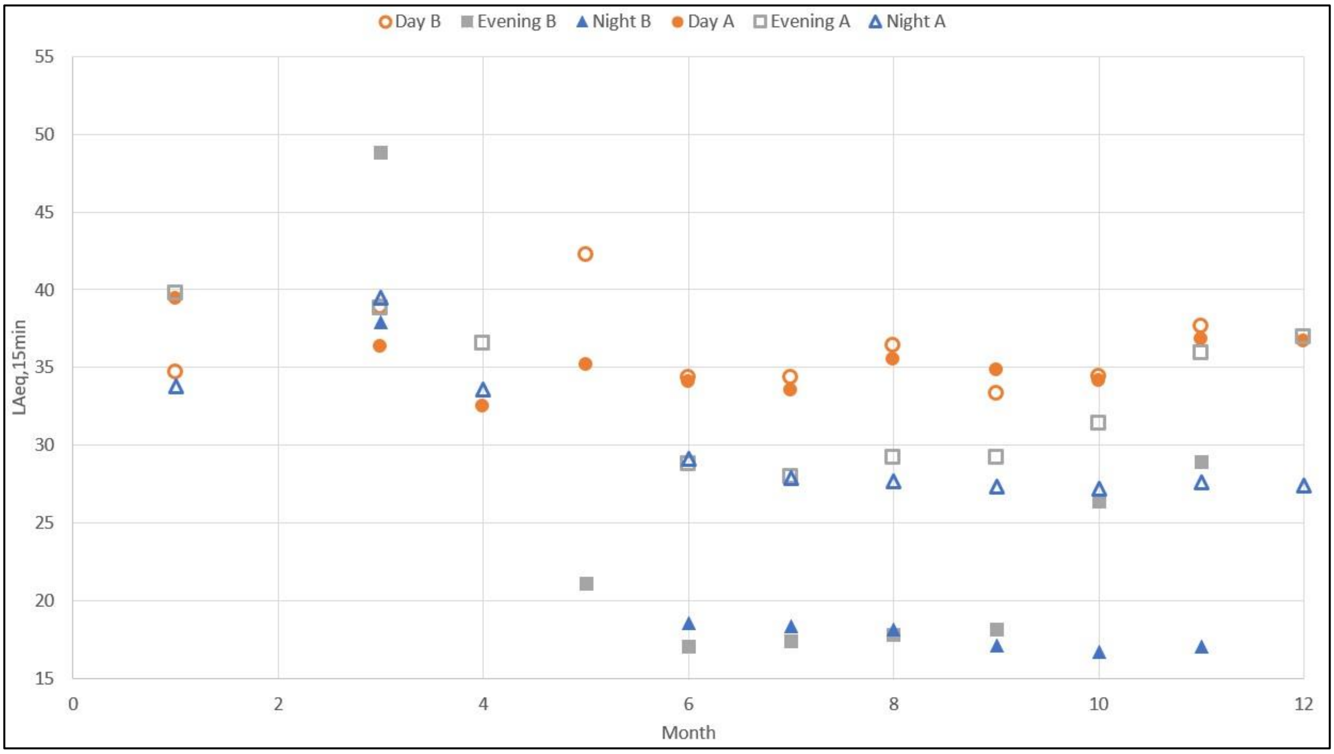
Night time levels at Location A approach different minima of around L_{Aeq} 23 dB with a median of L_{Aeq} 27 dB, due to contributions from mechanical plant associated with the nearby camp. This contribution is useful to understand (i.e. it does not adversely impact the result) as it indicates background levels that would likely occur at similar distances to other residential communities in the area.

4.3.2 Seasonal

The median 15-minute L_{Aeq} results for the day, evening and night periods recorded in each month are presented in **Figure 3**, to illustrate the potential for seasonal variance. Background noise levels change with seasonal weather activity, e.g. rainfall striking the ground, the wind-induced motion of plants, trees and other materials, and also differences in fauna (e.g. insect) activity.

As can be seen from **Figure 3**, typical ambient levels for day, evening and night periods were measured to be higher during the summer / monsoonal months, noting that there is reduced data in that period.

Figure 3 Median Day, Evening and Night $L_{aeq,15min}$ Values Versus Month of Year

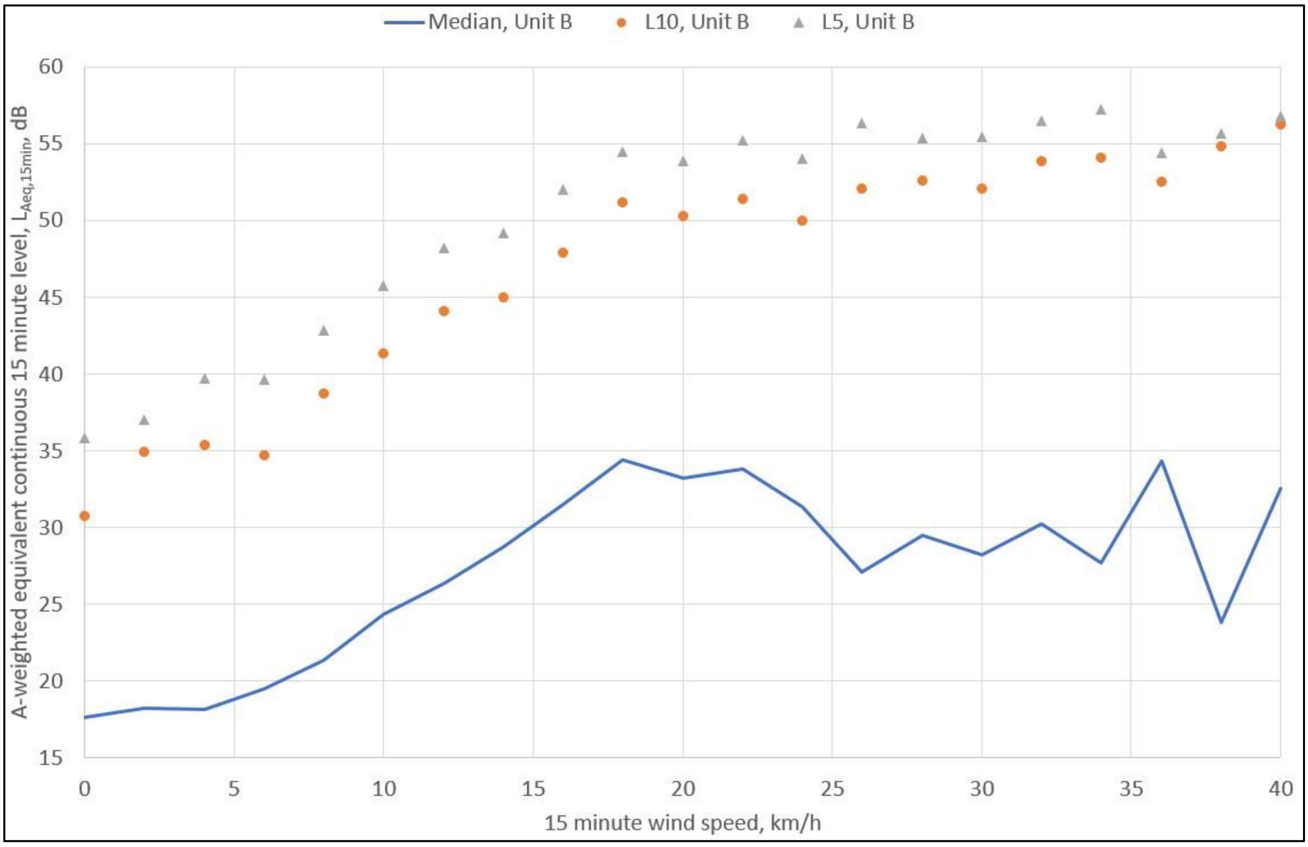


4.3.3 Weather

Figure 4 presents typical median $L_{Aeq,15min}$ results recoded at Mulga B versus 15-minute average wind speed results (regardless of time period) reported by the BoM at Karijini North. The figure indicates a general increase in ambient noise levels with increasing wind speed between 5 and 20 km/hr.

At lower wind speeds, the ambient noise level is attributed to contributions from nearby local fauna and distant transport noise (e.g. local site traffic and trucks on Great Northern Highway).

Figure 4 Median $L_{aeq,15min}$ Versus Reported Wind Speed, Mulga B



4.4 Spectral Results

Results in terms of third octave band noise levels were also recorded to determine if there are any relevant spectral characteristics.

4.4.1 Per Period

The median background noise level spectra in each time period determined for both locations for the monitoring period is provided in **Table 12**.

Table 12 Octave Band Median $L_{aeq,15min}$ Noise Level per Period

Period	Octave band centre frequency, Hz								Sum	
	63	125	250	500	1000	2000	4000	8000	dB	dB(A)
Day	59	48	38	31	25	21	19	14	60	38
Evening	36	26	18	13	12	12	13	9	37	20
Night	36	27	17	11	9	10	11	8	37	19

4.4.2 Per Hour

Table 13 presents the typical background level versus time of day at Mulga B. Although not shown in this figure, the data indicate consistently higher levels of noise in the upper frequency range (6 kHz – 10 kHz) in the early night time (2200 – 0300 hrs). This is expected to be from fauna (insects) in the area.

Table 13 Typical Third Octave Band Result by Hour of Day, Mulga B

Hour	Unweighted noise level for selected third octave bands, centre frequency in Hz																				Sum dB(A)
	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	
0 (to 1 am)	30	27	24	21	18	14	12	10	8	6	5	4	4	4	5	5	5	6	7	6	18
1	29	27	24	20	17	13	11	9	7	5	4	4	4	4	4	5	5	6	7	6	< 18
2	30	28	25	22	18	15	12	9	7	6	5	4	4	4	4	5	5	6	7	6	< 18
3	30	28	25	21	18	14	11	9	6	5	4	4	3	4	4	5	5	6	7	6	< 18
4	31	29	25	22	18	14	11	9	7	6	5	4	4	4	5	5	6	6	7	7	< 18
5	31	29	26	22	19	15	11	10	7	6	5	4	4	4	5	5	6	7	7	7	19
6	31	29	26	22	19	15	11	10	7	6	5	4	4	4	5	5	6	6	7	7	19
7	32	31	27	24	20	16	13	12	9	7	6	6	6	6	6	6	6	7	7	7	20
8	35	33	30	26	23	19	15	14	11	10	8	8	7	9	9	10	9	9	9	8	22
9	41	38	35	31	28	24	21	18	16	14	12	12	11	12	12	13	11	11	11	10	26
10	50	47	44	40	36	33	30	26	24	22	20	19	17	17	16	16	15	15	14	13	34
11	54	50	46	42	39	36	33	30	27	25	23	22	20	19	18	17	17	16	15	14	36
12	55	51	47	43	40	37	34	31	29	27	25	23	21	20	19	18	17	16	15	14	37
13	55	52	48	44	40	37	34	32	29	27	25	23	21	20	18	17	16	16	15	13	38
14	56	52	48	44	41	38	35	32	30	28	25	24	22	20	18	17	16	16	15	13	38
15	56	52	48	44	40	38	35	32	30	28	26	24	22	20	18	17	16	15	14	13	38
16	55	51	47	43	40	37	34	32	29	27	25	23	21	19	18	17	15	15	14	12	37
17	53	50	46	42	39	36	33	30	28	26	24	21	20	18	17	16	15	14	13	12	36
18	50	46	42	39	36	33	30	27	25	22	20	19	17	16	14	14	13	13	12	10	33
19	40	36	32	29	27	24	21	19	17	15	14	12	11	11	10	10	10	10	9	9	25
20	30	27	24	21	18	15	13	11	9	8	7	7	7	7	7	7	7	7	8	7	19
21	27	25	21	18	16	12	10	8	6	5	5	4	4	4	5	5	5	6	8	6	17
22	28	26	23	20	17	13	10	8	7	6	5	5	4	5	5	5	6	6	7	7	18
23	30	28	24	21	19	15	12	10	8	7	6	5	5	5	5	5	6	7	7	7	19

5 Discussion

5.1 Compliance

From the results presented it can be seen that a substantial volume of data was obtained over the course of a year. Gaps in the data are mostly during the summer and monsoonal periods when baseline noise levels are generally higher. Overall, typical ambient levels have been determined using statistical analyses, and the consistency in these results (particularly the six months to end of 2019 as per **Figure 3**) demonstrate that a suitably large sample set has been obtained.

On this basis, the noise monitoring program to date is therefore considered to be adequate to establish appropriate baseline noise levels in the context of the following relevant Regulations, policies and EPA guidance:

- Environmental Protection Authority, 2016, Environmental Factor Guideline – Social Surroundings.
- Environmental Protection Authority, 2015, Environmental Assessment Guideline for Environmental principles, factors and objectives (EAG 8).
- *Environmental Protection (Noise) Regulations 1997.*
- *State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP5.4).

5.2 Key Observations

The data obtained during the baseline monitoring program indicates the following:

- Key contributors to ambient sound levels are wind behaviour, distant road traffic (e.g. Great Northern Highway) and local fauna (insects).
- Ambient noise levels (as described by the median 15-minute L_{Aeq} value) broadly increase in the warmer months of the year as follows (**Figure 3**):
  - From December to March inclusive, L_{Aeq} 30-35 dB at night increasing to 35-40 dB during the day.
  - From April to November inclusive, L_{Aeq} < 20 dB at night increasing to 33-38 dB during the day.
- During high wind conditions, **Figure 4** suggests that ambient sound levels would often exceed the night time Assigned Noise Level of L_{A10} 35 dB.
- Mulga A has recorded higher night and evening noise levels than Mulga B, and this is attributed to its relative proximity (20 km) to the camp.

6 Conclusions

Baseline noise monitoring to date is considered to be adequate to establish baseline levels within environmental noise assessments.

Ambient sound levels were determined to be linked to ambient weather conditions, distant road traffic and local fauna. Ambient sound levels often exceeded night time Assigned Noise Levels under specific weather conditions such as high wind and/or heavy rain.

Suitable construction and/or operational design targets conditional on time period, season or live weather conditions may therefore be developed on this basis.

APPENDIX A

A Glossary

1. Sound Level or Noise Level

The terms ‘sound’ and ‘noise’ are almost interchangeable, except that ‘noise’ often refers to unwanted sound. Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being 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 x 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 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB 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	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	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

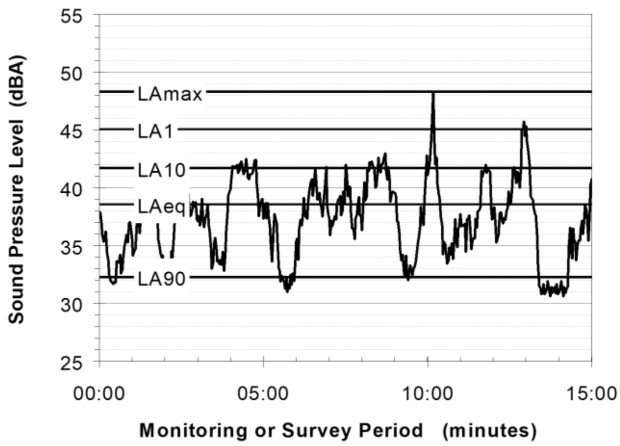
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of 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 various common statistical indices of interest.



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 The A-weighted equivalent 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.

5. Frequency Analysis

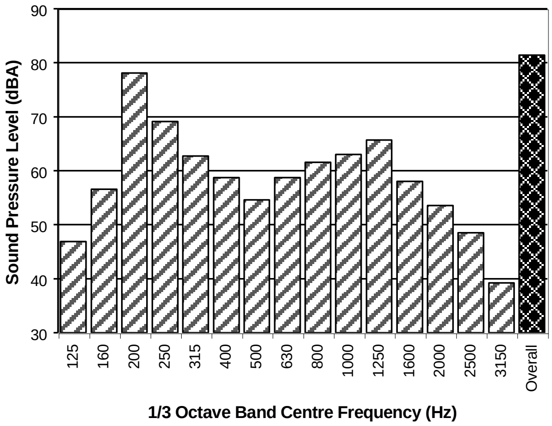
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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 (three 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.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. 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 incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal 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/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

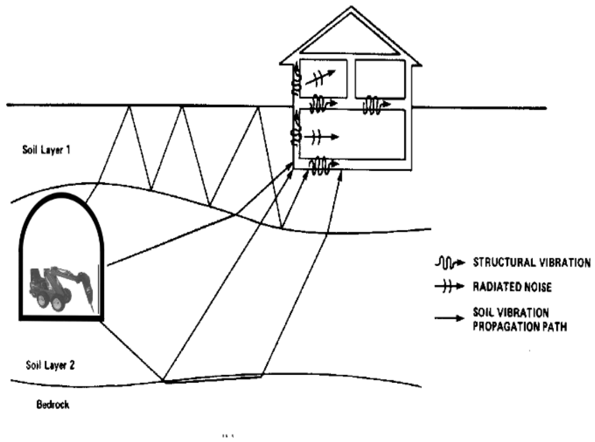
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience 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.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This 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 ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

APPENDIX B

B Noise Data

Figure B-1 Baseline Noise Measurements – May 2019 (Mulga A)

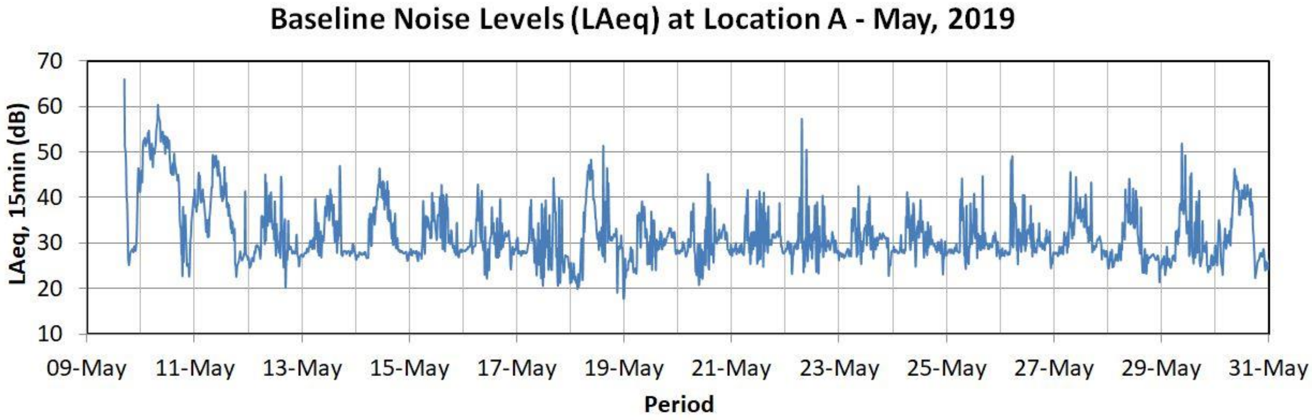


Figure B-2 Baseline Noise Measurements – May 2019 (Mulga B)

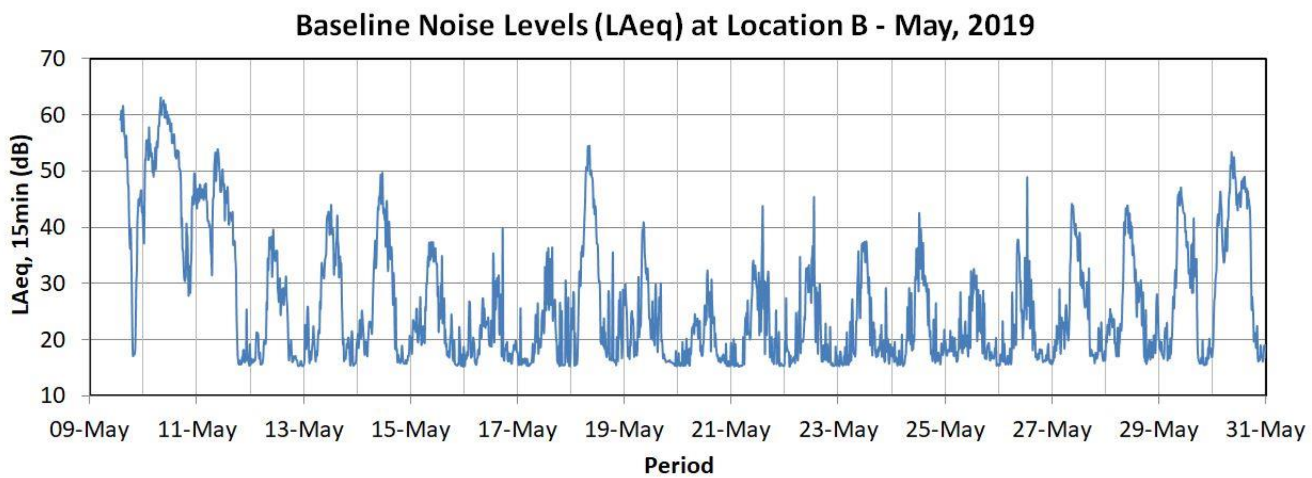


Figure B-3 Baseline Noise Measurements – June 2019 (Mulga A)

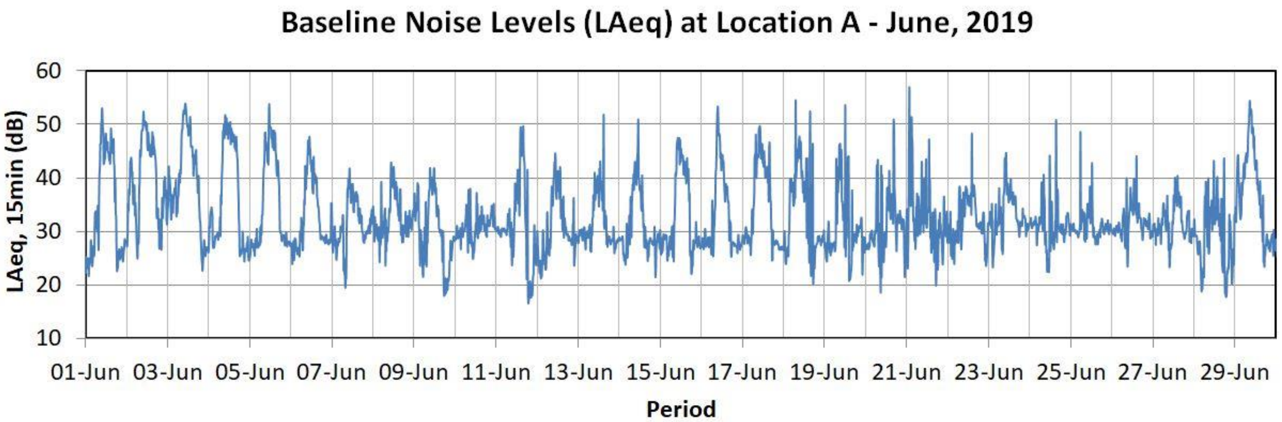


Figure B-4 Baseline Noise Measurements – June 2019 (Mulga B)

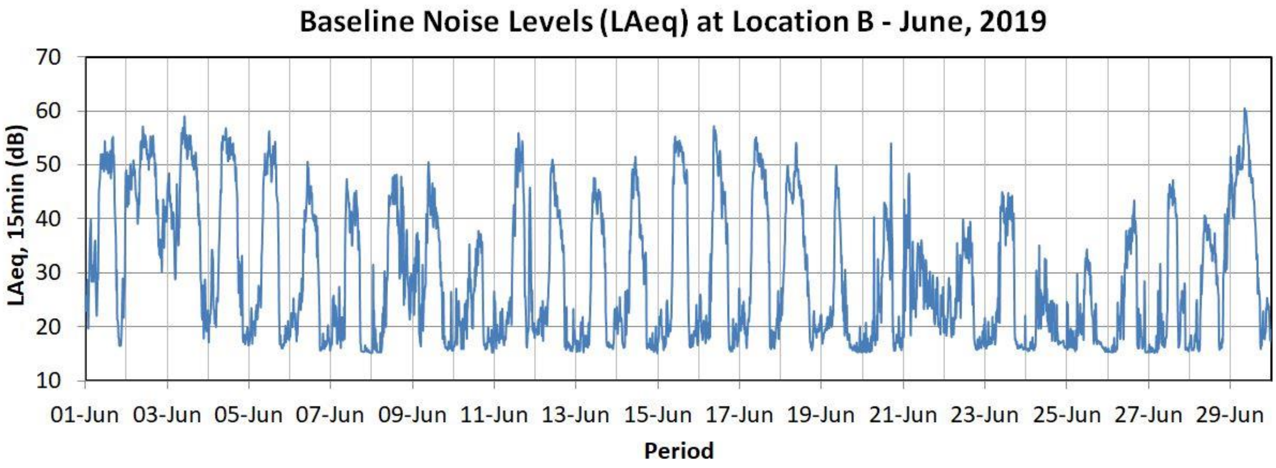


Figure B-5 Baseline Noise Measurements – July 2019 (Mulga A)

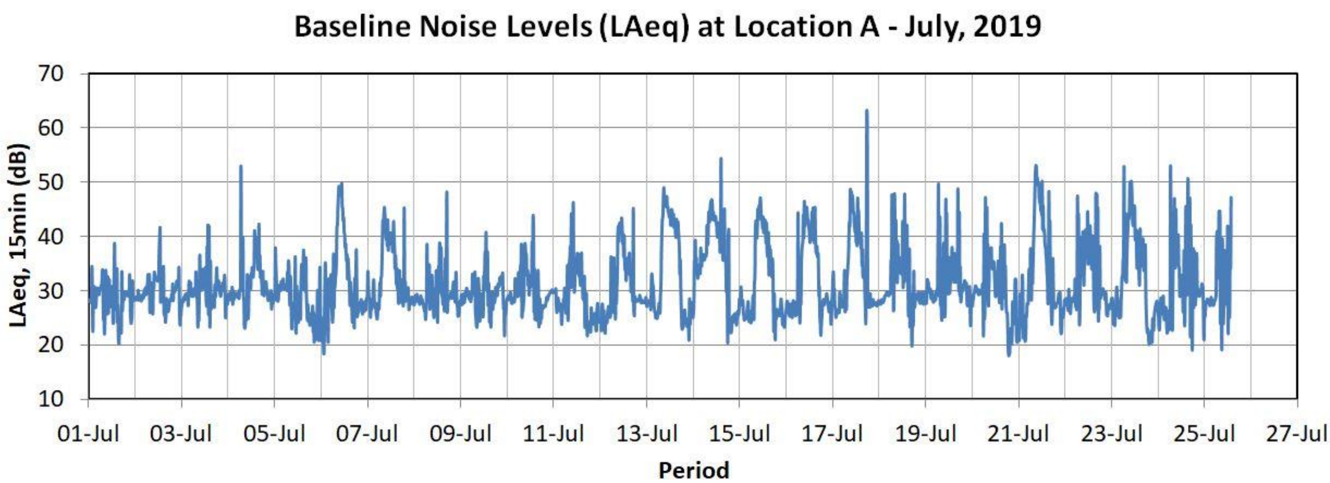


Figure B-6 Baseline Noise Measurements – July 2019 (Mulga B)

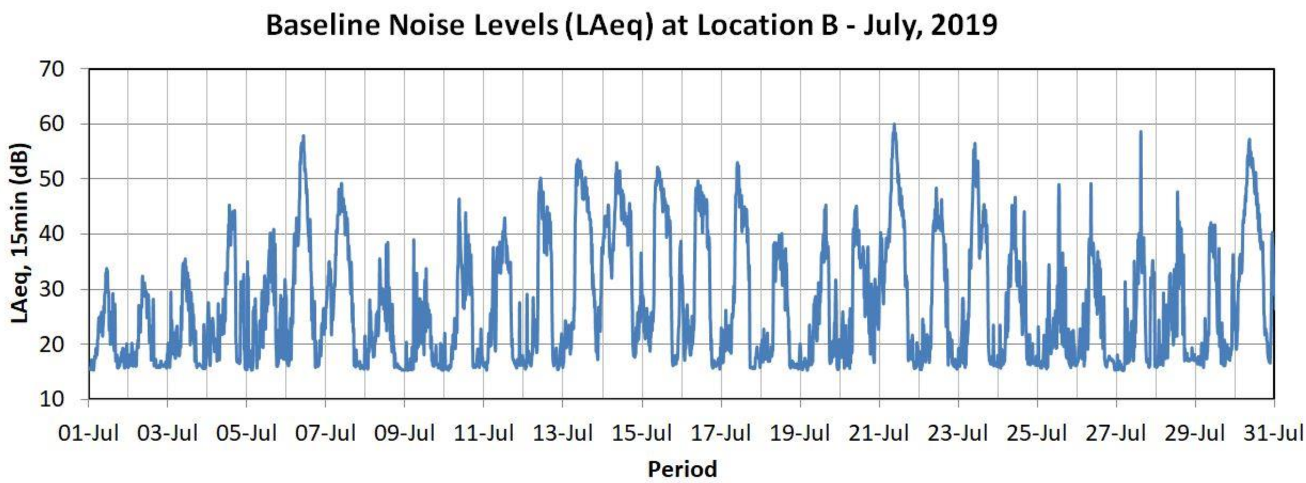


Figure B-7 Baseline Noise Measurements – August 2019 (Mulga A)

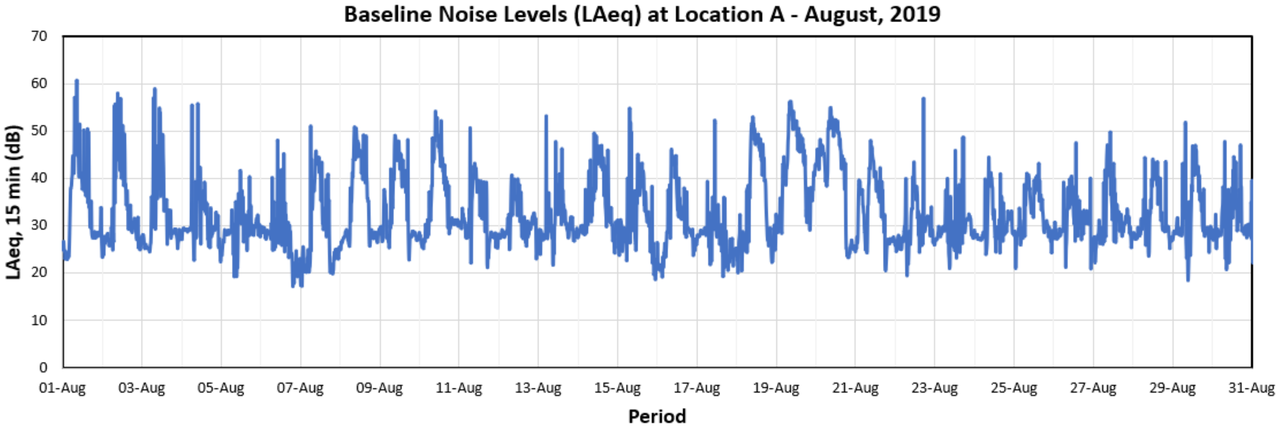


Figure B-8 Baseline Noise Measurements – August 2019 (Mulga B)

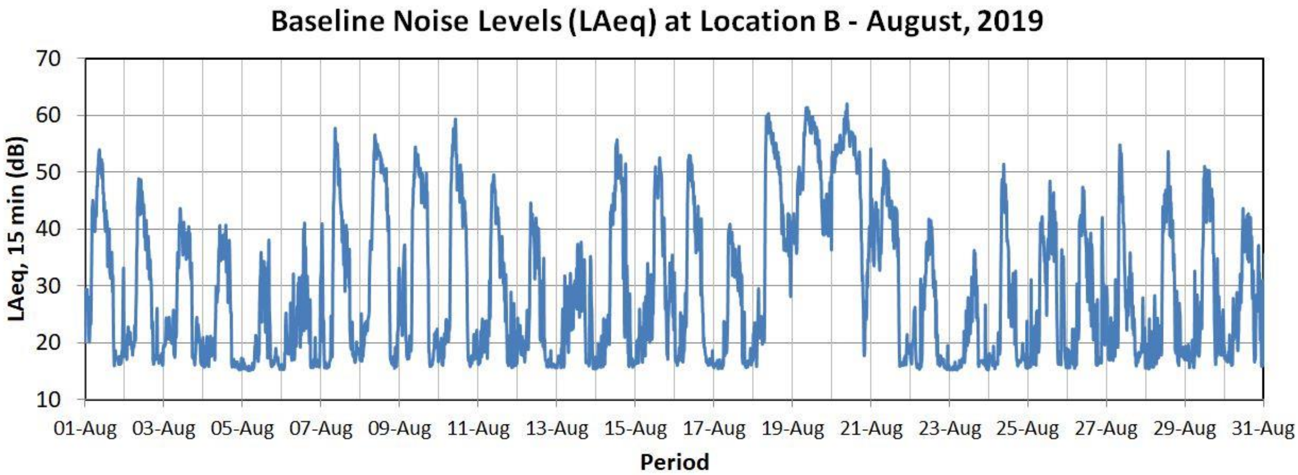


Figure B-9 Baseline Noise Measurements – September 2019 (Mulga A)

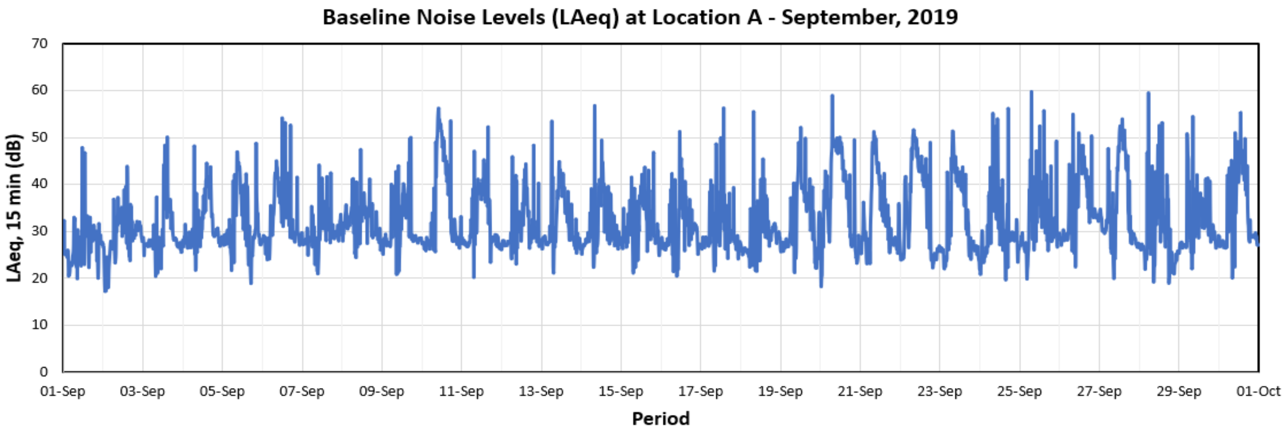


Figure B-10 Baseline Noise Measurements – September 2019 (Mulga B)

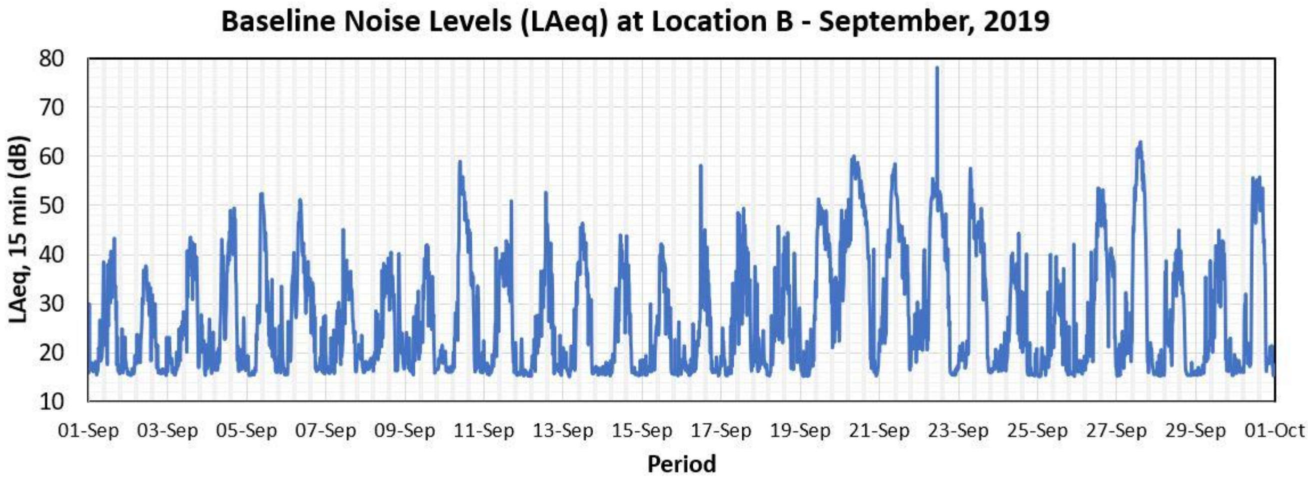


Figure B-11 Baseline Noise Measurements – October 2019 (Mulga A)

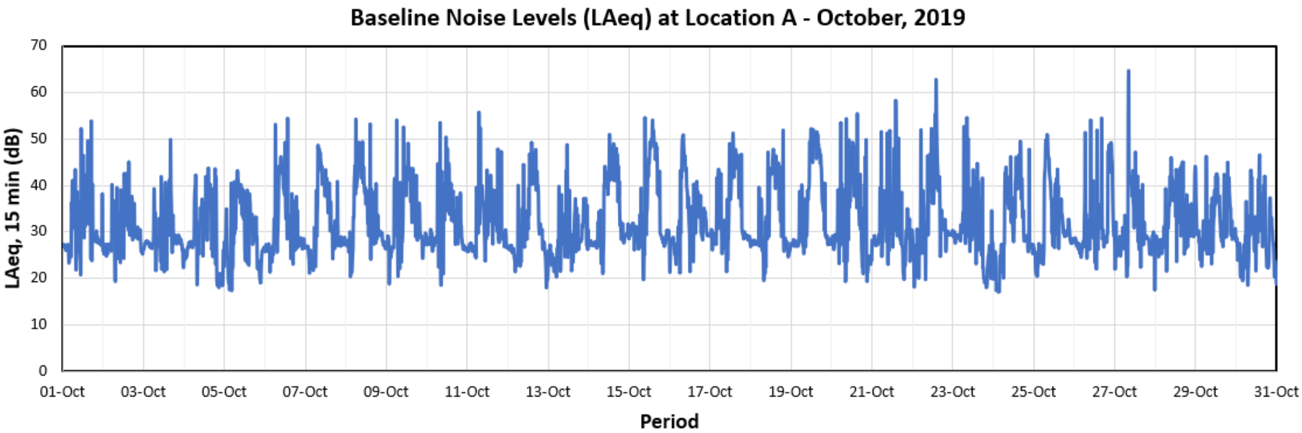


Figure B-12 Baseline Noise Measurements – October 2019 (Mulga B)

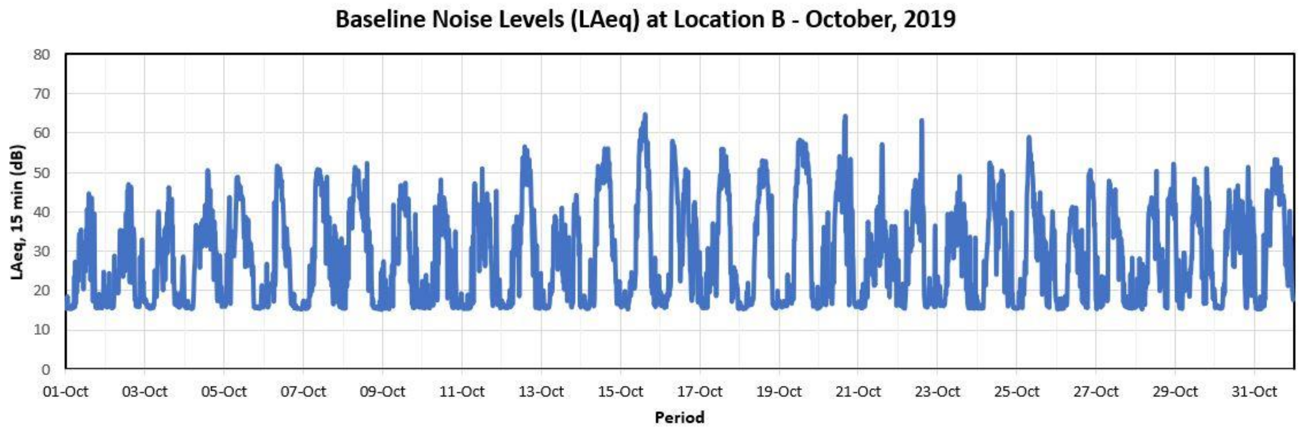


Figure B-13 Baseline Noise Measurements – November 2019 (Mulga A)

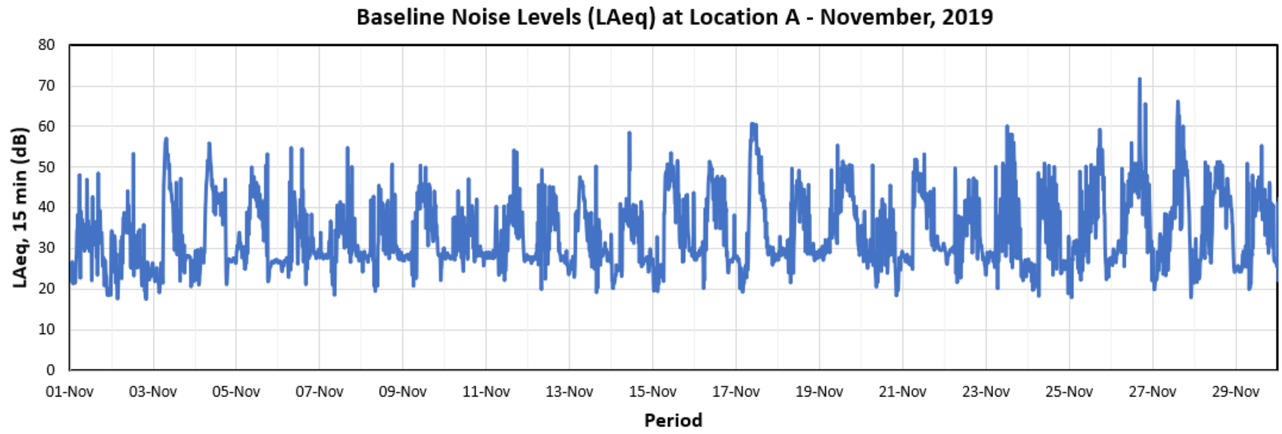


Figure B-14 Baseline Noise Measurements – November 2019 (Mulga B)

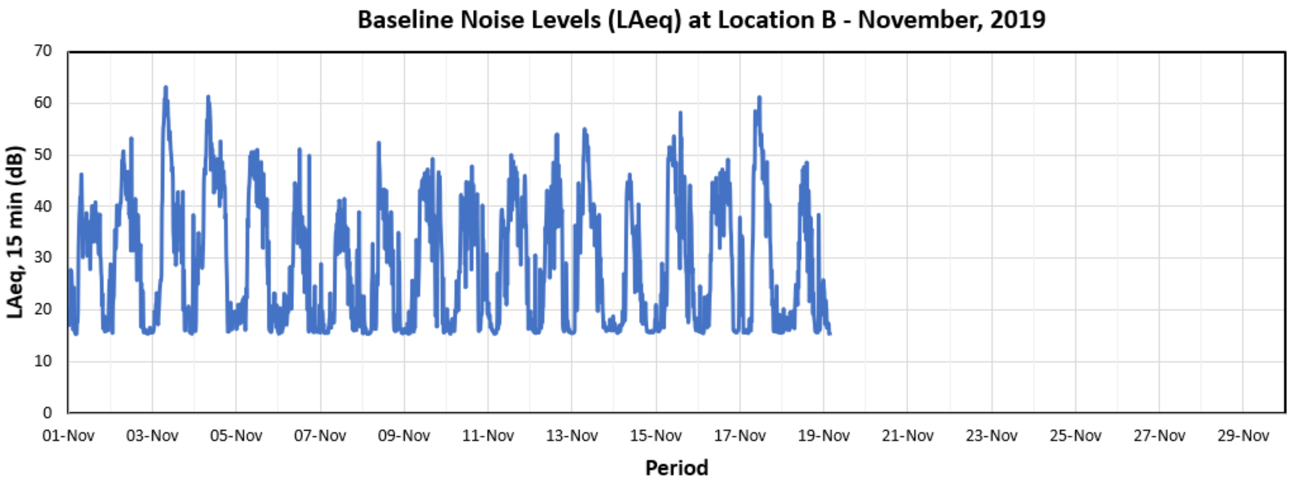


Figure B-15 Baseline Noise Measurements – December 2019 (Mulga A)

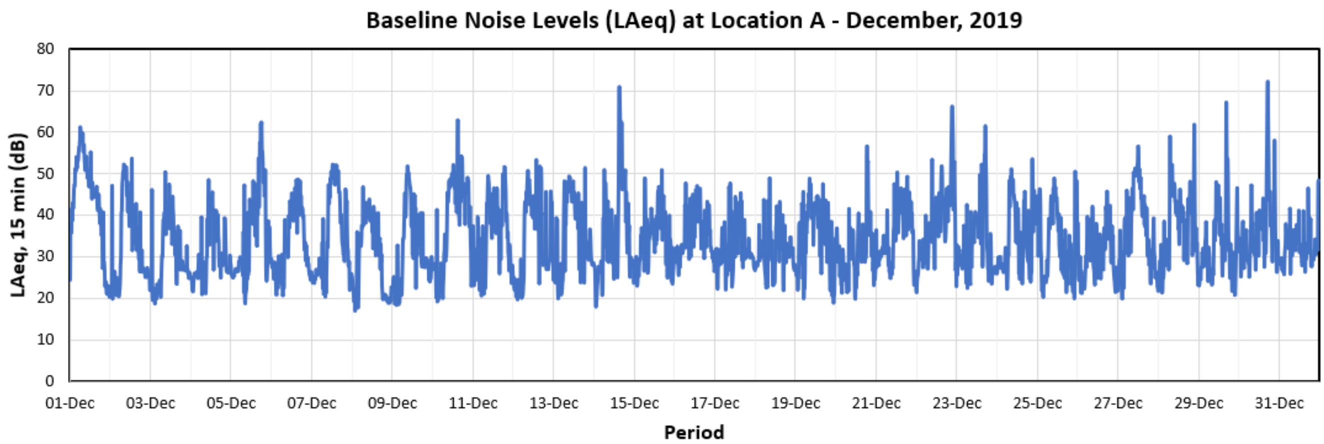


Figure B-16 Baseline Noise Measurements – January 2020 (Mulga A)

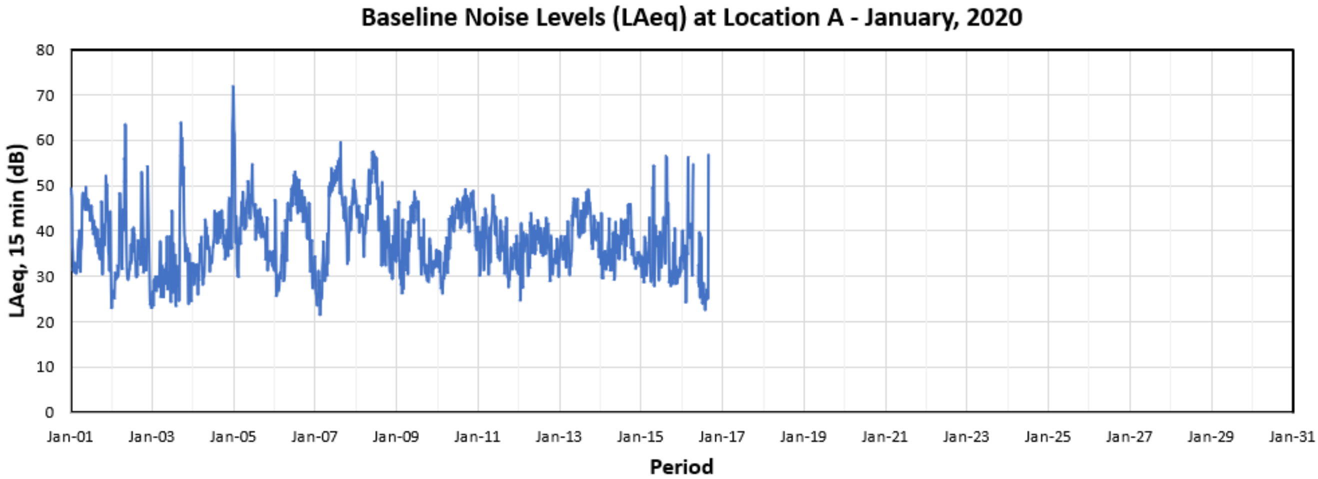


Figure B-17 Baseline Noise Measurements – March 2020 (Mulga A)

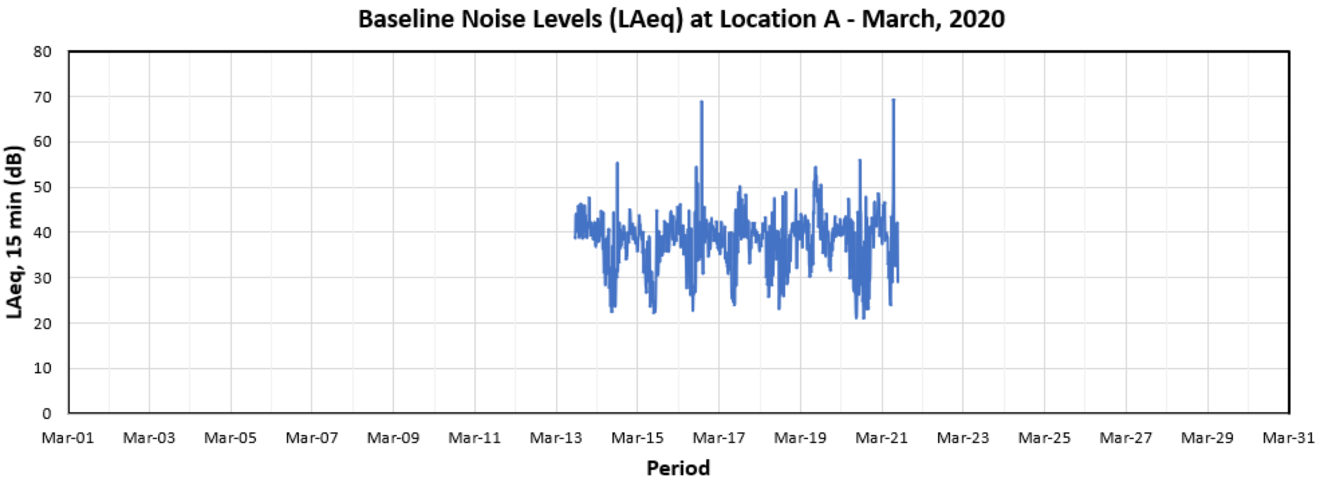


Figure B-18 Baseline Noise Measurements – March 2020 (Mulga B)

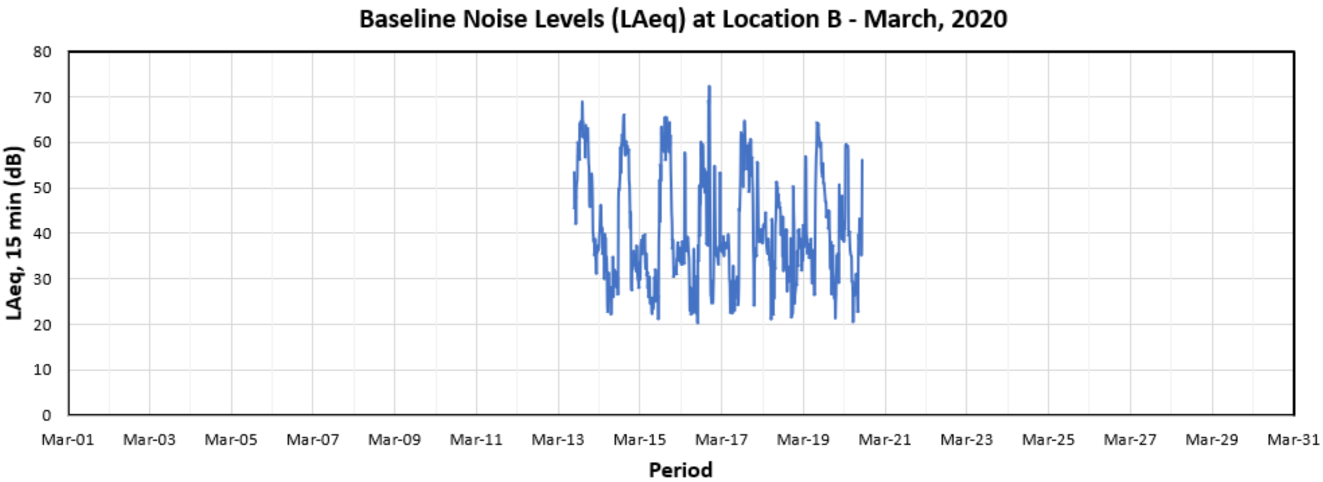


Figure B-19 Baseline Noise Measurements – April 2020 (Mulga A)

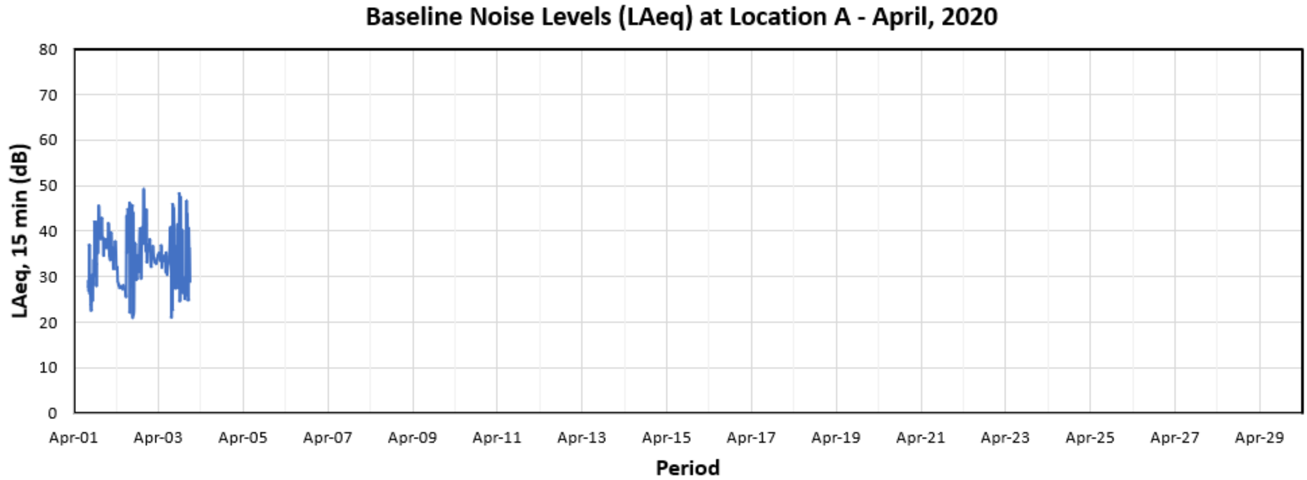


Figure B-20 Baseline Noise Measurements – May 2020 (Mulga A)

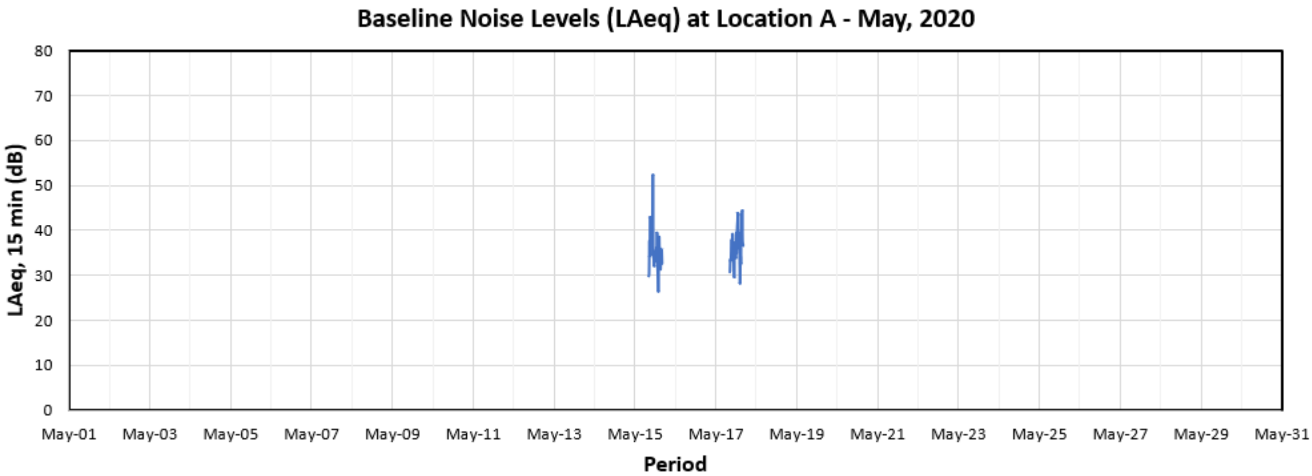
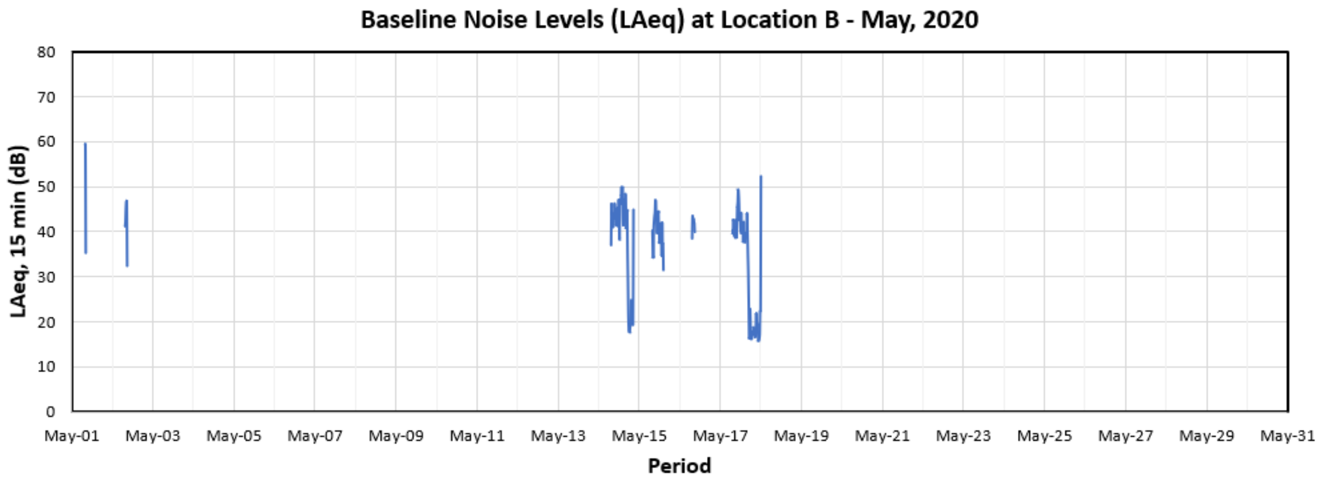


Figure B-21 Baseline Noise Measurements – May 2020 (Mulga B)



APPENDIX C

C Weather Data

This section (extracted from the Air Quality Technical Report[20]) presents a summary of the meteorological characteristics of the project area based on long-term data from an automatic weather station (AWS) operated by the Bureau of Meteorology (BoM) at Wittenoom (Station 05026, open 1949-2019), which was located approximately 40 km southwest of the Project area. Long term meteorological data is available from this station for the following parameters:

- Temperature (°C);
- Rainfall (mm);
- Relative humidity (%); and
- Wind speed (m/s) and wind direction (degrees).

These parameters are relevant to the study as they affect ambient sound levels and how sound propagates over large distances. For example, temperature and relative humidity influence how the speed of sound of air changes with height above ground (referred to as the sonic gradient), and therefore the ways that sound transmission paths curve through the atmosphere to increase or decrease long range propagation. Wind speed and direction is also relevant as it also affects the sonic gradient and generates wind-induced background noise at higher speeds.

Additional meteorological data was obtained from BoM's Karijini North AWS (Station 05098), which replaced the Wittenoom AWS when it was closed. This station is located approximately 20 km south of the Project area and has data available from June 2019.

A review of the long-term data available from the Wittenoom AWS is provided in the following sections. Data available from the Karijini North AWS is also presented.

C.1 Temperature

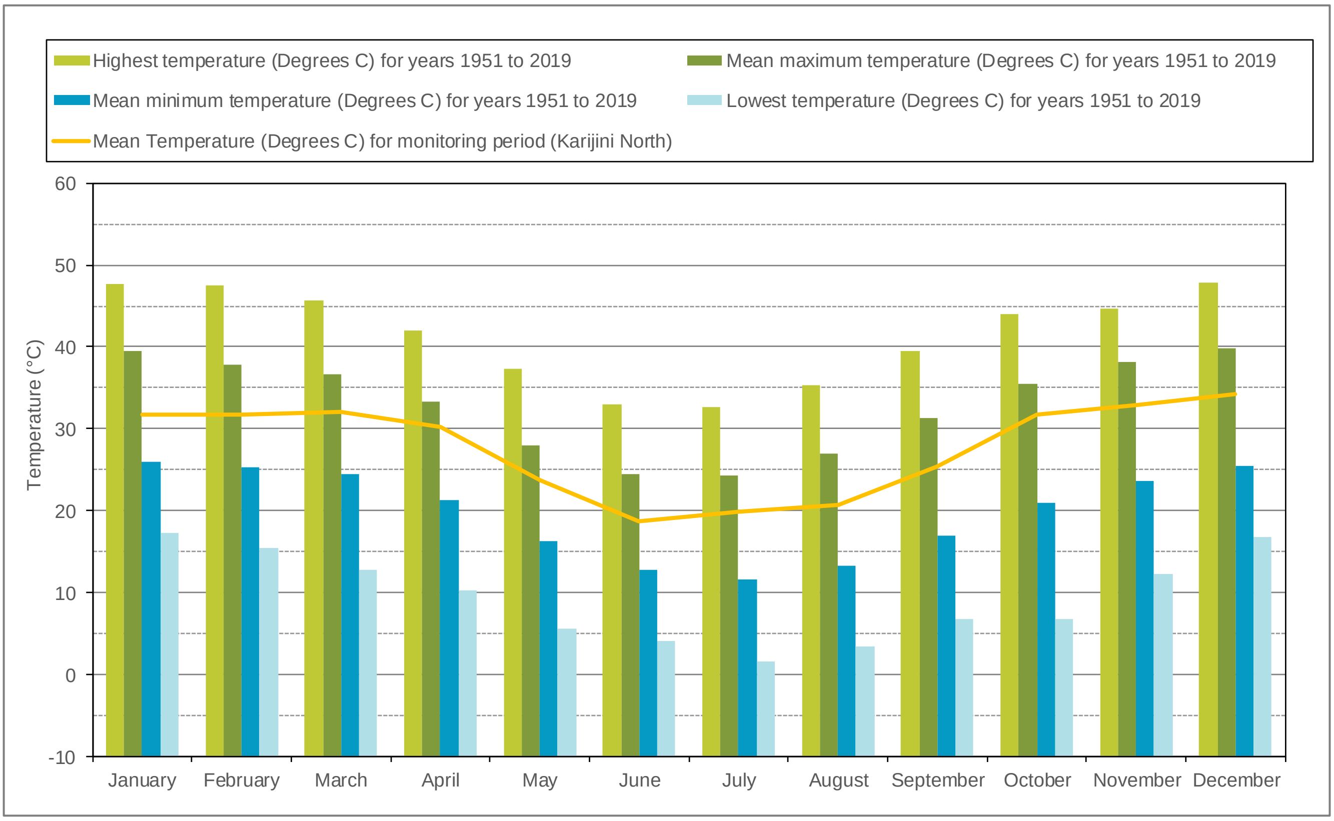
Long-term temperature statistics from the Wittenoom AWS are summarised in **Figure C-5**, and compared to data recorded by the Karijini North AWS during the baseline monitoring period.

The long-term data shows that mean maximum temperatures range from approximately 24°C in the dry season (May to October) to 40°C in the wet season (November to April), while mean minimum temperatures range from approximately 11°C in the dry season to 26°C in the wet season. Maximum temperatures above 45°C and minimum temperatures less than 5°C have been recorded.

The plot shows that temperatures recorded in the area during the baseline monitoring program were within the range of the long-term averages, although they tended to the warmer end of the range for most of the year.

[20] SLR Consulting, Phase 2 Mulga East Iron Ore Project - Ambient Air Quality Monitoring Program Technical Report, 675.11414-R04-v2.0, dated 10 September 2020.

Figure C-5 Temperature Data - Wittenoom (Long-Term) and Karijini North (Monitoring Period) AWS



C.2 Rainfall

Long-term rainfall statistics are summarised in **Figure C-6**, and compared to data recorded by the Karijini North AWS during the baseline air quality monitoring period.

The long-term data recorded by the Wittenoom AWS show that rainfall varies significantly between the wet (November to April) and dry seasons (May to October). The highest rainfalls occur from December to March, with January recording the highest mean rainfall of 116 mm. The lowest rainfalls occur between April and November, with September recording the lowest mean rainfall of 2.9 mm. The highest monthly rainfall recorded over the time period examined was 470 mm, recorded in January 2012.

The total wet and dry season rainfalls recorded by the Karijini North AWS during the baseline air quality monitoring period are compared to the long term data from Wittenoom in **Table C-14**. Tropical cyclone Damien occurred from 3 to 9 February 2020, however, while the monthly average rainfall for February 2020 was greater than the long-term averages for this month, the overall wet season rainfalls for the monitoring period were low compared to long term trends. Dry season rainfalls for the monitoring period were also significantly (70%) less than long term averages.

Figure C-6 Long Term Rainfall Data – Wittenoom (Long-Term) and Karijini North (Monitoring Period) AWS

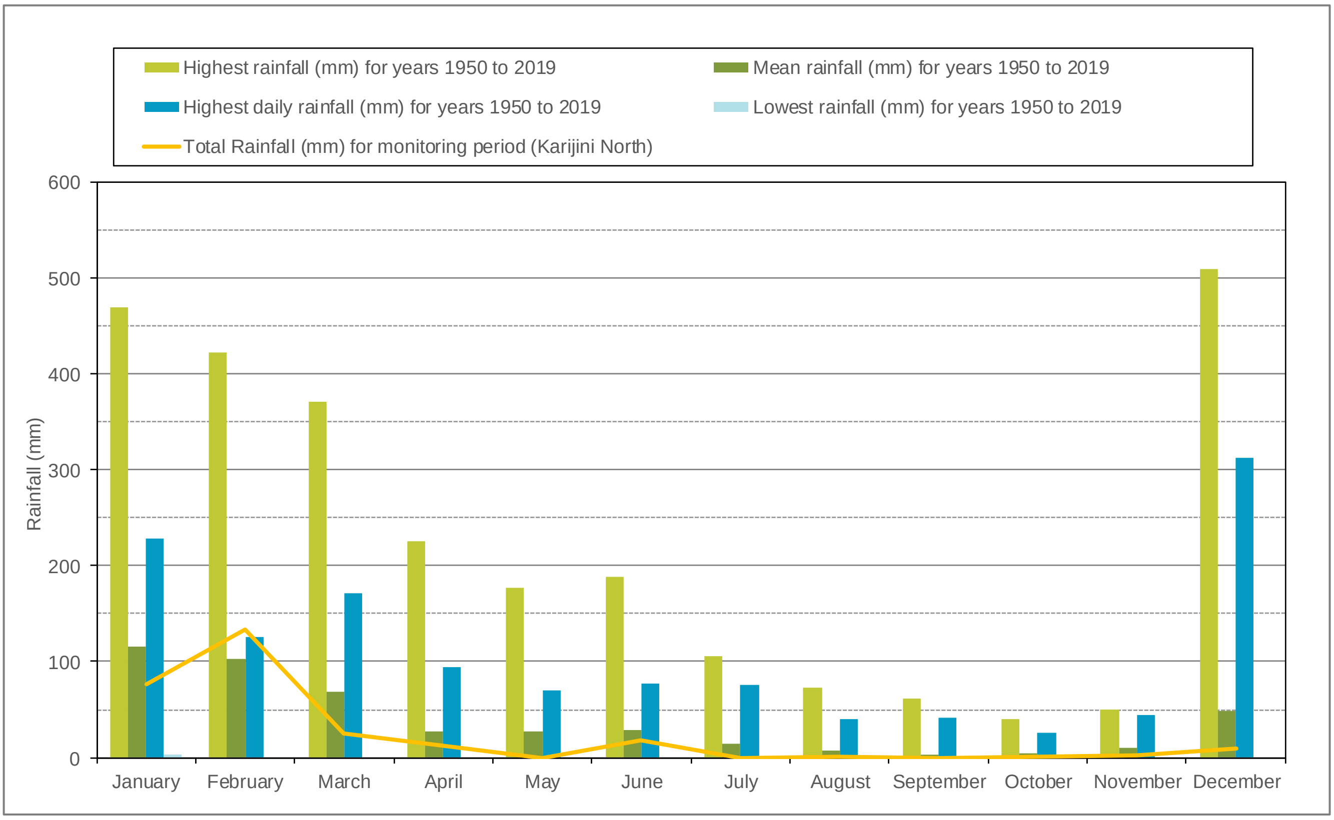


Table C-14 Comparison of Wet and Dry Season Rainfall

Description	Wet Season (November - April)	Dry Season (May - October)
Long Term Average 1950 to 2019 (Wittenoom)	373 mm	84 mm
June 2019 to May 2020 (Karijini North)	257 mm	20 mm
Difference	116 mm	64 mm
Percentage Difference	-31%	-76%

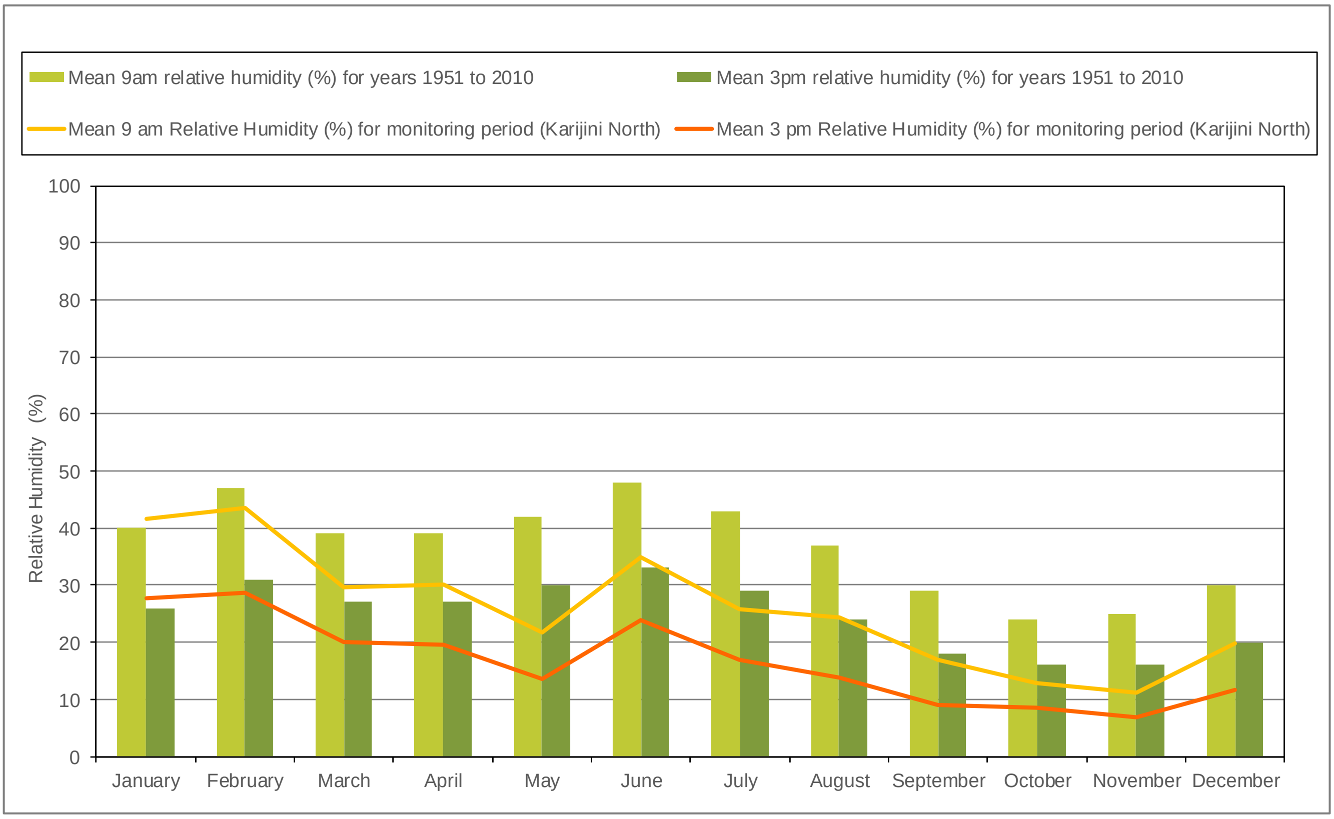
C.3 Relative Humidity

Long-term humidity statistics (9:00 am and 3:00 pm monthly averages) are presented in **Figure C-7**, and compared to data recorded by the Karijini North AWS during the baseline air quality monitoring period.

The long-term data shows that humidity levels are generally low throughout the year, as would be expected for the region. Morning humidity levels typically range from an average of around 23% late in the dry season to around 46% in the middle of the wet season. Afternoon humidity levels are lower, peaking at around 29% in the wet season and dropping to a low of 11% in the dry season.

During the monitoring period, both the 9:00 am and 3:00 pm relative humidity levels were generally lower than long term trends, reflective of the lower than average rainfalls recorded during this period (see **Section C.2**). However relative humidity levels were higher or equal to long term averages for the months of January and February respectively.

Figure C-7 Long Term Humidity Data - Wittenoom (Long-Term) and Karijini North (Monitoring Period) AWS



C.4 Wind

A wind rose shows the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from north). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e. northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus, it is possible to visualise how often winds of a certain direction and strength occur over the monitoring period.

Wind roses compiled from data recorded by the Karijini North AWS during the baseline monitoring program are presented in **Figure C-8**. The winds with the highest frequency are those from the eastern and the south-southwestern quadrants. There is minimal change in the wind distribution between the wet and dry seasons.

Figure C-9 presents a windspeed distribution plot for the monitoring period.

Figure C-8 Karijini North Wind Rose June 2019 to May 2020

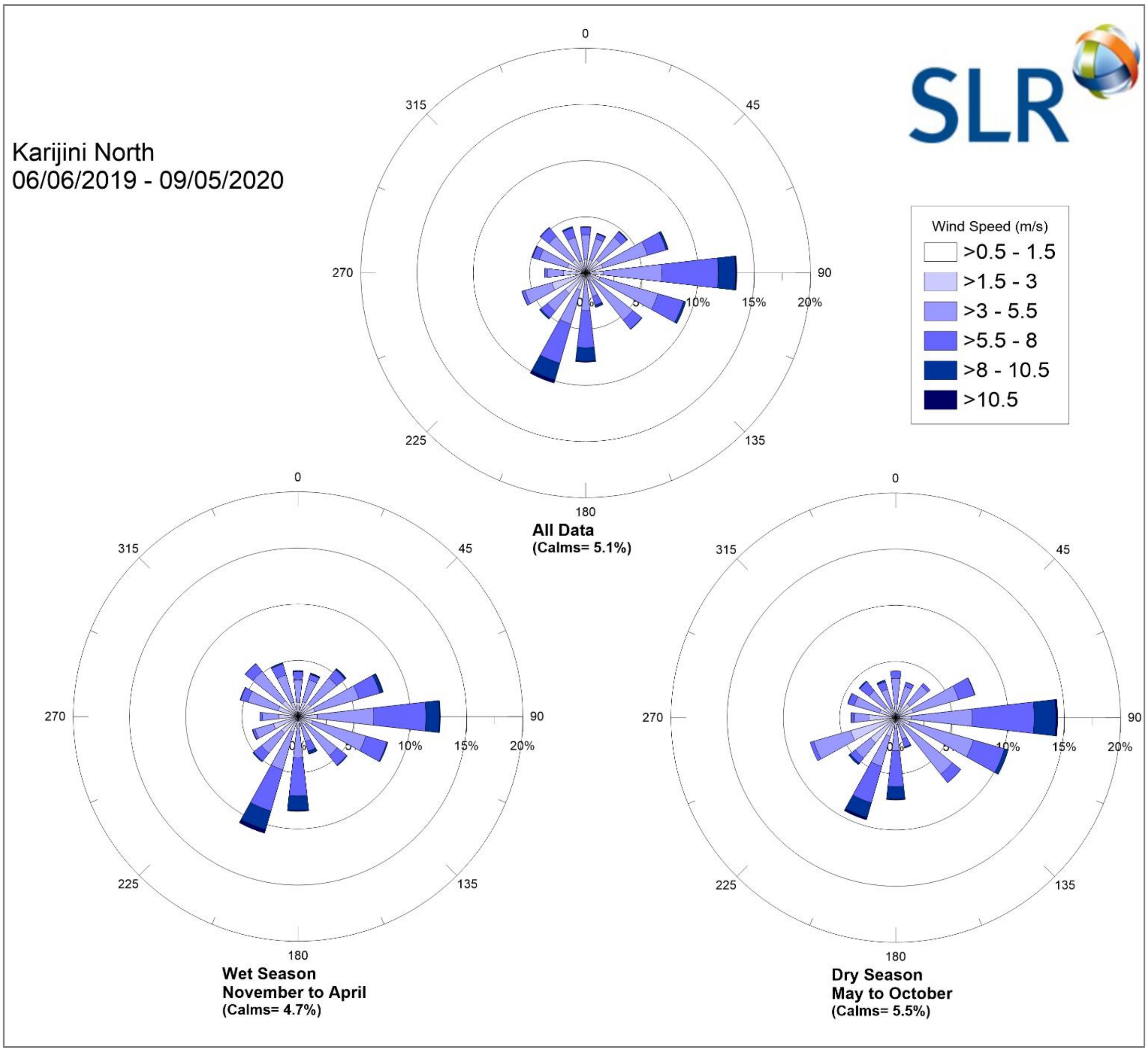
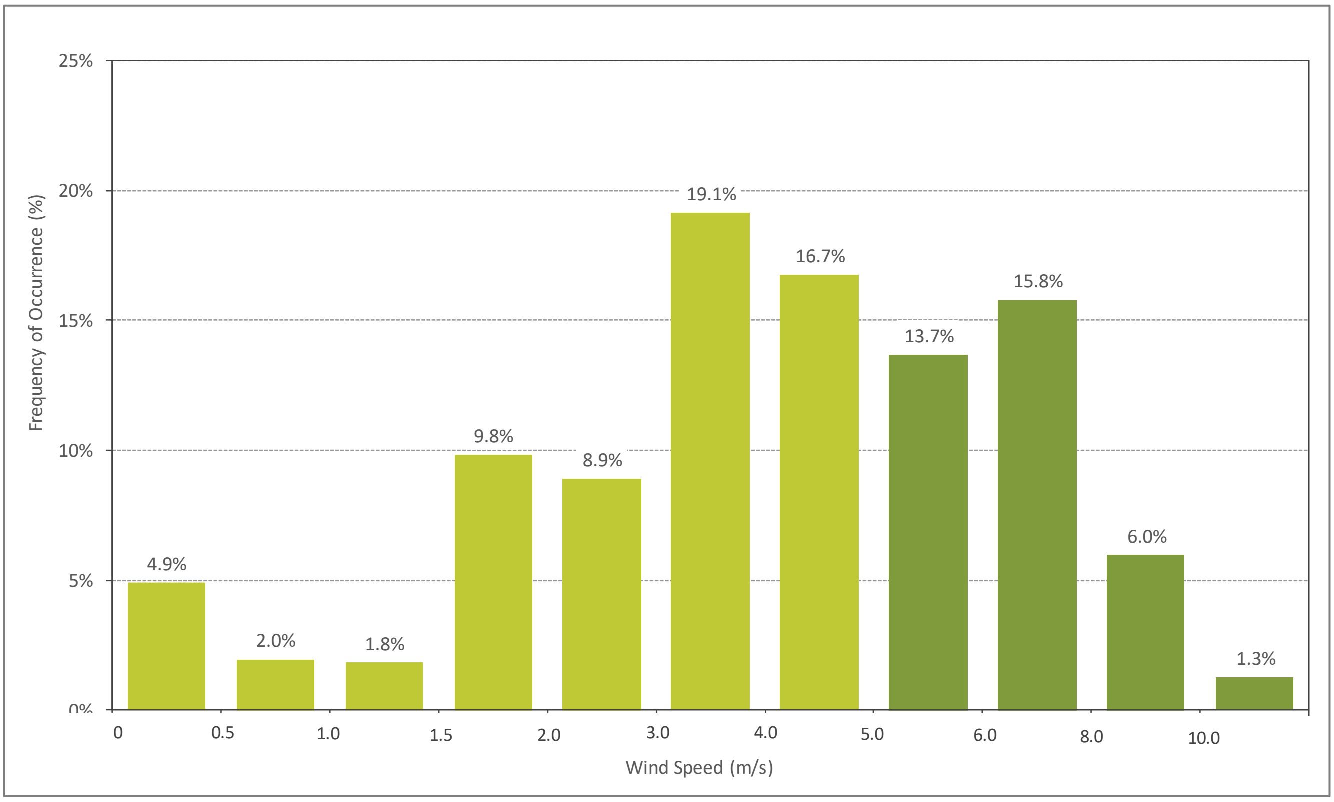


Figure C-9 Karijini North Wind Speed Frequencies June 2019 to May 2020



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