HORSLEY LOGISTICS PARK

State Significant Development Application
Noise and Vibration Impact Assessment

Prepared for:

ESR
Level 29
20 Bond Street
Sydney NSW 2000

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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 ESR (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
610.19360-R02-v1.3	17 July 2020	Mark Irish	Mark Russell	Mark Irish
610.19360-R02-v1.2	18 June 2020	Mark Irish	Mark Russell	
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1 Introduction

ESR (the Client) is proposing to develop a new industrial estate, the Horsley Logistics Park (the development), that will be located at 327-335 Burley Road, Horsley Park, in New South Wales (NSW).

SLR Consulting Australia Pty Ltd (SLR) has been engaged by ESR to prepare a Noise Impact Assessment (NIA) for the development to assess potential noise impacts associated with the construction and operation of the project. This report forms part of the State Significant Development Application (SSDA) for the development.

This report addresses the Secretary's Environmental Assessment Requirements (SEARs) relevant to the development (SSD 10436) issued June 2020.

This report summarises the results of ambient noise measurements undertaken at the site and assesses the potential noise impacts on the surrounding sensitive receivers from construction and operation of the development.

The assessment uses specific acoustic terminology. An explanation of common terms is included in **Appendix A**.

2 Project Description

The Client is developing an industrial estate of Lots 201, 202, 203 and 204 at 327-335 Burley Road, Horsley Park as part of the ESR Horsley Logistics Park. The site will comprise five industrial warehouses with attached offices, including internal roads, car parking spaces, hardstands and a guard house. The Development Site is located within the Western Sydney Employment Area (WSEA) and is currently zoned IN1 General Industry under the WSEA State Environmental Planning Policy (SEPP).

The proposal seeks approval for:

- Construction and operation of warehouses on Lots 201, 202, 203 and 204.

The Development Site is surrounded by the following:

- The Oakdale Central business Hub (SSD 6078) immediately to the north;
- Land zoned RU4 – Primary Production land that includes a number of rural residential lots to the east;
- Land zoned RU4 – Primary Production land and the residential subdivision Greenway Place to the south; and
- Horsley Park Warehousing Hub (MP 10_0129 & MP 10_0130) to the west.

The Development Site comprises a single allotment – Lot 103 DP 1214912 and is irregular in shape with a south-eastern boundary that follows the alignment of the E2 – Environmental Conservation corridor. The Development Site is currently used for a quarry and brickworks plant.

The Development Site comprises a large 20.8 hectare (ha) estate, for which approval has been granted for subdivision into four industrial lots. The construction on Stage 1 land of the Horsley Logistics Park is already underway, Stage 2 land is the subject of this assessment, and Stage 3 land will be the subject of a future application. The Draft Concept Masterplan of the Development Site is shown in **Figure 1**.

Figure 1 Draft Concept Masterplan of the Horsley Logistics Park

2.1 Development Layout

The development consists of 5 warehouses and associated offices, hardstands, parking and landscaping spread across 4 defined lots within Stage 2.

The locations of the development and surrounding receivers are shown in **Figure 2**. The masterplan design is shown in **Figure 3**.

Figure 2 Development Location, Sensitive Receivers Areas and Modelled Buildings

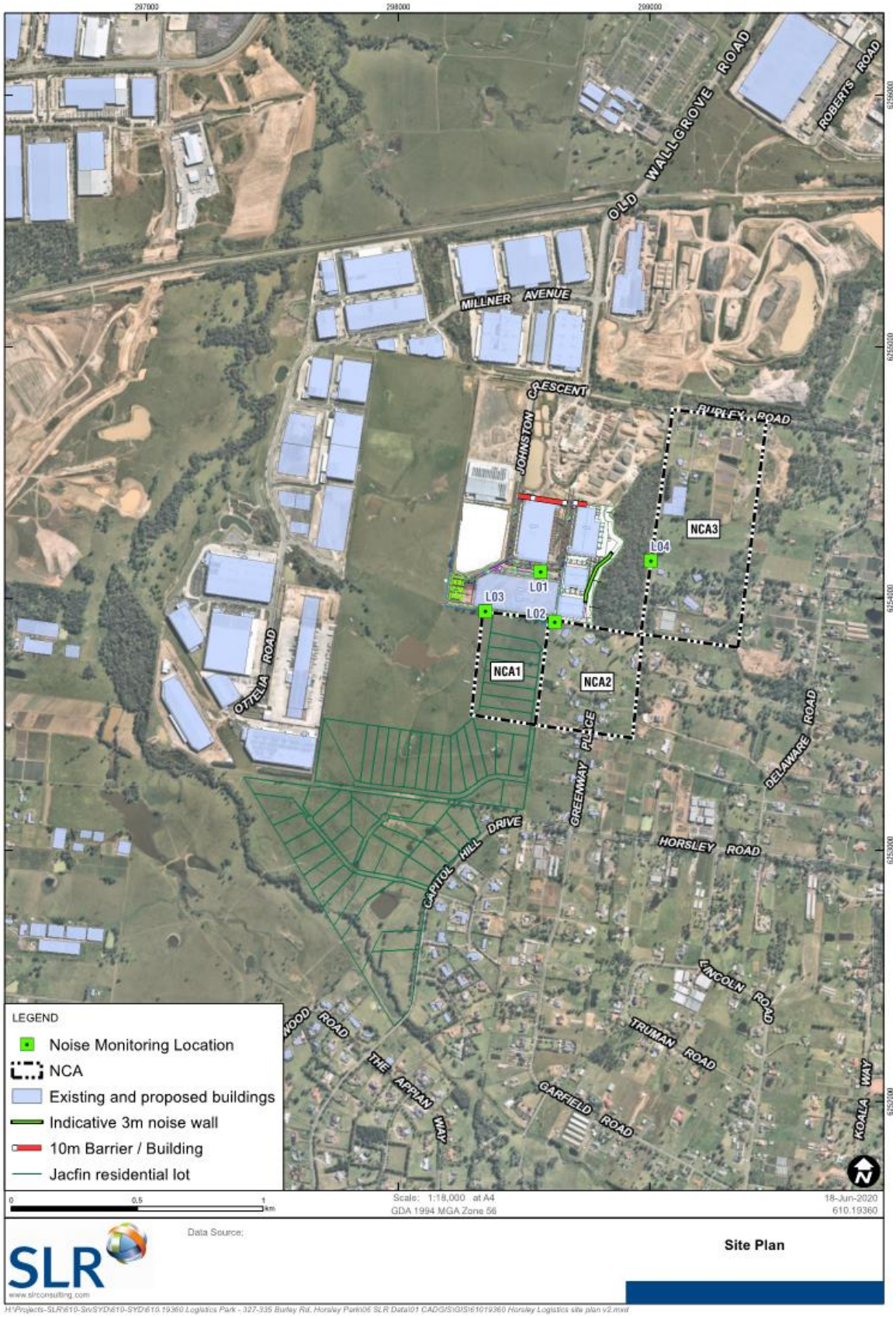
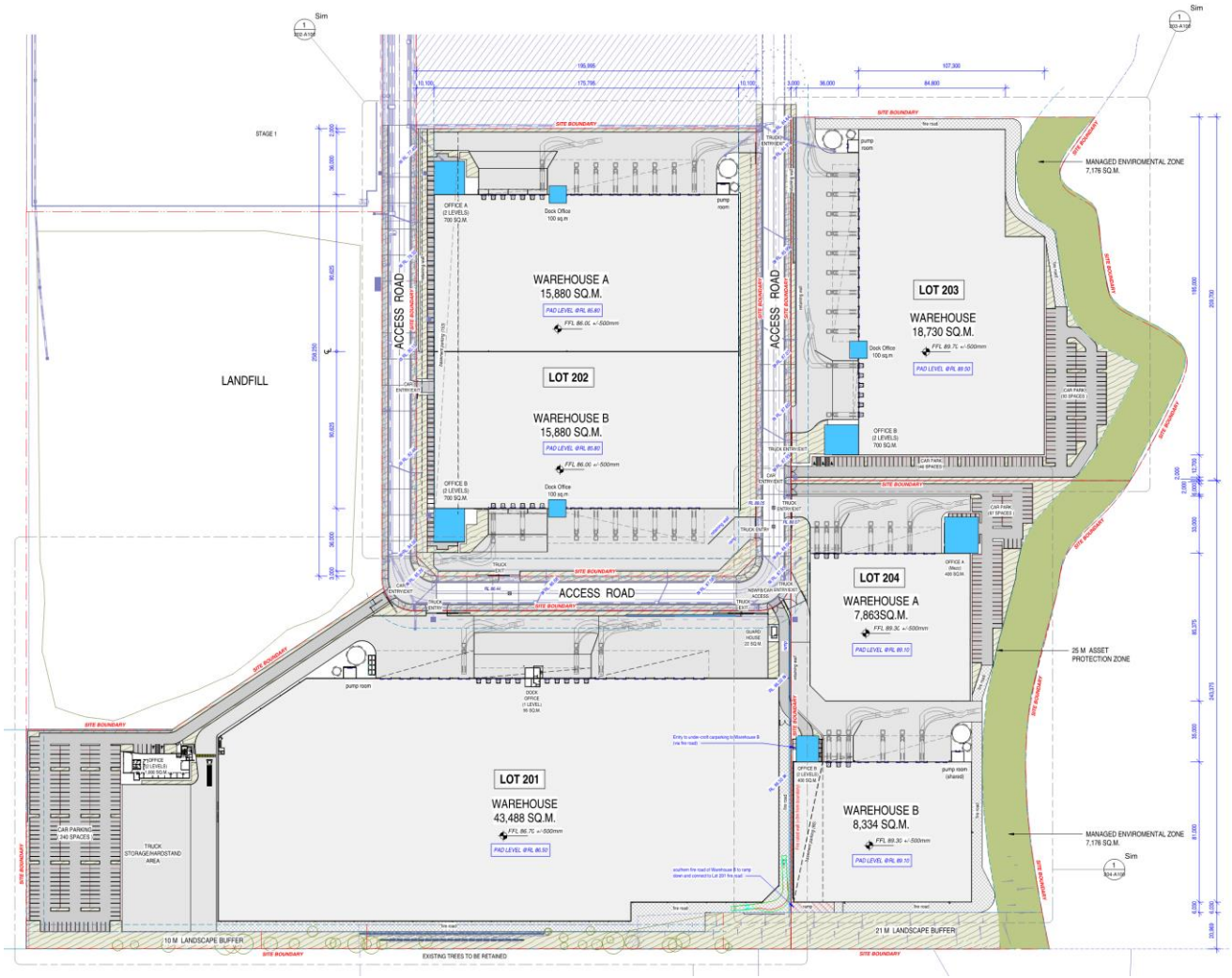


Figure 3 Proposed Masterplan Design



Note 1: Drawing provided by ESR, dated 6 May 2020.

2.2 Operating Hours

The development proposes to operate 24 hours per day, 7 days per week. Deliveries to and from the site may occur at any time during the operating hours, on any day of the week.

The identified sources of operational noise from the proposed development include:

- Heavy vehicles on site access roads and hardstands
- Light vehicles on site access roads and parking areas.
- Truck unloading operations including forklift use
- Mechanical plant

The access to the development is via Old Wallgrove Road, to the north of the development. The main access road runs through the centre of the development with the warehouses, hardstands and parking areas to either side.

2.3 Nearest Sensitive Receivers

The area surrounding the development has been divided into three Noise Catchment Areas (NCAs). The NCAs group together sensitive receivers with similar existing noise environments.

The NCAs and sensitive receivers in the area around the development are detailed in **Table 1** and are shown in **Figure 2.**

Table 1 Sensitive Receivers

NCA	Direction from Development	Description
NCA01	South	This NCA includes proposed receivers to the south of the development (Jacfin) where the noise environment is currently influenced by industrial noise from the CSR Quarry site and other industrial sites. Distant road traffic, natural noises (such as wind and insects), and local traffic on surrounding roads also influence the noise environment in this NCA. The receivers in this NCA are proposed to be detached residential dwellings. The closest residential receivers to the site boundary are likely to be around 20 m to the south.
NCA02	South	This NCA includes existing receivers to the south of the development where the noise environment is currently influenced by industrial noise from the CSR Quarry site and other industrial sites. Distant road traffic, natural noises (such as wind and insects), and local traffic on surrounding roads also influence the noise environment in this NCA. The receivers close to the development in this NCA include scattered rural residential dwellings with associated commercial/shed structures. The closest residential receivers to the site boundary are around 20 m to the south.
NCA03	East	This NCA includes receivers to the east of the development where the noise environment is influenced by distant road traffic noise, natural noises (such as wind and insects), and local road traffic on Delaware Road. The receivers in this NCA are primarily scattered rural residential dwellings with associated commercial/shed structures. The closest residential receivers to the site boundary are around 200 m to the east.

2.4 Development Consent DA 893.1/2013 and Modifications

Fairfield City Council DA 893.1/2013 and subsequent modifications include the Lot 103 DP 1214912 development site and the Notice of Determination includes reference to the following acoustic reports:

- TTM Consulting Pty Ltd report 14SYA0026 R0_2, dated 21 August 2014
- TTM Consulting Pty Ltd report 14SYA0026 R03_2, dated 13 February 2015

The existing Development Consent includes the following relevant Conditions relating to noise and vibration:

42. Unreasonable Noise and Vibration

The development, including operation of vehicles, shall be conducted so as to avoid unreasonable noise or vibration and cause no interference to adjoining or nearby occupations. Special precautions must be taken to avoid nuisance in neighbouring residential areas, particularly from machinery, vehicles, warning sirens, public address systems and the like.

63. Compliance Noise Monitoring

During the period of construction works, compliance noise monitoring shall be carried out to determine the effectiveness of noise control measures stipulated within the Acoustic Assessment Report prepared by TTM Consulting Pty Ltd (Reference:14SYA0026 R0_2) dated 21 August 2014. Within two (2) months of the construction works commencing, an acoustic report shall be prepared and submitted to Council for its assessment and approval which includes but is not limited to the following information:

a) Any complaints received in relation to construction activities conducted at the premises.

b) Verification that noise levels emitted from the premises and measured at identified noise sensitive receivers, comply with all relevant assessment criteria detailed in the above mentioned report.

c) Where monitoring indicates that noise emissions exceed the assessment criteria, the report shall provide recommendations in relation to additional noise attenuation measures required to be implemented in order to meet the criteria.

The above mentioned TTM Consulting acoustic reports are high level concept reports that include indicative noise source locations and mitigation measures. Operational noise emission criteria were set in these reports using the NSW Industrial Noise Policy (INP, 2000), which has been superseded by the EPA's Noise Policy for Industry (NPfI, 2017).

This report has been developed based on proposed layouts and vehicle movements and therefore provides recommendations for noise mitigation measures based on current input information and regulatory requirements. It is noted that the mitigation measures included in the TTM report, which included the existing earth bund to the South and rooftop plant screening have also been adopted in this assessment, along with additional noise barriers where further mitigation was found to be required.

This assessment includes noise monitoring carried out to determine project specific noise trigger levels in accordance with the requirements of the NPfI.

It is anticipated that construction noise monitoring may also be applicable to any future consent in accordance with the requirements of the NSW Interim Construction Noise Guideline (ICNG, 2009).

3 Existing Environment

3.1 Unattended Ambient Noise Monitoring

During March, unattended noise monitoring was completed at four locations around the boundary of the development to measure the existing ambient noise environment. The noise logger locations were selected with consideration of other noise sources which may influence the measurements, security of noise monitoring equipment and gaining access permission from residents and landowners. The noise logger locations are shown in **Figure 2**. There is an existing earth bund located along part of the Southern boundary which was in place during the background noise survey.

Calibration of the loggers was checked prior to and following measurements, and drift in calibration did not exceed acceptable tolerances. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

The measured data was processed with reference to the NSW EPA's *Noise Policy for Industry* (NPfI) and the data was filtered to remove extraneous noise events and periods affected by adverse weather conditions, based on Bureau of Meteorology automated weather station data (Horsley Park AWS 67119). A summary of the background noise monitoring locations and results is provided in **Table 2** and **Table 3**.

Table 2 Ambient Noise Monitoring Locations

Noise Monitoring Location ID	Representative Receiver Area	Monitoring Dates	Location Details
L01	n/a (used to determine the influence of the CSR quarry at the other monitoring locations.	10 March 2020 to 24 March 2020	Noise logger deployed in the centre of the existing CSR quarry site.
L02	NCA02	10 March 2020 to 24 March 2020	Noise logger deployed in an open area at the southern site boundary, adjacent to the nearest residence in NCA02.
L03	NCA01	10 March 2020 to 24 March 2020	Noise logger deployed in an open area at the southern site boundary, adjacent to the nearest proposed residence in NCA01.
L04	NCA03	10 March 2020 to 24 March 2020	Noise logger deployed in the conservation area at the eastern site boundary, adjacent to the nearest residence in NCA03.

Table 3 Summary of Ambient Noise Levels

Location ID	Measured Noise Level (dBA)[1]					
	Daytime		Evening		Night-time	
	RBL	LAeq	RBL	LAeq	RBL	LAeq
L01 Quarry	37	66	35	42	34	50
L02	35	66	39	57	38	60
L03	39	63	39	64	38	61
L04	39	53	38	46	36	42

Note 1: The Rating Background Levels (RBLs) and LAeq noise levels have been obtained from the measured data using the calculation procedures outlined in the NPfI.

Note 2: NPfI time periods – Day: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays and public holidays; Evening: 6:00 pm to 10:00 pm; Night: the remaining periods.

Daily graphs representing the measured noise levels are presented in **Appendix B**. The graphs represent each 24-hour period during the survey and show the L_{Amax}, L_{A10}, L_{Aeq} and L_{A90} noise levels in 15-minute intervals.

3.2 Attended Noise Monitoring

Short-term attended noise monitoring was conducted on-site on Friday 15 November 2019. The purpose of the attended measurements was to determine the various contributors to the acoustic environment. A summary of the attended monitoring is provided in **Appendix B**.

The attended measurements indicated that the ambient noise during the daytime was dominated by quarrying activities from the CSR quarry site, with the influence becoming more distant and natural noises (such as wind and insects) becoming more prominent at greater distances from the site.

3.3 Prevailing Weather Conditions

Certain meteorological/weather conditions can increase noise levels. This can occur during temperature inversions (where temperatures increase with height above ground level), or where there is a wind gradient (where wind speed increases with height).

In order to determine the prevailing weather conditions for the development area, 12 months of weather data (January 2016 to December 2016) was obtained from the Bureau of Meteorology automatic weather station at Horsley Park, which is approximately 6 km to the east of the development. This data was analysed to determine the frequency of noise-enhancing wind and temperature inversion conditions which may affect noise levels at the site. Weather data from 2016 was used as it is consistent with the analysis undertaken for the nearby Oakdale South industrial precinct and as such, would result in a consistent modelling of weather effects across both industrial sites.

3.3.1 Wind

Wind has the potential to increase noise at a receiver when it is light and stable and blows from the direction of the source of noise to the receiver. At higher wind speeds, the noise produced by the wind can obscure noise generated from industrial and transport sources.

Wind effects need to be considered where wind is a feature of the project area. The NPfI states that where wind blows from the source to the receiver at speeds up to 3 m/s for more than 30% of the daytime, evening or night-time in any season, then wind is considered to be a feature of the area and noise level predictions must be made under these conditions.

The measured weather data was analysed to determine the frequency of occurrence of wind speeds up to 3 m/s in each period. The results of the wind analysis for the daytime, evening and night-time periods are presented in **Table 4**, **Table 5** and **Table 6**, respectively. In each table, the wind direction and percentage occurrence are those dominant during each season.

Table 4 Seasonal Frequency of Occurrence of Wind Speed Intervals in 2016 – Daytime

Season	Dominant Wind Direction	Frequency of Occurrence			
		Calm	Up to 2 m/s	2 to 3 m/s	Up to 3 m/s
Annual	N	10.2%	14.7%	5.7%	20.4%
Summer	NNE	11.2%	14.3%	7.3%	21.6%
Autumn	N	10.9%	15.9%	5.9%	21.8%
Winter	NW	12.8%	18.8%	5.6%	24.4%

Table 5 Seasonal Frequency of Occurrence of Wind Speed Intervals in 2016 – Evening

Season	Dominant Wind Direction	Frequency of Occurrence			
		Calm	Up to 2 m/s	2 to 3 m/s	Up to 3 m/s
Annual	ESE	17.8%	9.1%	6.1%	15.2%
Summer	E	9.5%	10.4%	10.3%	20.8%
Autumn	S	25.4%	12.1%	6.3%	18.4%
Winter	WSW	24.1%	15.3%	8.2%	23.5%

Table 6 Seasonal Frequency of Occurrence of Wind Speed Intervals in 2016 – Night-time

Season	Dominant Wind Direction	Frequency of Occurrence			
		Calm	Up to 2 m/s	2 to 3 m/s	Up to 3 m/s
Annual	SW	37.8%	17.9%	8.7%	26.6%
Summer	SSW	42.0%	18.7%	8.8%	27.5%
Autumn	SW, WSW	44.0%	21.0%, 20.7%	10.6%, 9.7%	**31.6%, 30.3%**
Winter	WSW	32.1%	17.6%	9.9%	27.5%

The above indicates that during the daytime and evening periods, winds of up to 3 m/s did not exceed the 30% threshold during any season. However, the 30% threshold was exceeded during the night-time period in autumn, in both the SW and WSW directions.

On this basis, assessment of noise-enhancing weather during the daytime and evening periods is not required, although consideration of noise-enhancing conditions (wind) for night time operations is required.

3.3.2 Temperature Inversions

Temperature inversions have the ability to increase noise levels by focusing sound waves towards sensitive receivers. Temperature inversions occur predominantly at night-time when the atmosphere is stable and temperatures are cooler. For a noise-enhancing temperature inversion to be a significant characteristic of the area, the NPfI requires it to occur for at least 30% of the total night-time during any one season. This equates to approximately two nights per week.

There are seven atmospheric stability classes, ranging from extremely stable to extremely unstable, and these are shown in **Table 7**.

Table 7 Description of Atmospheric Stability Classes

Atmospheric Stability Class	Category Description
A	Extremely unstable
B	Moderately unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Moderately stable
G	Extremely stable

The measured weather data has been analysed to determine the frequency of occurrence of each stability class and is presented in **Table 8**. Noise-enhancing temperature inversions are categorised as atmospheric stability Class F or Class G.

Table 8 Night-time Stability Class Distribution – 2016

Stability Class	Frequency of Occurrence				
	Annual	Summer	Autumn	Winter	Spring
A	0.0%	0.0%	0.0%	0.0%	0.0%
B	0.0%	0.0%	0.0%	0.0%	0.0%
C	0.0%	0.0%	0.0%	0.0%	0.0%
D	39.5%	37.4%	34.7%	45.2%	41.5%
E	12.0%	11.7%	10.5%	12.4%	13.6%
F	12.9%	11.2%	13.7%	14.0%	12.9%
G	**35.5%**	**39.7%**	**41.1%**	28.5%	**32.0%**
F+G	**48.4%**	**50.9%**	**54.8%**	**42.4%**	**44.9%**

The above indicates that temperature inversions of Class F or Class G occur more than 30% of the night-time period during all four seasons. Therefore, noise-enhancing temperature inversions are required to be included in the assessment of noise impacts during the night-time period.

4 Noise and Vibration Assessment Criteria

4.1 Secretary's Environmental Assessment Requirements (SEARs)

The requirements of the project SEARs (SSD 10436) in relation to noise are reproduced in **Table 9**.

Table 9 Project SEARs (SSD 10436) Relevant to Noise and Vibration

Requirement	Where Addressed in this Document
• Description of all potential noise sources during the construction and operational phases of the development, including on and off-site traffic noise.	Construction noise and vibration – refer to **Section 5** Operational noise – refer to **Section 6**
• A cumulative noise impact assessment of all potential noise sources including those in nearby industrial developments in accordance with relevant NSW Environment Protection Authority guidelines.	Refer to **Section 6**
• Details of noise mitigation, management and monitoring measures including those approved under development consent DA 893.1/2013 and subsequent modifications.	Construction mitigation measures – refer to **Section 5.6** Operational mitigation measures – refer to **Section 6.3**

4.2 State Environment Planning Policy (Western Sydney Employment Area) 2009

The aim of this policy is to protect and enhance the land to which this Policy applies (the Western Sydney Employment Area) for employment purposes. Specifically, the particular aims of this Policy are as follows:

- to promote economic development and the creation of employment in the Western Sydney Employment Area by providing for development including major warehousing, distribution, freight transport, industrial, high technology and research facilities,
- to provide for the co-ordinated planning and development of land in the Western Sydney Employment Area,
- to rezone land for employment or environmental conservation purposes,
- to improve certainty and regulatory efficiency by providing a consistent planning regime for future development and infrastructure provision in the Western Sydney Employment Area,
- to ensure that development occurs in a logical, environmentally sensitive and cost-effective manner and only after a development control plan (including specific development controls) has been prepared for the land concerned,

to conserve and rehabilitate areas that have a high biodiversity or heritage or cultural value, in particular areas of remnant vegetation. The Site (as well as the CSR operations, Austral Bricks Plant 3 and proposed Horsley Park Warehousing Hub and Oakdale East Project) is located within the WSEA and therefore the aims of the WSEA SEPP apply to the Development Site The following is an extract from the WSEA SEPP in relation to noise:

Development adjoining residential land

(1) This clause applies to any land to which this Policy applies that is within 250 metres of land zoned primarily for residential purposes.

(2) The consent authority must not grant consent to development on land to which this clause applies unless it is satisfied that—

(d) noise generation from fixed sources or motor vehicles associated with the development will be effectively insulated or otherwise minimised

The assessment of operational noise from the site will be undertaken in accordance with the *Noise Policy for Industry* (NPfI) which sets out the NSW Environment Protection Authority's requirements for the assessment and management of noise from industry. By undertaking an assessment in accordance with the NPfI, the principles outlined in the WSEA SEPP for operational noise will be addressed. The WESA SEPP does not include any development standards or provisions for construction noise, which will be addressed through an assessment in accordance with the NSW *Interim Construction Noise Guideline*

4.3 Construction Noise Guidelines

4.3.1 NSW Interim Construction Noise Guideline (ICNG)

The NSW *Interim Construction Noise Guideline* (ICNG) sets out ways to assess and manage the impacts of construction noise on residences and other sensitive land uses in NSW. The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers based on the existing background noise in the area.

The NMLs are not mandatory limits, however where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

4.3.1.1 Residential Receivers

The approach provided in the ICNG for determining NMLs for a project at residential receivers is presented in **Table 10**.
More stringent requirements are placed on works that are completed outside of Standard Construction Hours which reflects the greater sensitivity of communities to noise impacts during these periods.

Table 10 Determination of NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$[1]	How to Apply
Standard hours Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	RBL + 10 dBA	• The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practises to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

	Highly Noise Affected
	75 dBA
		• The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise.
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
		  • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences.
		  • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside recommended standard hours	RBL + 5 dBA	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practises have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1 The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW *Noise Policy for Industry*.

4.3.1.2 Sleep Disturbance

Where construction works are planned to extend over more than two consecutive nights, the ICNG recommends that an assessment of sleep disturbance impacts be completed.

A method for assessing sleep disturbance is contained in the EPA's *Noise Policy for Industry* (NPfI). Although the NPfI sleep disturbance screening level relates to industrial noise, it is also considered relevant for reviewing potential impacts from construction noise as a screening level to identify the need for further assessment.

The NPfI notes that a detailed maximum noise level assessment should be undertaken where a project results in night-time noise levels which exceed:

- 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

4.3.1.3 Summary of Residential NMLs

The residential NMLs for the project have been determined using the background noise monitoring and are shown in **Table 11**.

Table 11 Residential Receiver Construction NMLs

NCA	Representative Background Monitoring Location	RBL, dBA			NML (dBA $L_{Aeq(15minute)}$)				Sleep Disturbance Screening Level (L_{Amax} dBA)
					Standard Construction Hours (RBL+10dB)	Out of Hours (RBL+5dB)			
		Day	Evening	Night	Day	Day	Evening	Night	Night
NCA01	L03	35	35 [1]	35 [1]	45	40	40	40	52
NCA02	L02	39	39	38	49	44	44	43	52
NCA03	L04	39	38	36	49	44	43	41	52

Note 1: RBL reduced to be no higher than the daytime RBL.

4.4 Construction Road Traffic Noise Guidelines

The potential impacts from construction traffic on public roads are assessed under the *Road Noise Policy* (RNP) and Roads and Maritime Services *Construction Noise and Vibration Guideline* (CNVG).

To assess noise impacts that may result from construction traffic, an initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2 dB with the addition of construction traffic at nearby residential and other sensitive receivers. Where this is considered likely further assessment is required using the RNP base criteria shown in **Table 12**.

Table 12 RNP Criteria for Assessing Construction Vehicles on Public Roads

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

4.5 Construction Ground-borne Noise Guidelines

Construction works can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Vibration can be transmitted through the ground and into the structure of nearby buildings, which can then create audible noise impacts inside buildings. The ICNG provides evening and night-time ground-borne noise NMLs for residences to protect the amenity and sleep of residents. The ICNG ground-borne noise NMLs are:

- Evening $L_{Aeq(15minute)}$ 40 dBA
- Night-time $L_{Aeq(15minute)}$ 35 dBA

The NMLs only apply where internal ground-borne noise levels are higher than noise transmitted through the air. This situation can occur where buildings near to construction works have high performing facades which attenuate the airborne component or where sensitive internal areas do not have facades which face the construction works.

4.6 Construction Vibration Guidelines

The effects of vibration on buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed
- Those where the building contents may be affected
- Those in which the integrity of the building or the structure itself may be prejudiced.

4.6.1 Human Comfort Vibration

People can perceive vibration impacts when vibration generating construction works are located close to occupied buildings.

Vibration from construction works tends to be intermittent in nature and the EPA's *Assessing Vibration: a technical guideline* (2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in **Table 13**. Vibration generating activities should be designed to achieve the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum may be used.

Table 13 Vibration Dose Values for Intermittent Vibration

Building Types	Assessment Period	Vibration Dose Value ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg hospital operating theatres, precision laboratories)	Day or Night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or Night-time	0.40	0.80

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods, and is dependent on the level of vibration as well as the duration.

4.6.2 Effects on Building Contents

Humans perceive vibration at levels well below those likely to cause damage to building contents. For most receivers, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes which can have more stringent vibration requirements than those for human comfort, are located in buildings near to construction works. No such receivers have been identified in the study area.

4.6.3 Cosmetic Damage Vibration

If vibration from construction works is high enough it can cause damage to affected buildings. The levels of vibration required to cause cosmetic damage tend to be at least an order of magnitude (10 times) higher than those at which people can perceive vibration. Examples of damage that can occur includes cracks or loosening of drywall surfaces, cracks in supporting columns and loosening of joints.

Structural damage vibration limits are contained in British Standard BS 7385.

BS 7385

British Standard BS 7385 recommends vibration limits for transient vibration which are judged to give a minimal risk of vibration induced damage to effected buildings. The limits for residential and industrial buildings are shown in **Table 14**.

Table 14 Transient Vibration Guide Values – Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Note 1: Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values may need to be reduced by up to 50%.

For heritage buildings, the standard states that *"a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive"*.

4.6.4 Minimum Working Distances for Vibration Intensive Works

Minimum working distances for typical vibration intensive construction equipment are provided in the CNVG and are summarised in **Table 15**. The minimum working distances are for both cosmetic damage (from BS 7358) and human comfort (from the NSW EPA Vibration Guideline) and are based on empirical data which suggests that where works are further from receivers than the quoted minimum distances then impacts are not considered likely.

Table 15 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Rating / Description	Minimum Distance	
		Cosmetic Damage (BS 7385)	Human Response (NSW EPA Guideline)
Vibratory Roller	< 50 kN (Typically 1-2t)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4t)	6 m	20 m
	< 200 kN (Typically 4-6t)	12 m	40 m
	< 300 kN (Typically 7-13t)	15 m	100 m
	> 300 kN (Typically 13-18t)	20 m	100 m
	> 300 kN (Typically > 18t)	25 m	100 m
Small Hydraulic Hammer	300 kg - 5 to 12t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg - 12 to 18t excavator	7 m	23 m
Large Hydraulic Hammer	1600 kg - 18 to 34t excavator	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 to 100 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

The minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions. The distances apply to cosmetic damage of typical buildings under typical geotechnical conditions.

4.7 Operational Noise Guidelines

4.7.1 Noise Policy for Industry

The *Noise Policy for Industry* (NPfI) was released in 2017 and sets out the NSW Environment Protection Authority's (EPA's) requirements for the assessment and management of noise from industry in NSW.

4.7.1.1 Trigger Levels

The NPfI describes 'trigger levels' which indicate the noise level at which feasible and reasonable noise management measures should be considered. Two forms of noise criteria are provided – one to account for 'intrusive' noise impacts and one to protect the 'amenity' of particular land uses.

- The **intrusiveness** of an industrial noise source is generally considered acceptable if the L_{Aeq} noise level of the source, measured over a period of 15 minutes, does not exceed the background noise level by more than 5 dB. Intrusive noise levels are only applied to residential receivers. For other receiver types, only the amenity levels apply.
- To limit continual increases in noise levels from the use of the intrusiveness level alone, the ambient noise level within an area from all industrial sources should remain below the recommended **amenity** levels specified in the NPfI for that particular land use.

For this assessment, the area surrounding the proposal is 'rural' given its existing setting and zoning.

4.7.1.2 Impacts with Surrounding Industrial Developments

The methodology within the NPfI requires the PTNL to be "shared" amongst the noise-makers. Operational noise limits for NCA1 and NCA2 receivers have been previously established for Oakdale South Estate (SSD 6917). These limits are reproduced in **Table 16** below, with the relevant NCA noted

Table 16 Oakdale South Estate Operational Noise Limits – Residential

Location (NCA)	Day	Evening	Night
	LAeq(15minute)	LAeq(15minute)	LAeq(15minute)
L1 North of Warragamba Pipeline (N/A)	37	37	37
L2 Horsley Park (NCA2)	39	39	39
L3 Kemps Creek, Mt Vernon, Jacfin and Capitol Hill (NCA1)	40	40	40

The Project Noise Trigger Level (PNTL) has adopted the noise limits detailed in **Table 16** for both NCA1 and NCA2. This was done to ensure a consistent approach with the adjoining commercial operators in addition to establishing noise limits which were not influenced by quarry operations at the potentially most impacted receivers. This approach results in a lower PNTL for NCA1 and NCA2 than what would have been established if the PNTL were derived using recent noise monitoring. A discussion on the cumulative impacts from the operation of multiple industrial sites is presented in **Section 6.3.4**.

4.7.1.3 Project Specific Criteria

The noise emission trigger levels for operational noise generated by the development are provided in **Table 17**. The Project Noise Trigger Level (PNTL) is the lowest value of the intrusiveness or amenity noise level for each period and are shown below in bold.

Table 17 Project Trigger Noise Levels

NCA	Receiver Type	Period	Recommended Amenity Noise Level $L_{Aeq(period)}$ (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
				RBL[1]	$L_{Aeq(period)}$	Intrusiveness	Amenity[2,3]
NCA1[4]	Residential	Day	50	39	63	**40**[4]	48
		Evening	45	39	64	**40**[4]	43
		Night	40	38	61	**40**[4]	38
NCA2[4]	Residential	Day	50	35	66	**39**[4]	48
		Evening	45	35[5] (39 actual)	57	**39**[4]	43
		Night	40	35[5] (38 actual)	60	**39**[4]	38
NCA3[4]	Residential	Day	50	39	53	**44**	48
		Evening	45	38	46	**43**	**43**
		Night	40	36	42	41	**38**

Note 1: RBL = Rating Background Level.

Note 2: The recommended amenity noise levels have been reduced by 5 dB to give the project amenity noise levels due to other sources of industrial noise being present in the area, as outlined in the NPfI.

Note 3: The project amenity noise levels have been converted to a 15 minute level by adding 3 dB, as outlined in the NPfI.

Note 4: Project Noise Trigger Level for NCA1 and NCA2 based on established cumulative limits for these receivers – refer **Section 4.7.1.2**.

Note 5: RBL reduced to be no higher than the daytime RBL.

4.7.2 Sleep Disturbance

Guidance for assessing the potential for sleep disturbance impacts on nearby residences is provided in Section 2.5 of the NPfI, which states:

> *Where the subject development/premises night-time noise levels at a residential location exceed:*
>
> - $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
> - L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,
>
> *a detailed maximum noise level event assessment should be undertaken*

Note that the $L_{Aeq(15minute)}$ criteria would be equal to or higher than the Project Noise Trigger Levels outlined in **Table 17**. As such, the assessment against Project Noise Trigger Levels is considered to address this part.

The night-time sleep disturbance L_{Amax} screening noise levels for the residential areas in the vicinity of the development are presented in **Table 18**.

Table 18 Night-time Sleep Disturbance Screening Noise Levels

Residential Receiver Area	Noise Level (dBA)	
	Measured Night-time RBL	Sleep Disturbance Screening Noise Level (L_{Amax})
NCA1	38	52
NCA2	35 (38 actual)	52
NCA3	36	52

Where the sleep disturbance screening noise level is predicted to be exceeded then a detailed maximum noise level event assessment should be undertaken.

The detailed assessment should discuss the predicted level of the events, the exceedance of the screening level, existing maximum noise levels, and consider guidance from current literature regarding sleep disturbance, such as the *Road Noise Policy*.

4.8 Operational Road Traffic Noise Guidelines

The potential impacts from operational traffic once it moves off-site and onto public roads are assessed under the NSW EPA *Road Noise Policy* (RNP).

To assess noise impacts that may result from off-site operational road traffic, an initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2 dB with the addition of the traffic from the development at nearby residential and other sensitive receivers. Where this is considered likely further assessment is required using the RNP base criteria shown in **Table 19**.

Table 19 RNP Criteria for Assessing Operational Vehicles on Public Roads

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

5 Construction Noise and Vibration Assessment

Exact details on the construction of the development are not currently known at this stage of the project. As such, it has been necessary to make certain assumptions as to the type and location of equipment together with details regarding construction activities. These assumptions are defined in the following sections.

5.1 Construction Works

5.1.1 Working Hours

Where possible, the majority of construction works would be undertaken in accordance with the ICNG during the standard daytime construction working hours of:

- 7:00 am to 6:00 pm Monday to Friday
- 8:00 am to 1:00 pm on Saturdays.

Where works are required to be undertaken outside standard construction hours, the works will be conducted in accordance with an approved Out of Hours protocol to be prepared, submitted and approved as part of the Construction Environmental Management Plan (CEMP) prior to commencement of the works.

5.1.2 Construction Works Scenarios

The assessment uses 'realistic worst-case' scenarios to determine the potential airborne noise impacts from the noisiest 15-minute period for each work scenario, as required by the ICNG.

Construction activities would occur sequentially, and it is expected that there would be relatively long periods where construction noise levels are much lower than the worst-case levels presented in this assessment. There would also be times when works are not audible at receivers due to no noisy items of equipment being used.

Sound power levels for the typical operation of construction equipment used in the modelling have been taken from verified test data and global standards that form part of SLR's noise database and are listed in **Appendix C**.

Table 20 Construction Scenario Descriptions

Scenario	Description
Site establishment	These works are required to establish the construction compounds and works areas. This scenario would works such as setup of perimeter fencing, compound facilities, signage, lighting, etc. Site establishment works would require the use of noisy earthmoving equipment for activities such as diversion of catchment drains.
Bulk earthworks	This scenario covers the majority of earthmoving activities which would require the use of noisy earthmoving equipment for activities such as: - Stripping of top soil - Stockpiling and relocation and compaction of selected material for earthworks balance and batter stabilization - Construction of fill embankments including foundation drainage - Importation, placement and compaction of fill materials to meet earthworks balance requirements Earthworks will be limited to levelling of existing constructed pad levels (main pad levels undertaken under separate consent).
Infrastructure works	These works are required to construct the infrastructure components of the development

5.2 Construction Airborne Noise Assessment

SoundPLAN has been used for modelling the airborne noise emissions from construction of the development using the ISO 9613 noise prediction algorithms. The three-dimensional model includes ground topography, buildings and representative noise sources.

5.2.1 Overview of Predicted Construction Airborne Noise Levels

The following overview is based on the predicted impacts at the most affected receivers and is representative of the realistic worst-case noise levels (without additional mitigation) that are likely to occur during construction. Receivers which are further away from the works and/or shielded from view would have substantially lower impacts. The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

The assessment shows the predicted impacts based on the exceedance of the management levels, as per the categories in **Table 21**. The likely subjective response of people affected by the impacts is also shown in the table, noting that the subjective response would vary and depends on the period in which the impacts occur (eg people are generally less sensitive to impacts during the daytime and more sensitive in the evening and night-time).

Table 21 Exceedance Bands and Corresponding Subjective Response to Impacts

Exceedance of Management Level	Likely Subjective Response	Impact Colouring
No exceedance	No impact	
1 to 10 dB	Minor to marginal	
11 dB to 20 dB	Moderate	
>20 dB	High	

The noise levels are also shown as a range (eg 55 to 68 dBA), which represents the likely noise levels when works are 'near' to 'far' from a particular receiver.

For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted at the most-exposed receiver, as the noise levels presented in this report are based on each scenario occurring at the site boundary. No predictions have been included for NCA01 as there are currently no sensitive receivers as the land is yet to be developed. In the instance that development of NCA01 were to occur prior to construction of the site, the CNVMP which will be prepared prior to the commencement of construction works will include predictions to NCA01.

Table 22 Predicted Worst-Case Construction Airborne Noise Levels – Standard Daytime Construction Hours

Receiver Category	NCA	Day NML	Predicted Worst-case LAeq(15minute) Noise Level (dBA)					
			Site establishment		Bulk earthworks		Infrastructure works	
			Far	Near	Far	Near	Far	Near
Residential	NCA01	49	-	-	-	-	-	-
	NCA02	45	46	56	48	58	44	54
	NCA03	45	40	51	42	53	38	49

Legend
No Exceedance | 1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

The above assessment shows that:

- The highest construction noise impacts are predicted during bulk earthworks when construction equipment is located the southern portion of the site, near sensitive receivers in NCA02. Worst case noise levels are predicted to be up to 58 dBA which is a moderate exceedance of the daytime NML of 45 dBA. Nosie levels would be expected to drop to a minor noise exceedance (3dB above NML) when works are located in other portions of the site.
- Due to the large offset distance between the works and nearby receivers, the majority of construction works are predicted to be minor or compliant with NMLs.
- Implementation of feasible and reasonable construction noise mitigation measures should be undertaken where exceedances of the NMLs are predicted. Construction noise and vibration mitigation measures are discussed in **5.6.1**

5.2.1.1 Highly Noise Affected Residential Receivers

The assessment shows that the nearest receivers to the site are not predicted to be Highly Noise Affected (>75 dBA) during construction works. This is due to the large offset distance between the works and the nearby receivers.

5.2.1.2 Works Outside Standard Construction Hours

No works outside of standard construction hours are currently planned for the development.

Should the need for out of hours works arise, the works will be conducted in accordance with an approved Out of Hours protocol to be prepared, submitted and approved as part of the Construction Environmental Management Plan (CEMP) prior to commencement of the works.

5.3 Construction Road Traffic Noise Assessment

The construction road traffic (heavy vehicles and employee vehicles) is anticipated to access the site via Old Wallgrove Road, travelling from the Great Western Highway or M4 Motorway in the north, or M7 Motorway in the south.

No anticipated construction vehicle numbers have been provided in the Traffic Impact Assessment (TIA) for the development prepared by Ason Group (report reference P1328r01 dated 30 March 2020). It is noted in the TIA that construction traffic volumes are expected to be lower than the operational Stage 1 proposal.

5.4

5.4 Construction Ground-borne Noise

Construction works can cause ground-borne noise impacts in nearby buildings when vibration generating equipment is in use. Ground-borne noise impacts should be considered where the ground-borne noise levels are higher than noise transmitted through the air, such as where buildings near to construction works have high performing facades which attenuate the airborne component.

All receivers are sufficiently distant from the works for ground-borne noise impacts to be insignificant compared to airborne noise.

5.5 Construction Vibration Assessment

Vibration intensive items of plant proposed for use during the construction of the development would include rockbreakers and vibratory rollers. These items of equipment are proposed to be used primarily during enabling works and bulk earthworks.

Site specific vibration mitigation measures should be utilised where works requiring the use of vibration intensive items of plant are proposed within the minimum working distances of sensitive receivers (outlined in **Table 15**).

5.6 Construction Noise and Vibration Mitigation Measures

The ICNG acknowledges that due to the nature of construction works it is inevitable that there will be impacts where construction is near to sensitive receivers. Examples of potential mitigation and management measures which could be applied to the project to minimise the impacts are provided below.

Specific strategies would be determined as the project progresses and detailed in the Construction Environmental Management Plan (CEMP) for the project before any works begin. This plan provides a detailed assessment of the potential impacts from the work and define the site specific mitigation and management measures to be used to control the impacts, particularly where evening or night-time works are required.

5.6.1 Standard Mitigation

The Roads and Maritime *Construction Noise and Vibration Guideline* (CNVG) contains a number of standard measures for mitigating and managing construction impacts on development projects. Whilst it is acknowledge that this project is not a road project, the mitigation measures are considered suitable for all form of construction works.

The measures are shown in **Table 23** and should be applied where feasible and reasonable to minimise the impacts from the works as far as practicable.

Table 23 Recommended Standard Mitigation and Management Measures

Action Required	Applies To	Details
Management Measures		
Implementation of any project specific mitigation measures required.	Airborne noise	Implementation of any project specific mitigation measures required.
Implement community consultation or notification measures.	Airborne noise Ground-borne noise & vibration	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night time period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of 7 calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required. Website (If required) Contact telephone number for community Email distribution list (if required) Community drop in session (if required by approval conditions).
Site inductions	Airborne noise Ground-borne noise & vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.

Action Required	Applies To	Details
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Airborne noise Ground-borne noise & vibration	Where specified under Appendix C of the CNVG a noise verification program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Where required attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise Ground-borne noise & vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement of activities with the potential to cause property damage
Source Controls		
Construction hours and scheduling.	Airborne noise Ground-borne noise & vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours work	Ground-borne noise & vibration Airborne noise	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed 3 hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers.
Equipment selection.	Airborne noise Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits. Ensure plant including the silencer is well maintained.
Plant noise levels.	Airborne-noise	Noise generating equipment will be regularly checked and effectively maintained, including checking of hatches/enclosures regularly to ensure that seals are in good condition and doors close properly against seals
Use and siting of plant.	Airborne-noise	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers. Only have necessary equipment on site.

Action Required	Applies To	Details
Plan worksites and activities to minimise noise and vibration.	Airborne noise Ground-borne vibration	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. Very noise activities should be scheduled for normal working hours. If the work cannot be undertaken during the day, it should be completed before 11:00 pm. Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations such as before or during Higher School Certificate and at the end of higher education semesters. If programmed night work is postponed the work should be re-programmed and the approaches in this guideline apply again.
Reduced equipment power	Airborne noise Ground-borne vibration	Use only the necessary size and power
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction sites.	Airborne noise	Compounds and worksites will be designed to promote one-way traffic and minimise the need for vehicle reversing. Where practicable, work compounds, parking areas, and equipment and material stockpiles will be positioned away from noise-sensitive locations and take advantage of existing screening from local topography. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.
Engine compression brakes	Construction vehicles	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc.	Airborne noise	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities.	Airborne noise	Where practicable, work compounds, parking areas, and equipment and material stockpiles will be positioned away from noise-sensitive locations and take advantage of existing screening from local topography.
Receptor Control		
Structural surveys and vibration monitoring	Ground-borne vibration	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.

6 Operational Noise Assessment

Exact details on the various uses of the development are not currently known at this stage of the project. As such, it has been necessary to make certain assumptions as to the type and location of equipment together with details regarding operational measures. These assumptions are defined in the following sections.

6.1 Operational Noise Modelling

SoundPLAN has been used for modelling the noise emissions from the operation of the development using the CONCAWE industrial noise prediction algorithms. The three-dimensional model includes ground topography, buildings and noise sources.

Based on the analysis of prevailing weather conditions (refer to **Section 3.3**), the noise model includes standard weather conditions during the daytime and evening periods, with noise-enhancing weather conditions during the night-time period, using an F-class temperature inversion with a 3 m/s source to receiver drainage flow.

6.1.1 Noise Model Inputs

6.1.1.1 Vehicle Movements

In order to assess the operational noise impacts from the development, worst-case peak light and heavy vehicle movements have been modelled. Light vehicles have been modelled on the access roads and in the car parking areas, and heavy vehicles on the access roads and in the hardstand areas.

Vehicle volumes were taken from Table 11 of the Traffic Impact Assessment (TIA) prepared by Ason Group. The following assumptions have been adopted based the information provided:

- Daytime/Evening Peak 1-hour – 291 two-way vehicle movements (based on AM Peak)
- Night-time Peak 1-hour – 214 two-way vehicle movements (based on PM peak)
- Light vehicles comprise 50% of the total vehicles, with heavy vehicles the remaining 50%.

The modelled vehicle movements are detailed in **Table 24** for each individual lot.

Table 24 Daily and Peak Vehicle Movements by Lot Number

Lot Number	Peak		Total
	AM Peak 1hr (day)	PM Peak 1hr (day)	Daily
201	110	81	1176
202-A	44	32	463
202-B	43	32	463
203	52	38	552
204-A	21	16	224
204-B	21	16	224

The peak 1-hour movements outlined above were further broken down to peak 15-minute movements in order to assess the noise emissions against the PTNLs. The peak 1-hour movements have been assumed to be spread evenly across each 15-minute period.

External forklift movements (ie outside of the warehouses) have been modelled in the at-grade dock areas of the hardstands. It has been assumed that forklifts would operate continuously during any one 15-minute period. One forklift for every two heavy vehicles onsite has been modelled operating externally in the hardstand areas for each of the warehouses.

Sound power levels (SWLs) and speed assumptions for the modelled vehicle movements are outlined in **Table 25**.

Table 25 Sound Power Levels for Onsite Vehicle Movements

Noise Source	Sound Power Level (SWL), per vehicle	Average Speed
Heavy Vehicles	103 dBA[1]	25 km/h
Light Vehicles	96 dBA	40 km/h
Gas-powered Forklifts[2]	93 dBA	n/a

Note 1: Based on SLR's noise measurement database, this sound power level is typical of trucks travelling at low speeds, such as within industrial estates.

Note 2: If electric forklifts are proposed for the development, noise emissions from forklifts would be considerably lower than gas-powered forklifts.

In order to assess the possibility of sleep disturbance, heavy vehicle brake releases and reverse alarms (non-tonal) have been modelled along the heavy vehicle routes and in the hardstand areas of the development with a L_{Amax} SWL of 118 dBA, and light vehicles have been modelled with a L_{Amax} SWL of 100 dBA.

6.1.1.2 Mechanical Plant

Mechanical plant design and selection will be confirmed during the detailed design phase of the project. For the purposes of this assessment, external fixed mechanical plant has been modelled on the warehouse rooftops. Rooftop fixed plant units have been modelled with an indicative SWL of 90 dBA and an estimated number of rooftop units based on building area. **Table 26** details the breakdown of the modelled mechanical plant.

Table 26 Mechanical Plant

Lot Number	Number of rooftop mounted mechanical plant
201	15
202-A	6
202-B	6
203	7
204-A	3
204-B	3

6.2 Predicted Operational Noise Levels

The project will be constructed and commence operations as one stage. Overall noise levels associated with the site when fully operational (ie the Masterplan), have been considered together with cumulative noise emissions from other nearby industrial premises where applicable.

6.2.1 Masterplan Development

The predicted operational noise levels at the nearest receivers from industrial noise emissions for the fully operational masterplan development are summarised in **Table 27**. The results represent the simultaneous peak operation of all warehouses (Lots 201, 202, 203, and 204).

A combination of source and path noise control measures were included in the operational noise model to predict indicative potential reductions in noise impact. These measures comprised the following:

- Orientation of heavy vehicle loading areas and access routes away from the southern and eastern site boundary as far as practicable, to take advantage of screening afforded by the building envelope.
- An indicative 3 m high noise barrier along the site boundary to the east as illustrated in **Figure 1**.
- The addition of rooftop plant screening and limiting the rooftop plant to an effective SWL per unit 80 dBA.

Noise contours are provided for day/evening (standard weather) in and night-time (noise-enhancing weather) in **.**

Table 27 Masterplan Scenario - 3 m Noise Barrier and Mechanical Plant Screening

NCA	Receiver Type	Period (weather)	$L_{Aeq(15\ minutes)}$ Noise Level (dBA)				L_{Amax} Noise Level (dBA)			
			Project Noise Trigger Level	Predicted	Exceedance	Compliance	Sleep Disturbance Screening Noise Level	Predicted	Exceedance	Compliance
NCA01	Residential	Daytime (standard)	40	32	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	40	32	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	40	36	-	Yes	52	**49**	-	Yes
NCA02	Residential	Daytime (standard)	39	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	39	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	39	34	-	Yes	52	**58**	**6**	**No**
NCA03	Residential	Daytime (standard)	44	38	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	43	38	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	38	**43**	**5**	**No**	52	**59**	**7**	**No**

Note 1: **Bold** text indicates an exceedance of the project noise trigger level.

Note 2: L_{Amax} criteria are not applicable during this time period.

Figure 4 Predicted Noise Levels – Day/Evening – Standard Weather Conditions – Masterplan Scenario

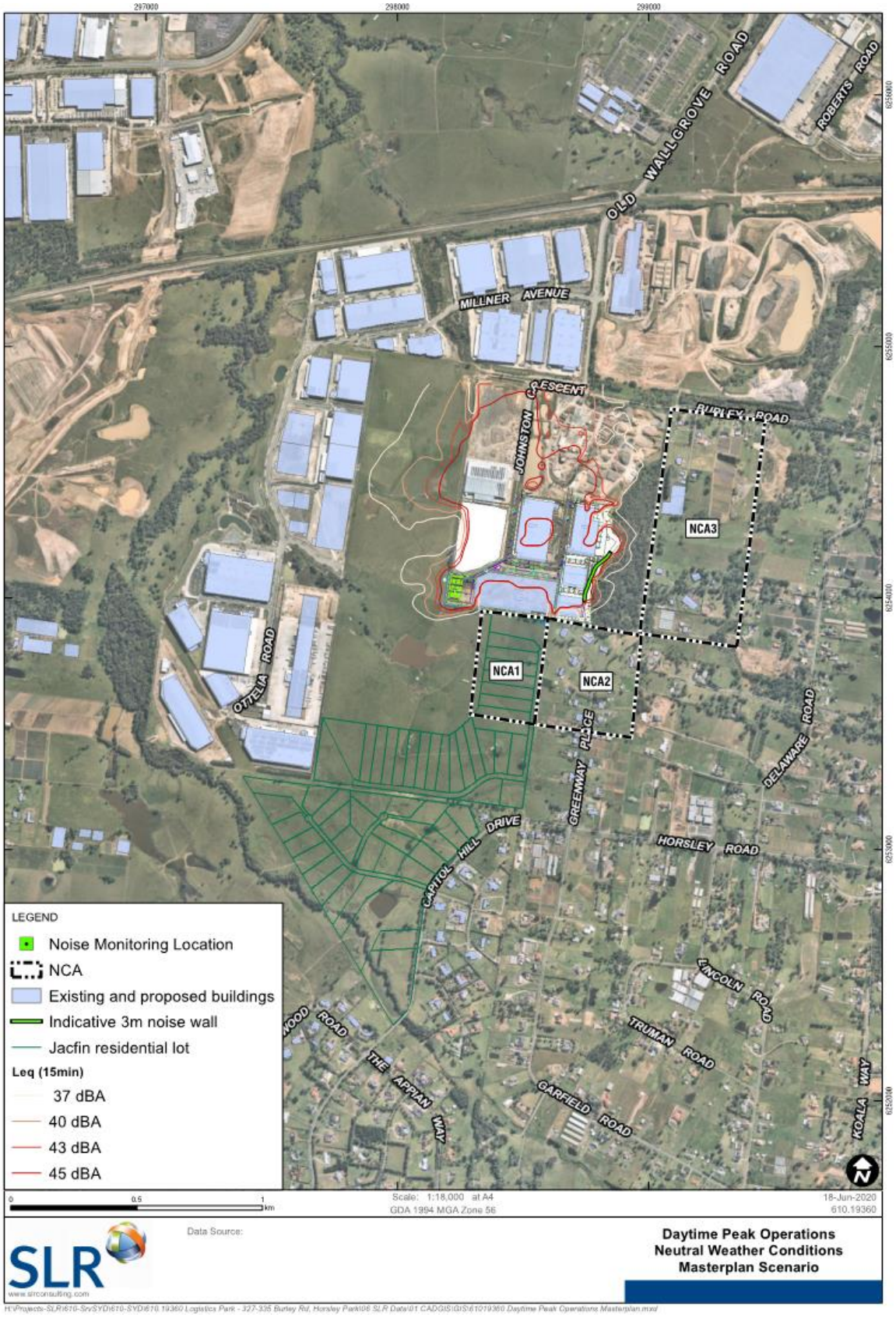


Figure 5 Predicted Noise Levels – Night – Noise-Enhancing Weather Conditions – Masterplan Scenario

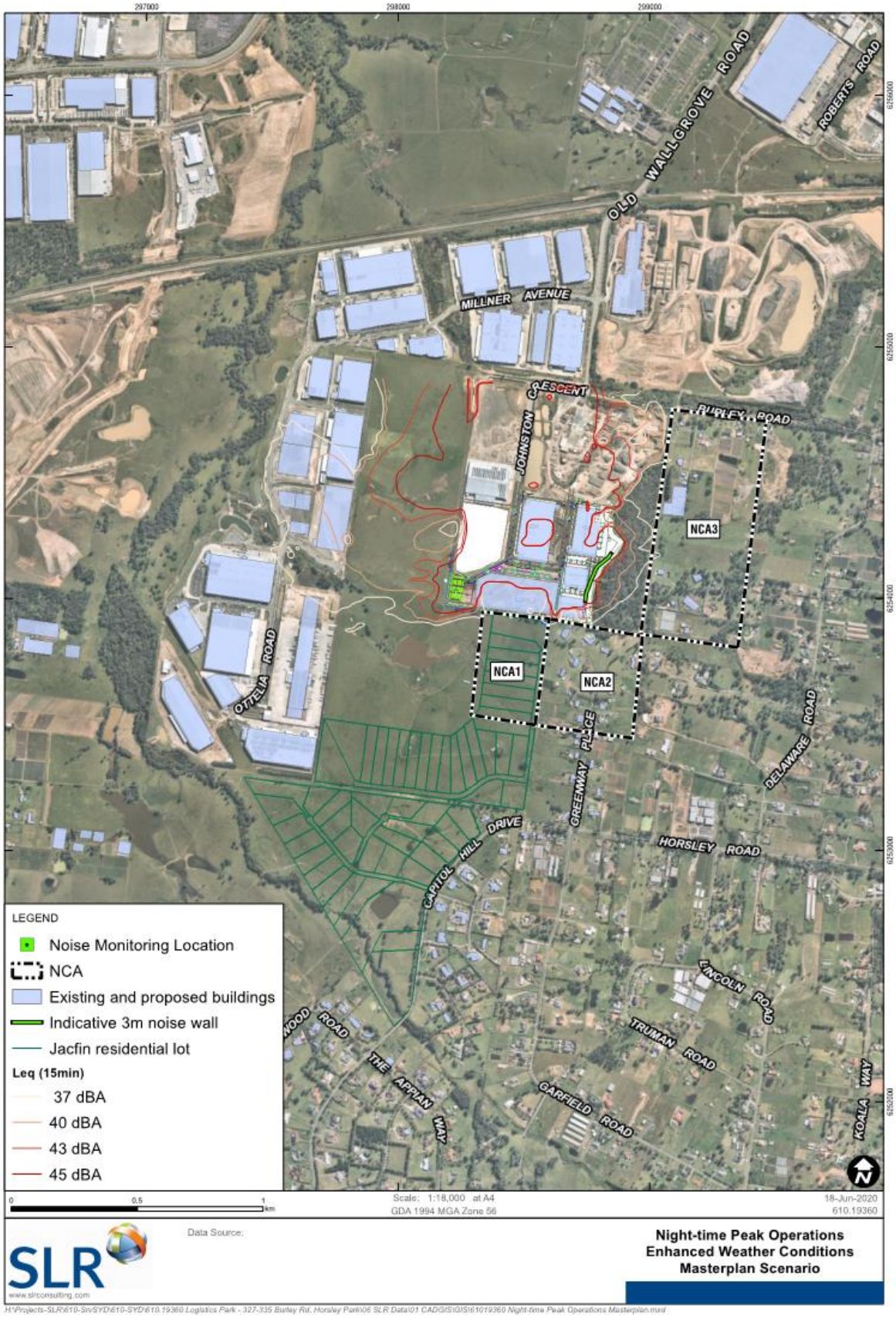


Table 27 shows that compliance is predicted at all receivers for daytime and evening operation.

For night-time operation under enhanced weather conditions, exceedances of up to 5 dB in operational L_{Aeq} noise levels and 7 dB in operational L_{Amax} noise levels are predicted.

From a review of the results in **Table 27** and noise contours in **Figure 5**, it is apparent that the exceedances in NCA3 are primarily impacting receivers to the northern end of the catchment, adjacent to the future Stage 3 development site. Until Stage 3 is constructed there would be no screening to the receivers located north of the Stage 2 site.

Reasonable and feasible operational noise mitigation and management measures should be considered to minimise noise impacts at the receivers where the L_{Aeq} criteria is predicted to be exceeded. Potential operational noise mitigation and management measures are discussed further in **Section 6.3**.

6.3 Operational Noise Mitigation and Management Measures

Where noise impacts from the development are predicted to exceed the relevant noise criteria, feasible and reasonable operational noise mitigation and management measures should be considered, with the aim of reducing noise emissions to the relevant criteria.

The typical hierarchy for mitigation and management of industrial noise sources is as follows:

- Reducing noise emissions at the source (ie noise source control)
- Reducing noise in transmission to the receiver (ie noise path control)
- Reducing noise at the receiver (ie at-receiver control)

The NPfI recognises that residual noise impacts may exist after the implementation of feasible and reasonable noise mitigation and management measures.

The NPfI generally considers the significance of residual impacts as summarised in **Table 28**.

Table 28 Significance of Residual Impacts

Exceedance of the Criteria	Significance of Residual Noise Impacts	Example of Potential Treatment
0 to 2 dBA	Negligible	The exceedances would generally not be discernible by the average listener and therefore would not warrant receiver-based treatments or controls.
3 to 5 dBA with minimal increase to cumulative industrial noise	Marginal	Provision of mechanical ventilation to enable windows to be closed without compromising internal air quality/amenity.
3 to 5 dBA with significant increase to cumulative industrial noise	Moderate	Provision of mechanical ventilation along with upgrade facade elements, such as windows, doors or roof insulation, to further increase the ability of the building facade to reduce noise levels.
>5 dBA but less than recommended amenity noise level		
>5 dBA and greater than recommended amenity noise level	Significant	May include suitable commercial agreements where considered feasible and reasonable.

The significance of any potential residual noise impacts should be taken into account when considering the reasonableness and feasibleness of operational noise mitigation and management measures.

The below sections discuss potential options for mitigating and managing operational noise emissions from the development. These measures should be investigated further during detailed design of the development, including an assessment of whether the option is feasible and reasonable for the benefit that it provides.

6.3.1 Noise Source Control

It should be noted that the predicted operational noise impacts assume peak 15-minute operations would occur concurrently across all lots within the development. Some of the noise source control measures outlined below would occur naturally as the different offices and warehouse across the development would likely have different shift times for their employees and delivery/pickup times for heavy vehicles, however these could be emphasized further through scheduling, if required.

Potential options for mitigating and managing sources of operational noise may include the combination of several measures, such as:

- Relocating heavy vehicle access routes away from the site boundary, taking advantage of screening afforded by the building envelope
- Reducing peak 15-minute heavy vehicle movements across the development by staggering delivery/pickup times.
- Reducing peak 15-minute light vehicle movements across the development by staggering shift change times for employees.
- Minimising the concurrent use of forklifts and other mobile plant outside the warehouses (ie in the hardstand areas) and/or limiting their use to the less sensitive daytime and evening periods.
- The use of quieter mobile plant options, such as electric forklifts instead of gas-powered forklifts.
- Locating fixed mechanical plant away from the most-affected sensitive receivers, such as ground-level locations instead of rooftop locations, and/or shielded behind the warehouse/office structures.
- The use of quieter fixed mechanical plant options, noting that this assessment assumes an indicative noise level for modelled mechanical plant.
- Acoustic screening, no less than 500 mm higher than the top of the plant, located as close as practicable to the plant.
- Best management practice – such as switching vehicles and plant off when not in use, no yelling/swearing/loud music onsite, education of staff and drivers regarding noise impacts, regular maintenance of plant and equipment to minimise noise emissions, use of silent or non-tonal reverse alarms instead of tonal alarms, minimising use of reverse alarms by providing forward manoeuvring where practicable.

6.3.2 Noise Path Control

Noise path control is typically in the form of noise barriers and/or noise mounds. Barriers and mounds work best when located close to the noise source or close to the receiver.

As the receivers surrounding the development are generally isolated residences on large private lots, construction of noise barriers or mounds close to receivers would be unlikely to be feasible.

6.3.3 Stage 3 Mitigation Scenario

The operational L_{Aeq} exceedances in **Table 27** were identified as receivers in NCA3 located adjacent to the future Stage 3 site and hence afforded no screening from Stage 2 activities.

In order to determine the impact of noise mitigation provided by future Stage 3 buildings or other temporary screening measures at the Stage 2 site boundary, an indicative 10m barrier/building was included to the northern boundary of Lot 202 and Lot 203 as illustrated in **Figure 2**.

The results are summarised in **Table 29**. Noise contours are provided for day/evening (standard weather) in **Figure 6** and night-time (noise-enhancing weather) in **Figure 7.**

Table 29 Mitigation Scenario - Indicative Noise Level Reduction with 10 m Building/Barrier to Stage 3 Boundary

NCA	Receiver Type	Period (weather)	$L_{Aeq(15\ minutes)}$ Noise Level (dBA)				L_{Amax} Noise Level (dBA)			
			Project Noise Trigger Level	Predicted	Exceedance	Compliance	Sleep Disturbance Screening Noise Level	Predicted	Exceedance	Compliance
NCA01	Residential	Daytime (standard)	40	32	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	40	32	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	40	36	-	Yes	52	49	-	Yes
NCA02	Residential	Daytime (standard)	39	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	39	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	39	35	-	Yes	52	**58**	**6**	**No**
NCA03	Residential	Daytime (standard)	44	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Evening (standard)	43	30	-	Yes	n/a[2]	n/a[2]	n/a[2]	n/a[2]
		Night-time (noise-enhancing)	38	35	-	Yes	52	**59**	**7**	**No**

Note 1: **Bold** text indicates an exceedance of the project noise trigger level.

Note 2: L_{Amax} criteria are not applicable during this time period.

Figure 6 Predicted Noise Levels – Day/Evening – Standard Weather Conditions – Mitigation Scenario

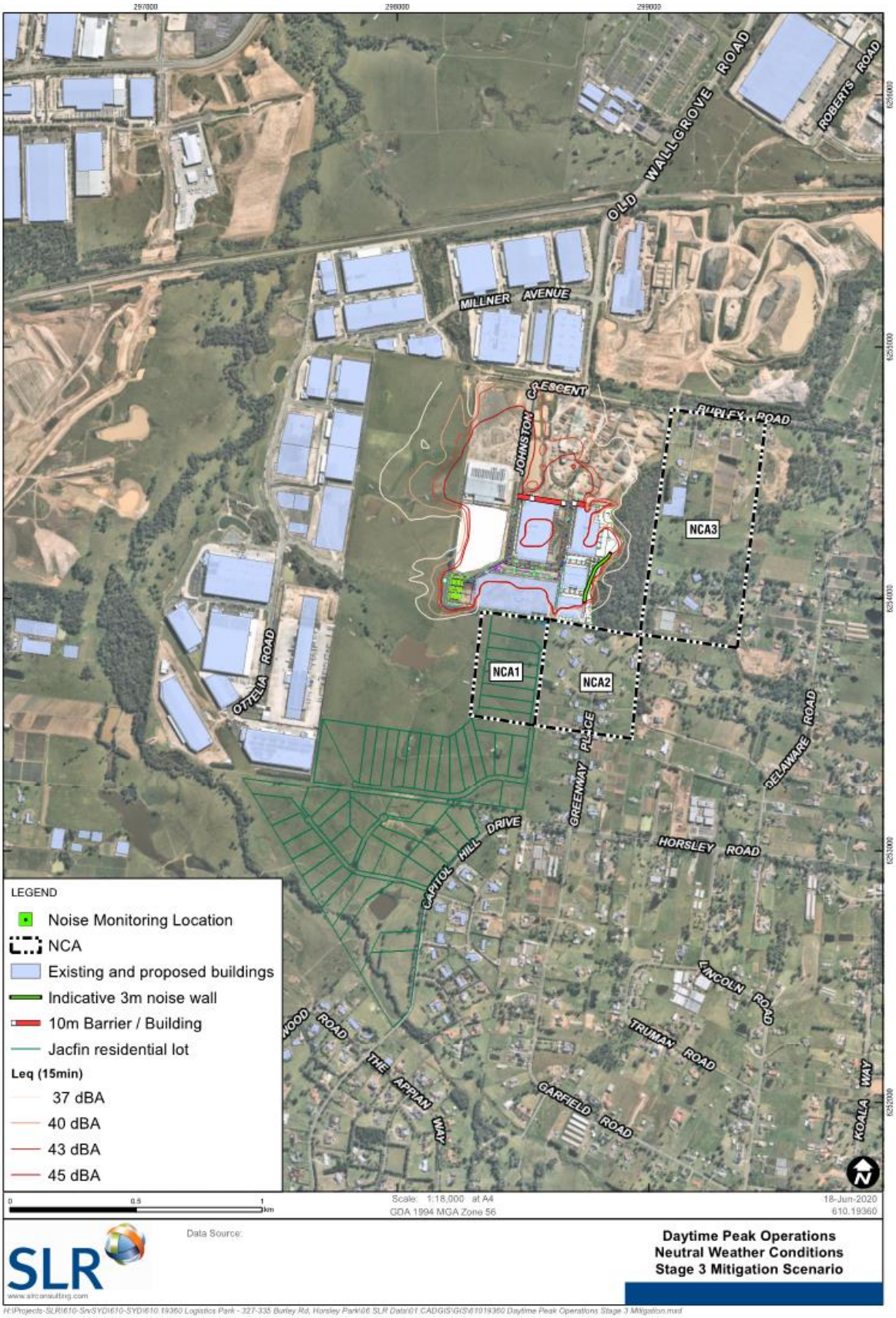


Figure 7 Predicted Noise Levels – Night – Noise-Enhancing Weather Conditions – Mitigation Scenario

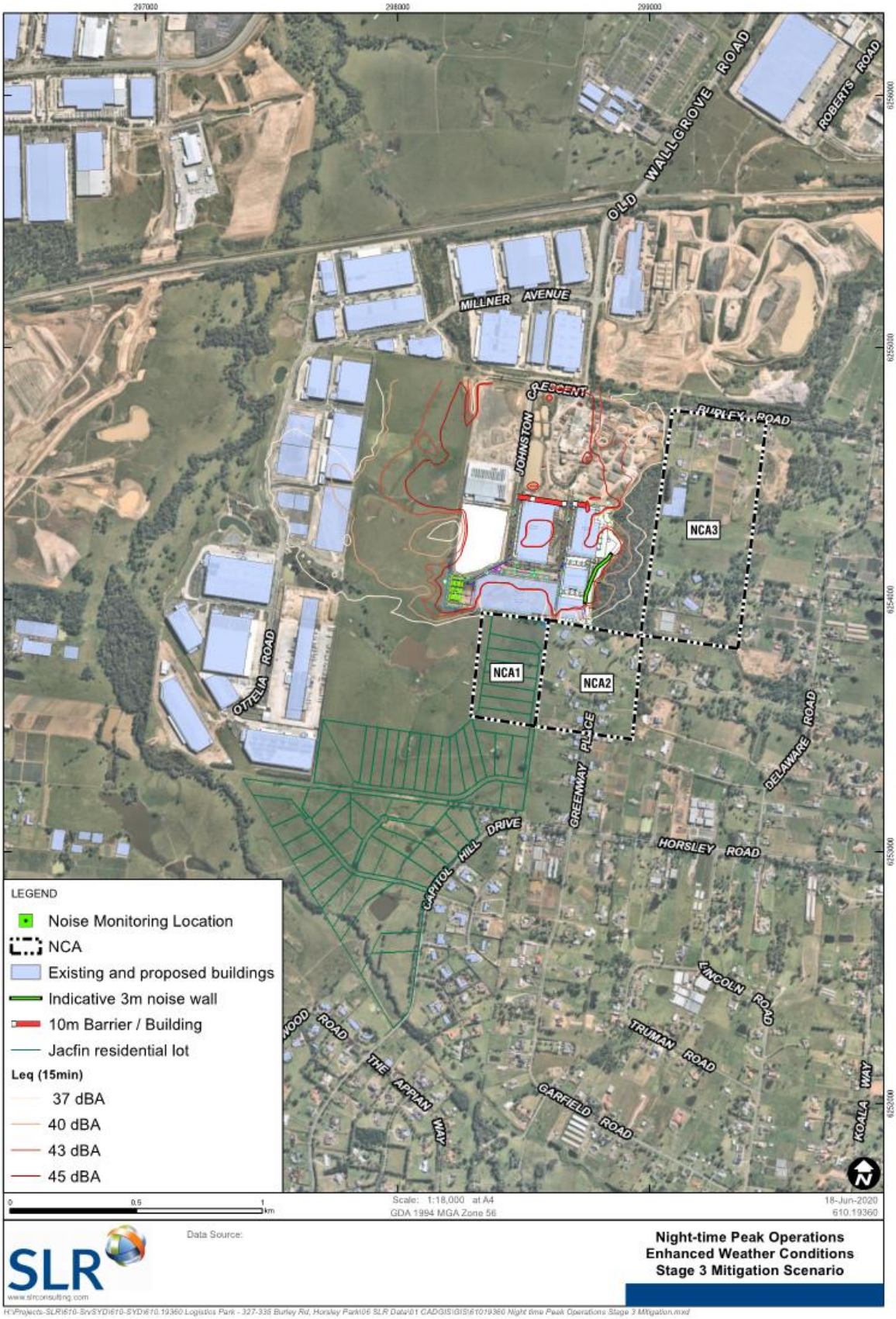


Table 29 shows that significant reductions in operational L_{Aeq} noise impacts can be achieved with screening provided by buildings or barriers on or adjacent to the Stage 3 development site, with compliance now indicated at all receivers for daytime, evening and night-time operation.

6.3.3.1 Maximum Noise Levels

For night-time operation under enhanced weather conditions, exceedances of up to 7 dB in operational L_{Amax} noise levels are predicted. The Stage 3 mitigation scenario is provided to give an indication of the levels of improvement to operational L_{Aeq} noise impacts that may be achieved with preliminary path noise controls. Refinement of road and building pad heights and barrier/building extents during design development is anticipated to further reduce operational L_{Amax} noise levels.

As outlined in **Section 4.7.2**, where the sleep disturbance screening noise level is predicted to be exceeded then a detailed assessment of maximum noise events should be undertaken. The detailed assessment should discuss the predicted level of the events, the exceedance of the screening level, existing maximum noise levels, and consider guidance from current literature regarding sleep disturbance, such as the *Road Noise Policy* (RNP).

The RNP provides context in relation to maximum noise levels and potential for sleep disturbance. The RNP concludes that maximum internal noise levels of 50-55 dBA are unlikely to awaken people, and one or two events per night with maximum internal noise levels of 65-70 dBA are not likely to affect health and wellbeing significantly. This results in corresponding external noise levels of 60-65 dBA and 75-80 dBA assuming a 10 dB loss through open windows.

Based on the RNP guidance outlined above, the results in **Table 27** and **Table 29** indicate that maximum noise levels from the operational development are predicted to be below L_{Amax} 60 dBA externally and therefore unlikely to significantly exceed the sleep disturbance screening level for the most affected receivers.

6.3.3.2

6.3.4 Cumulative Operational Noise Impacts with Other Industry

The NPfI aims to limit continuing increases in noise levels from progressive developments with the application of the amenity criteria. The recommended amenity noise levels represent the objective for the total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

To account for cumulative noise from the development with existing industrial premises in the area, the recommended amenity noise level is reduced by 5 dBA to give the project amenity noise level. The project amenity noise level is used in conjunction with the project intrusiveness noise level to determine the Project Noise Trigger Levels (PTNLs) for operational noise from the development (refer to **Section 4.7**).

It is noted that cumulative noise limits have been previously established for NCA1 and NCA2 as discussed in **Section 4.7.1.2**.

The noise contours in and indicate that the cumulative noise limits for NCA1 and NCA2 are achieved for the future receivers located to the northern end of Jacfin development site, closest to the subject development. For the future receivers located to the southern and western end of the Jacfin site, noise contributions from the subject development are predicted to be at least 3 dB lower than the cumulative noise limits, which allows for noise contributions from other industrial sites including Oakdale South Estate.

As such, it is considered that cumulative noise impacts from the development with existing industrial noise sources in the area have been accounted for with the adoption of the project trigger noise levels in the assessment of operational noise impacts detailed in **Section 6.2** and **Section 6.3**.

6.3.5 At-Receiver Control

At-receiver mitigation measures can be utilised to reduce noise impacts where residual noise impacts are present after implementation of feasible and reasonable noise source and path controls, or where those controls are not considered to be feasible and reasonable.

At-receiver mitigation typically involves using architectural treatments such as thicker glazing and doors or upgraded facade constructions to achieve appropriate internal noise levels. Architectural treatments are more effective when they are applied to masonry buildings than lightly clad timber frames structures, and caution should be taken before providing treatments to buildings in a poor state as they may not be effective.

Architectural treatments are typically limited to:

- Fresh air ventilation systems that meet the Building Code of Australia requirements with the windows and doors shut
- Upgraded windows and glazing and solid core doors on the exposed facades of the substantial structures only (eg masonry or insulated weather board cladding with sealed underfloor)
- Upgrading window or door seals and appropriately treating sub-floor ventilation
- The sealing of wall vents
- The sealing of the underfloor below the bearers and appropriately treating sub-floors ventilation
- Roof insulation
- The sealing of eaves.

Alternative at-receiver mitigation can include:

- The installation of acoustic screen walls that break line-of-sight between the affected facade window and the noise sources where they are feasible and reasonable and are preferred by the owner. This option can also minimise noise impacts on outdoor areas of the receiver property, such as laws and courtyards.

Identification of residual noise impacts and receivers eligible for consideration of at-receiver noise treatments would be undertaken during the detailed design stage after consideration of any noise source and path mitigation and management measures.

APPENDIX A

Acoustic Terminology

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 2×10^{-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

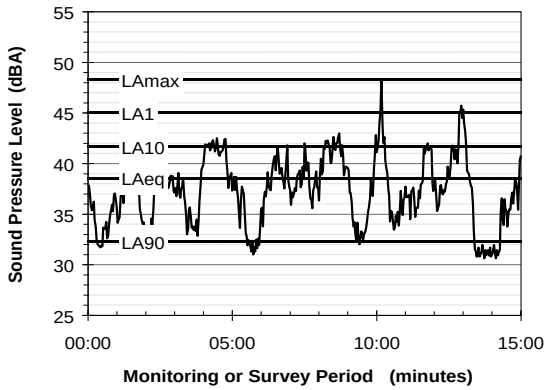
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

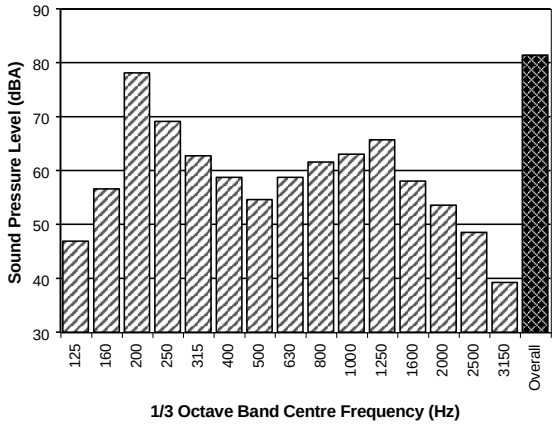
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

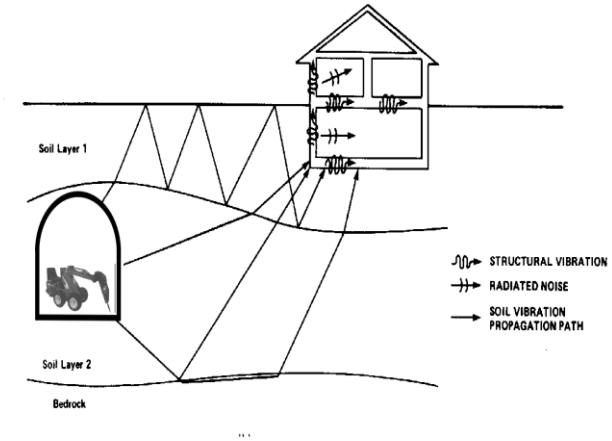
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience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

Noise Monitoring Results

Noise Monitoring Location	L01	Map of Noise Monitoring
Noise Monitoring Address	**327-335 Burley Rd, Horsley Park**	

Logger Device Type: Svantek 957, Logger Serial No: 23815

Ambient noise logger deployed in an open area at the centre of the site, approximately 700 m from Burley Road.

Attended noise measurements were not conducted at this location due to the presence of heavy vehicles and excavators which were a safety risk.

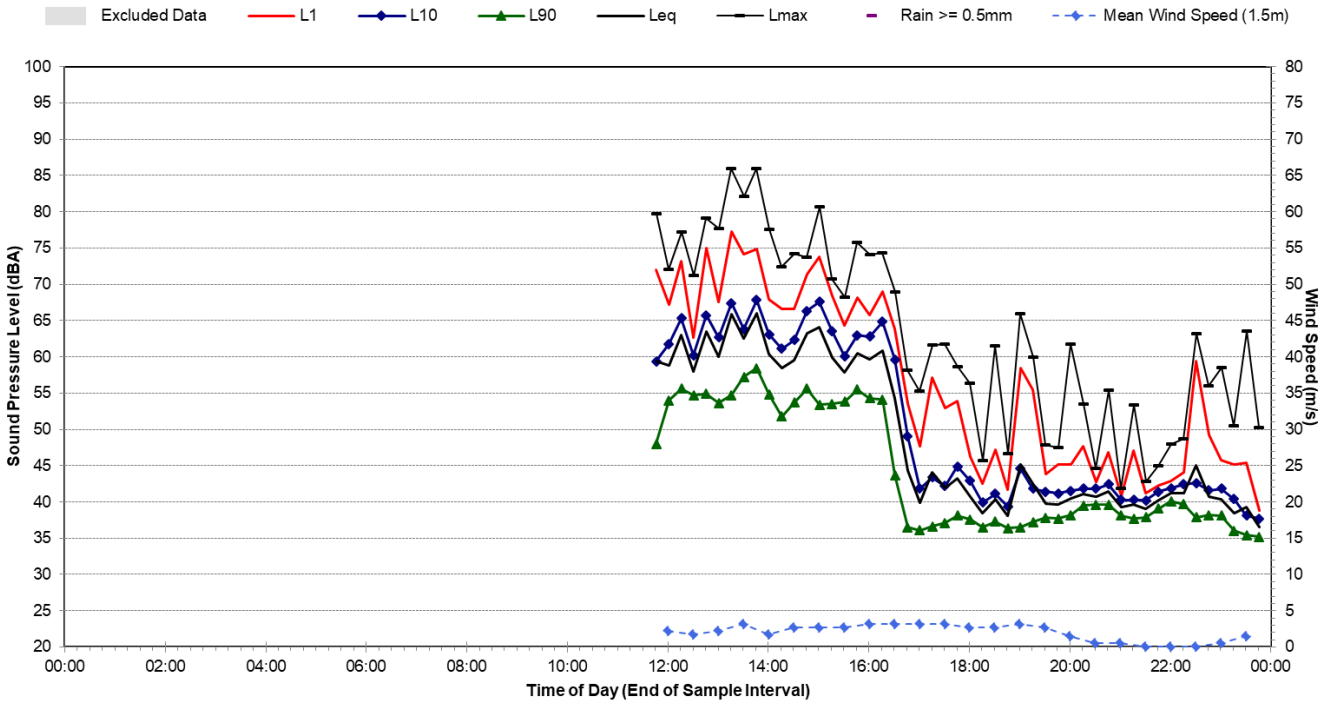
Ambient Noise Logging Results – NPfI Defined Time Periods					Photo of Noise Monitorin
Monitoring Period	**Noise Level (dBA)**				
	RBL	**LAeq**	**L10**	**L1**	
Daytime	37	66	63	67	
Evening	35	42	42	46	
Night-time	34	50	41	44	

Ambient Noise Logging Results – RNP Defined Time Periods		
Monitoring Period	**Noise Level (dBA)**	
	LAeq(period)	**LAeq(1hour)**
Daytime (7am-10pm)	64	72
Night-time (10pm-7am)	50	64

Attended Noise Measurement Results				
Date	**Start Time**	**Measured Noise Level (dBA)**		
		LA90	**LAeq**	**LAmax**
-	-	-	-	-

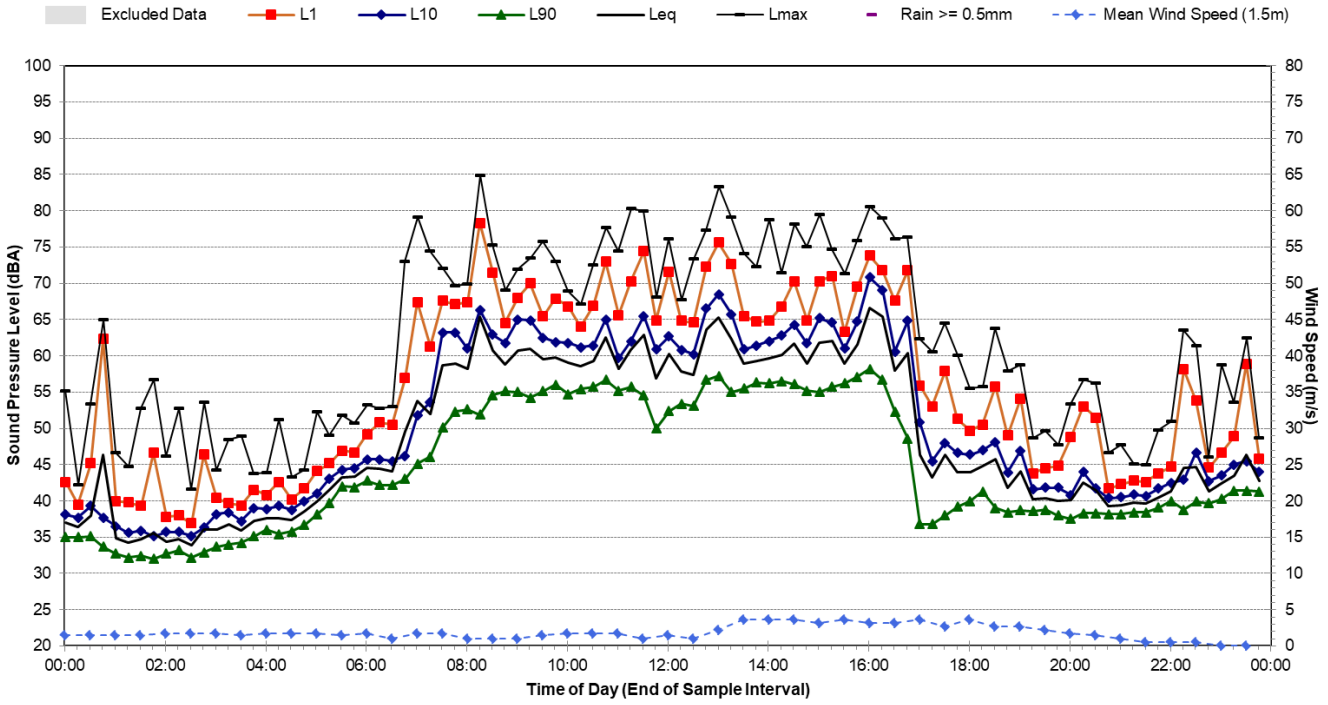
Statistical Ambient Noise Levels

L01 - Tuesday, 10 March 2020



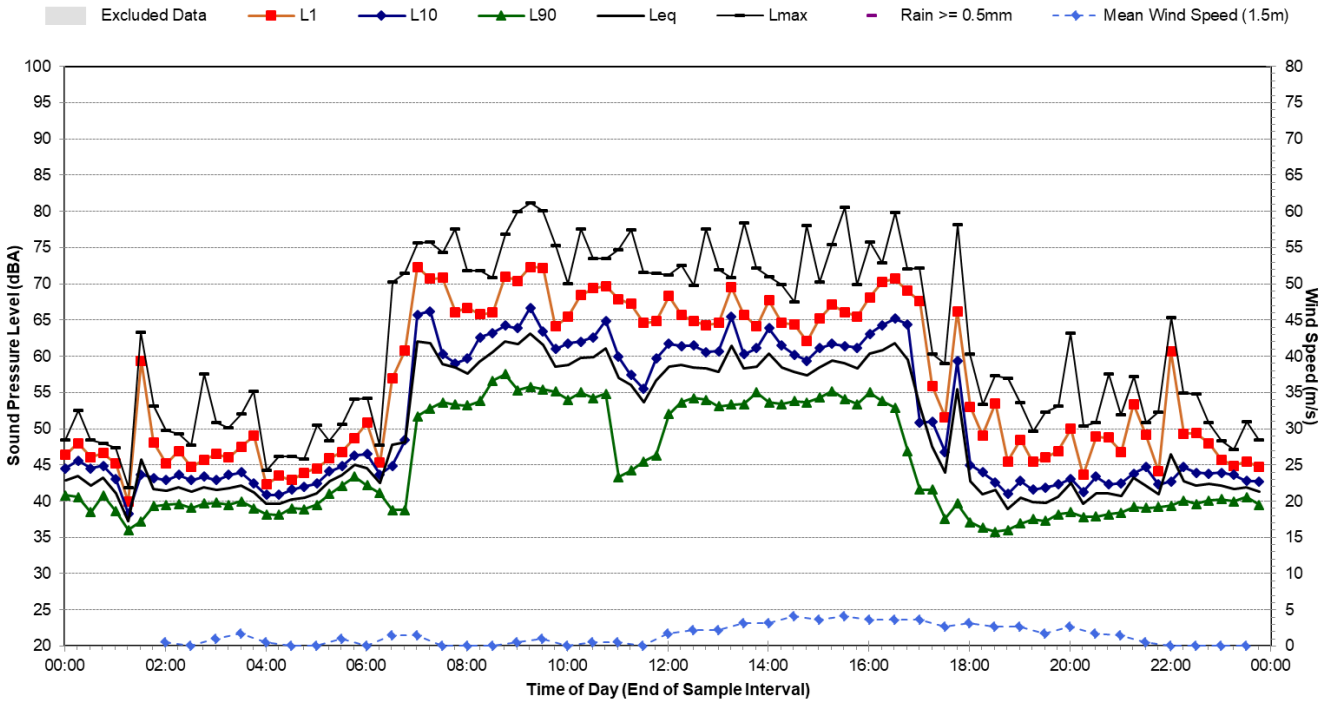
Statistical Ambient Noise Levels

L01 - Wednesday, 11 March 2020



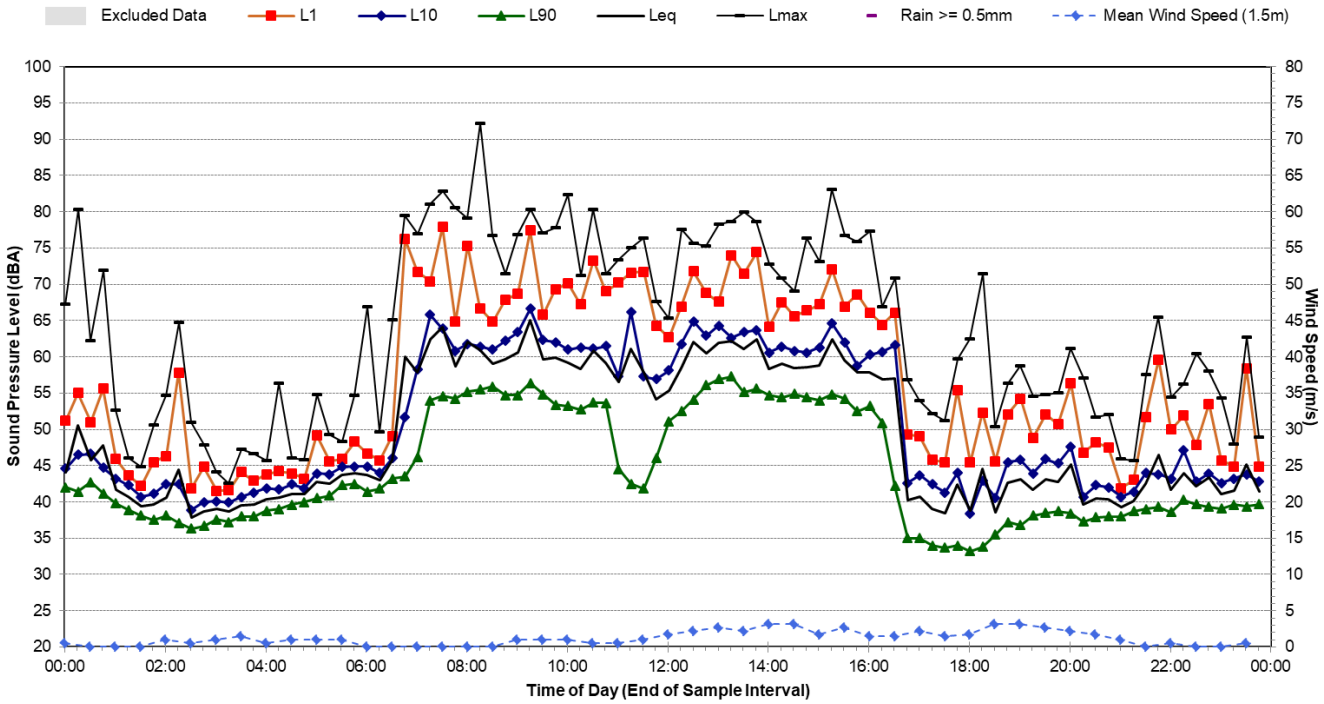
Statistical Ambient Noise Levels

L01 - Thursday, 12 March 2020



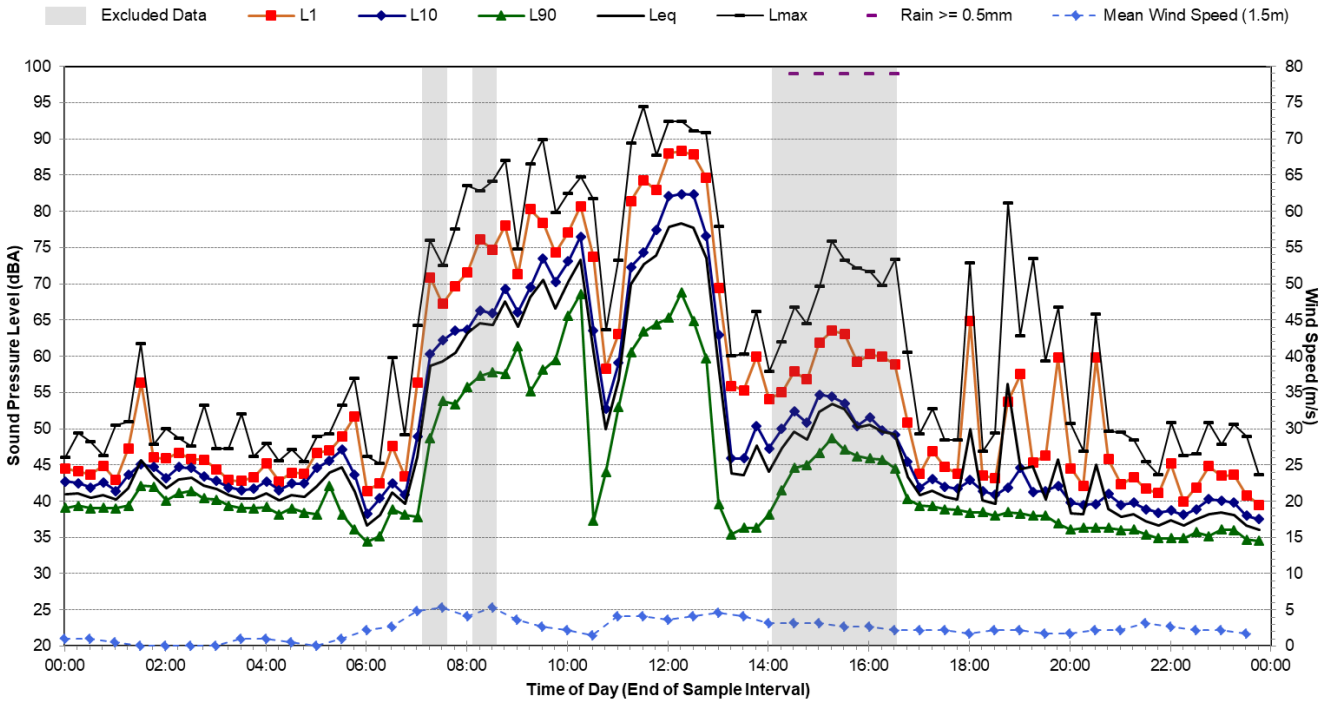
Statistical Ambient Noise Levels

L01 - Friday, 13 March 2020



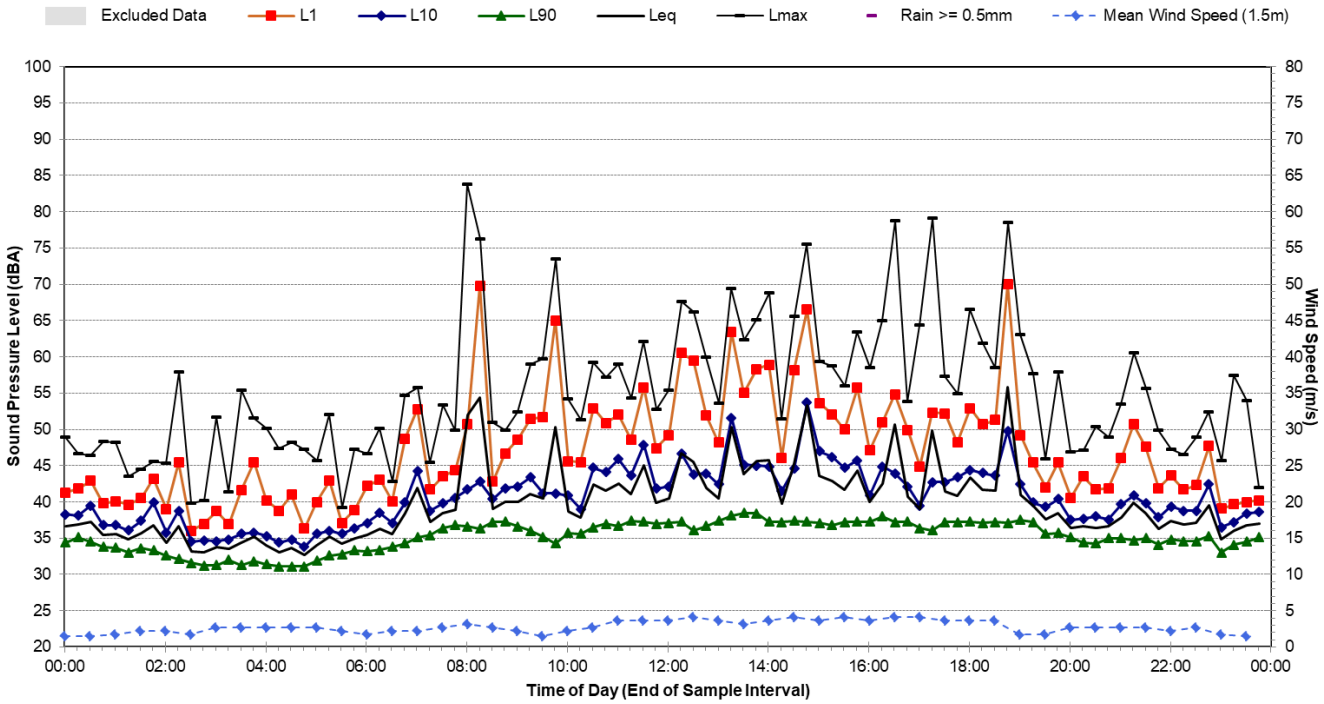
Statistical Ambient Noise Levels

L01 - Saturday, 14 March 2020



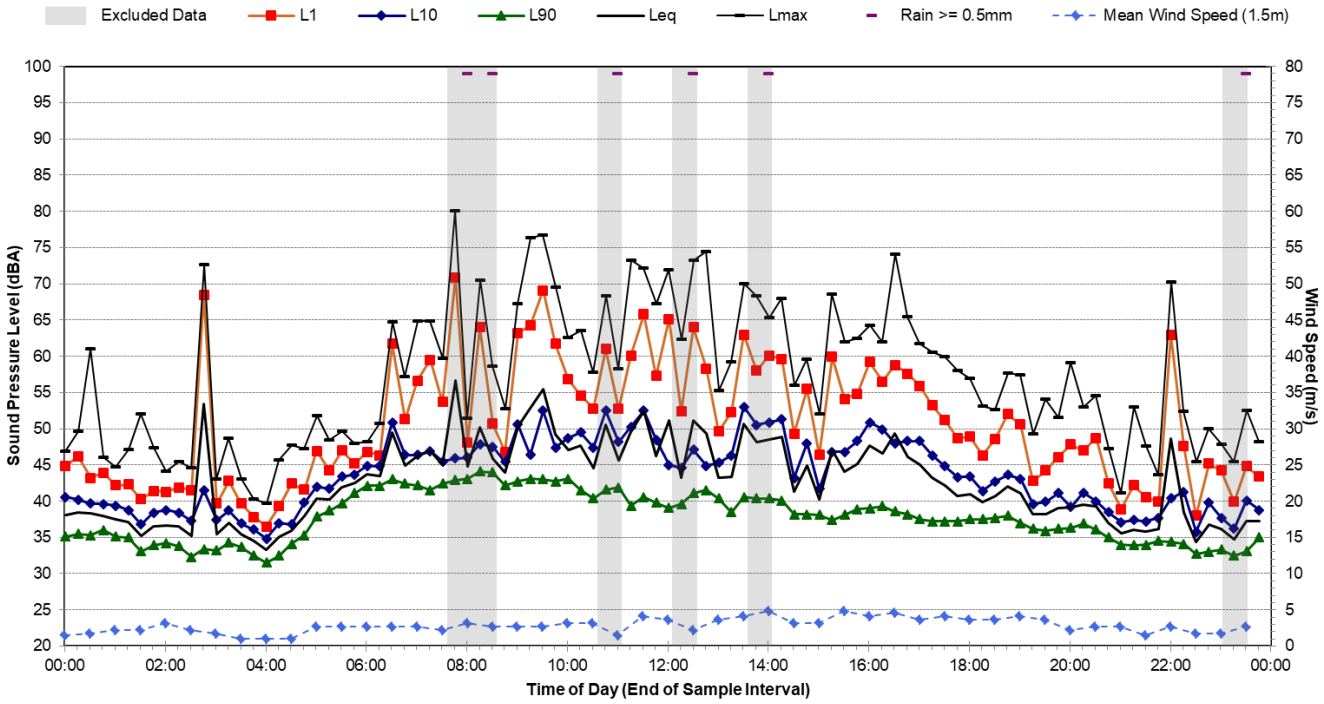
Statistical Ambient Noise Levels

L01 - Sunday, 15 March 2020



Statistical Ambient Noise Levels

L01 - Monday, 16 March 2020



Statistical Ambient Noise Levels

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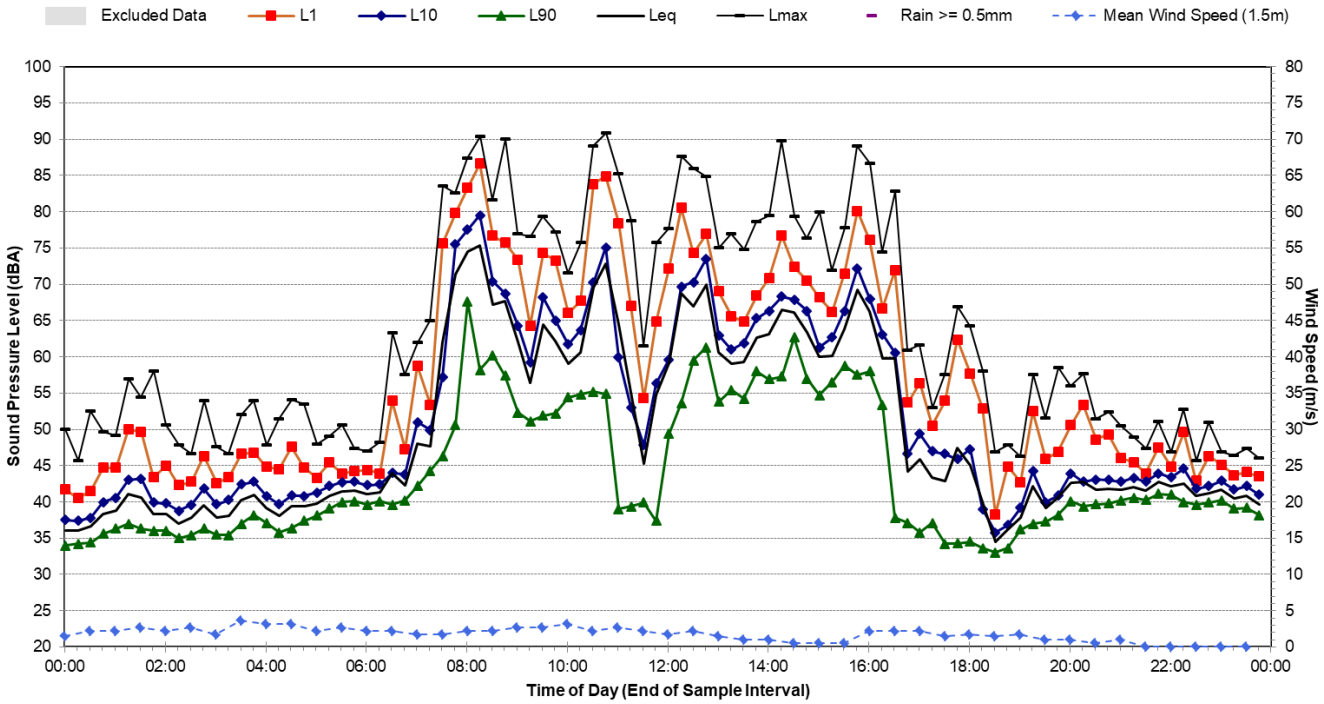
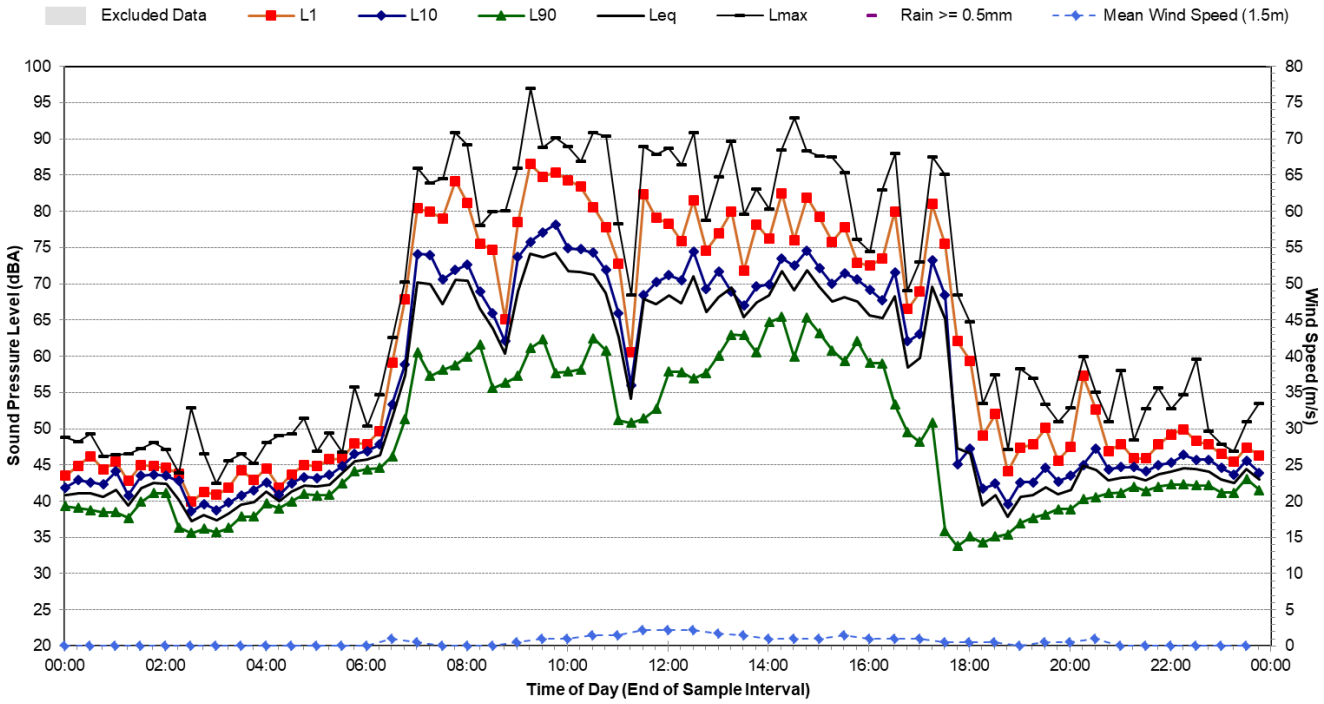


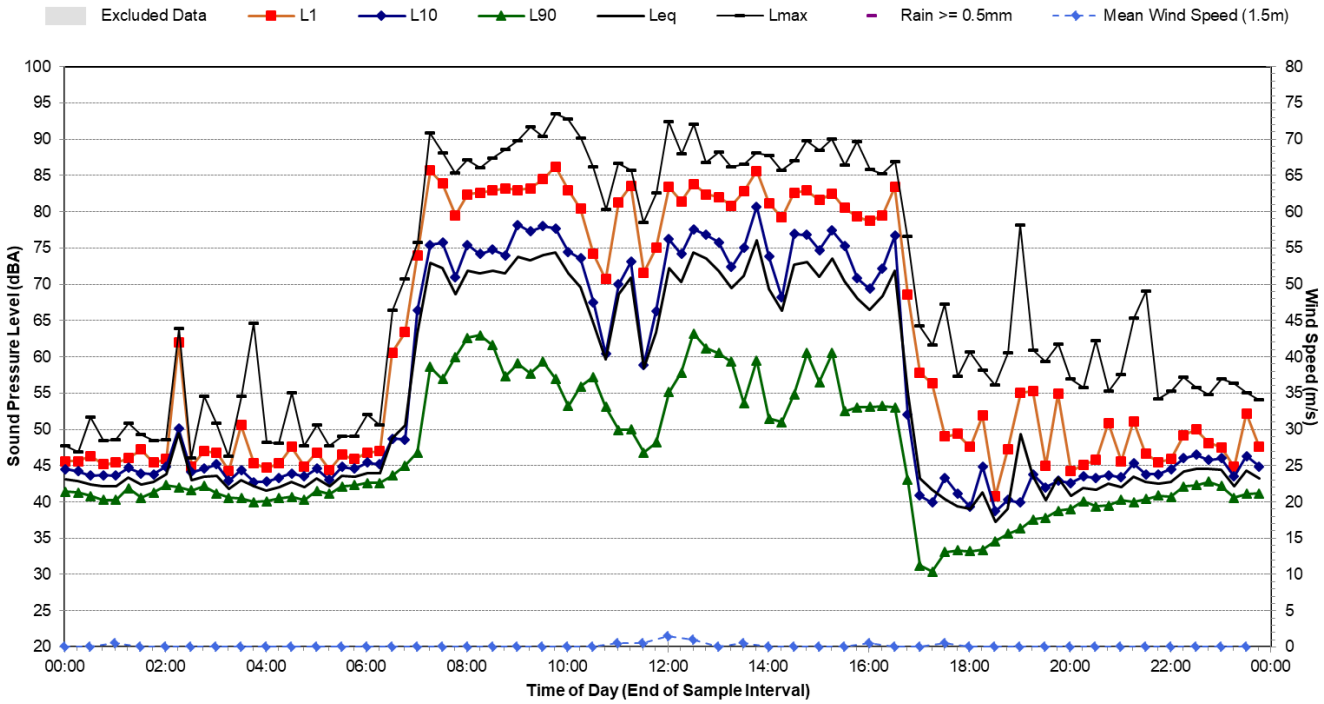
Statistical Ambient Noise Levels

L01 - Wednesday, 18 March 2020



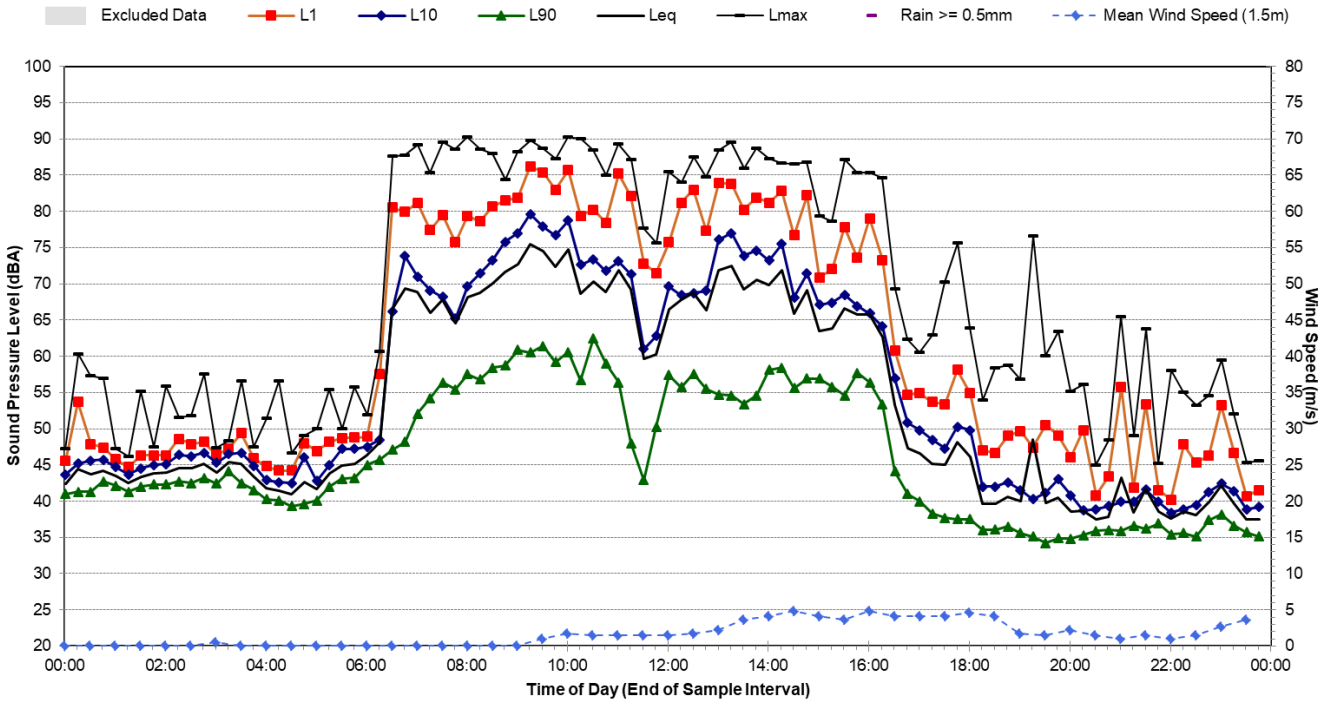
Statistical Ambient Noise Levels

L01 - Thursday, 19 March 2020



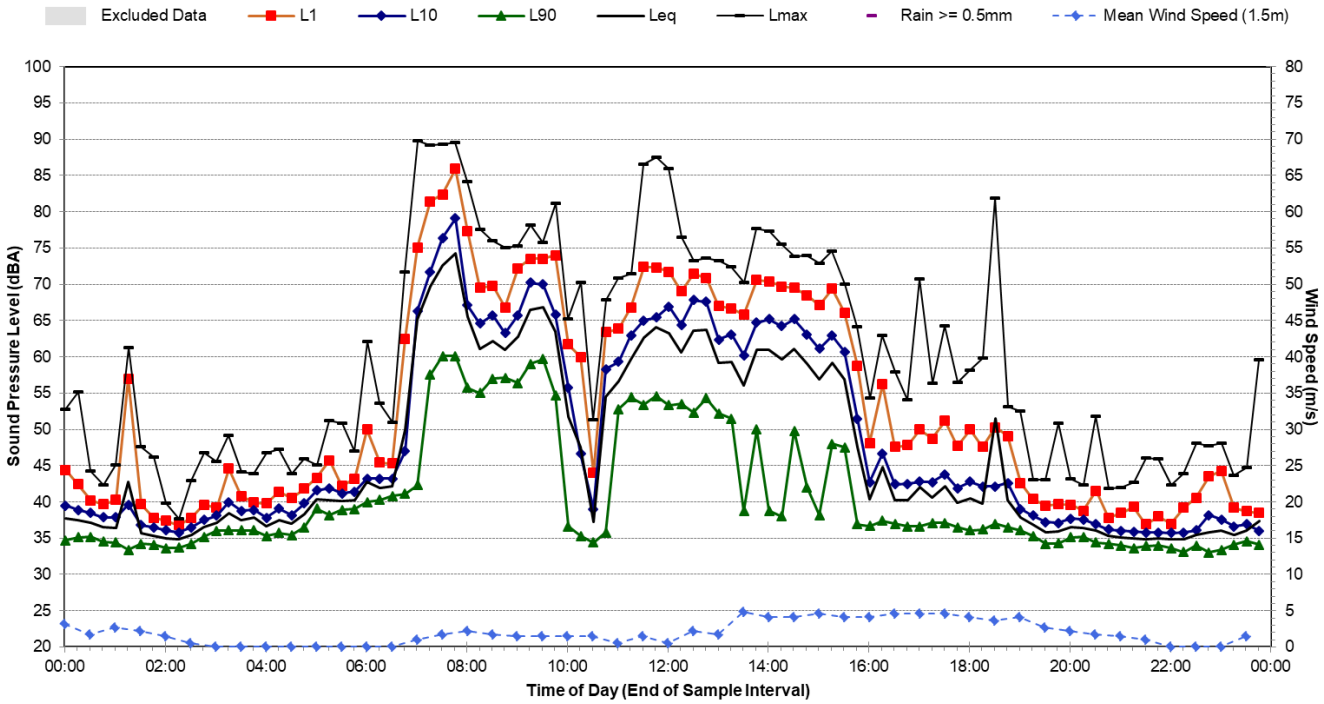
Statistical Ambient Noise Levels

L01 - Friday, 20 March 2020



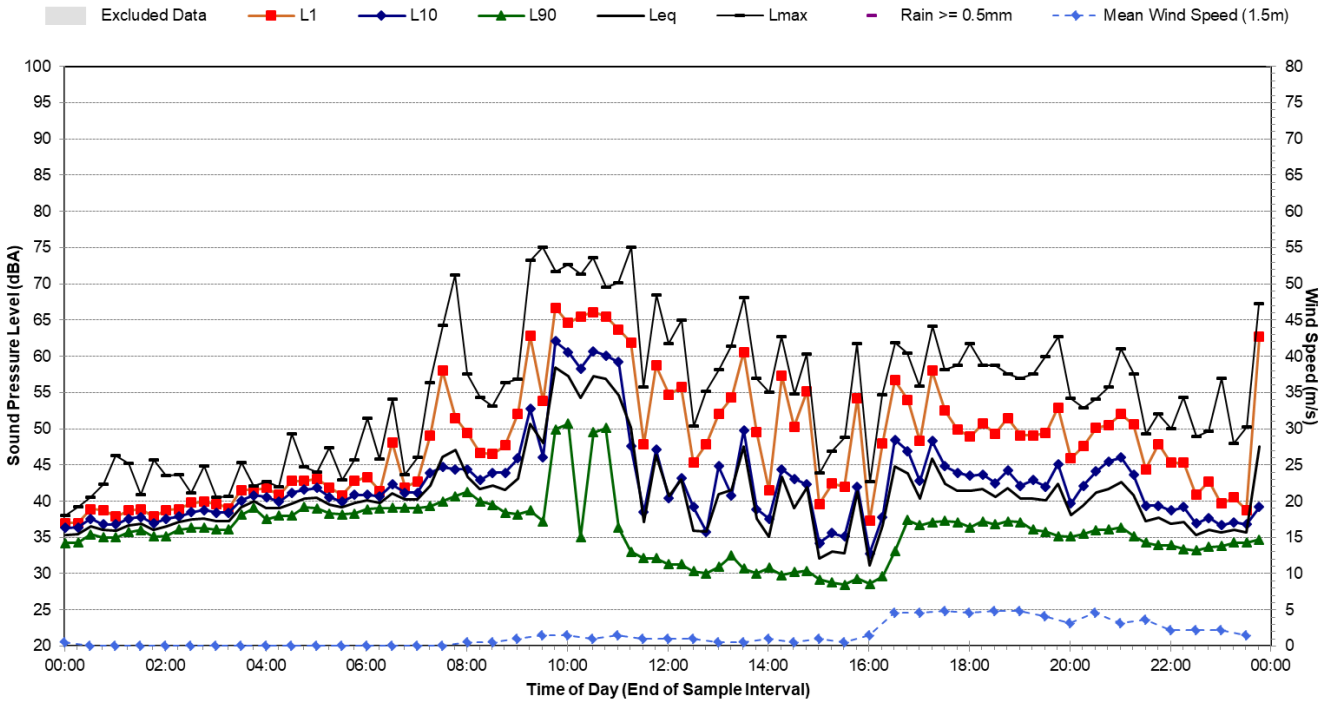
Statistical Ambient Noise Levels

L01 - Saturday, 21 March 2020



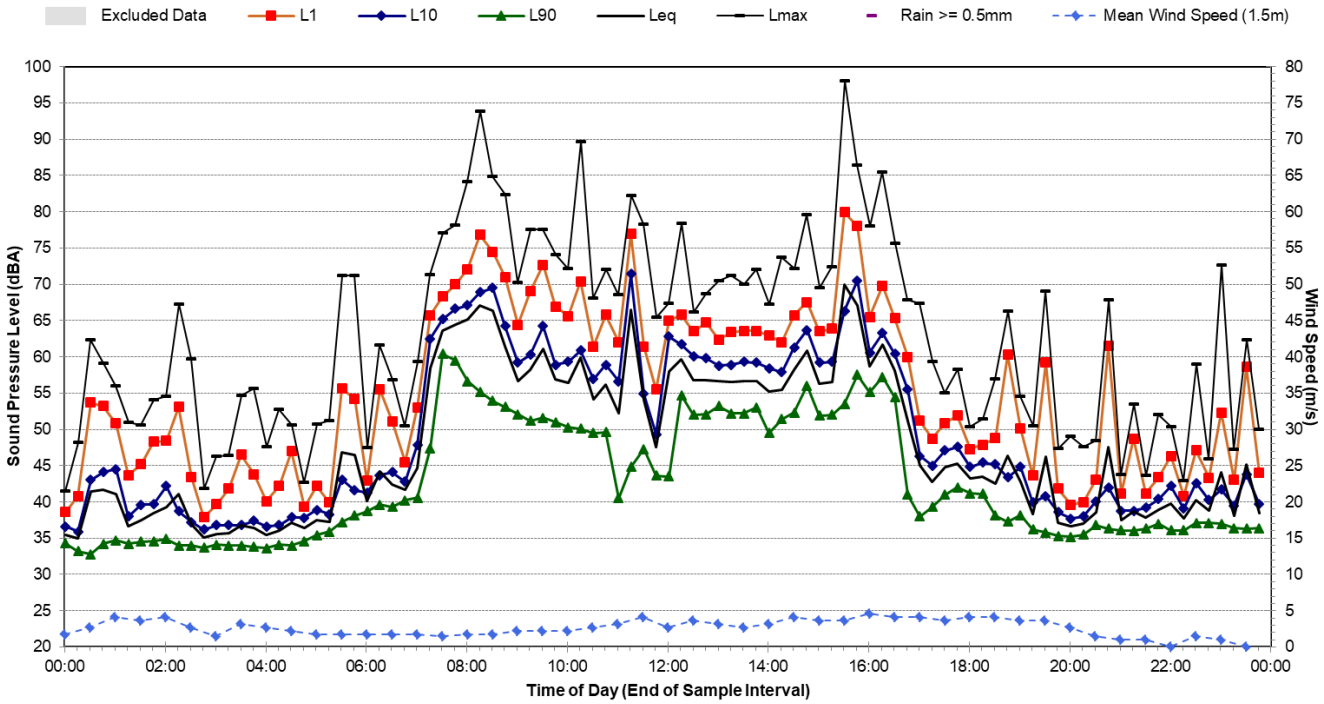
Statistical Ambient Noise Levels

L01 - Sunday, 22 March 2020



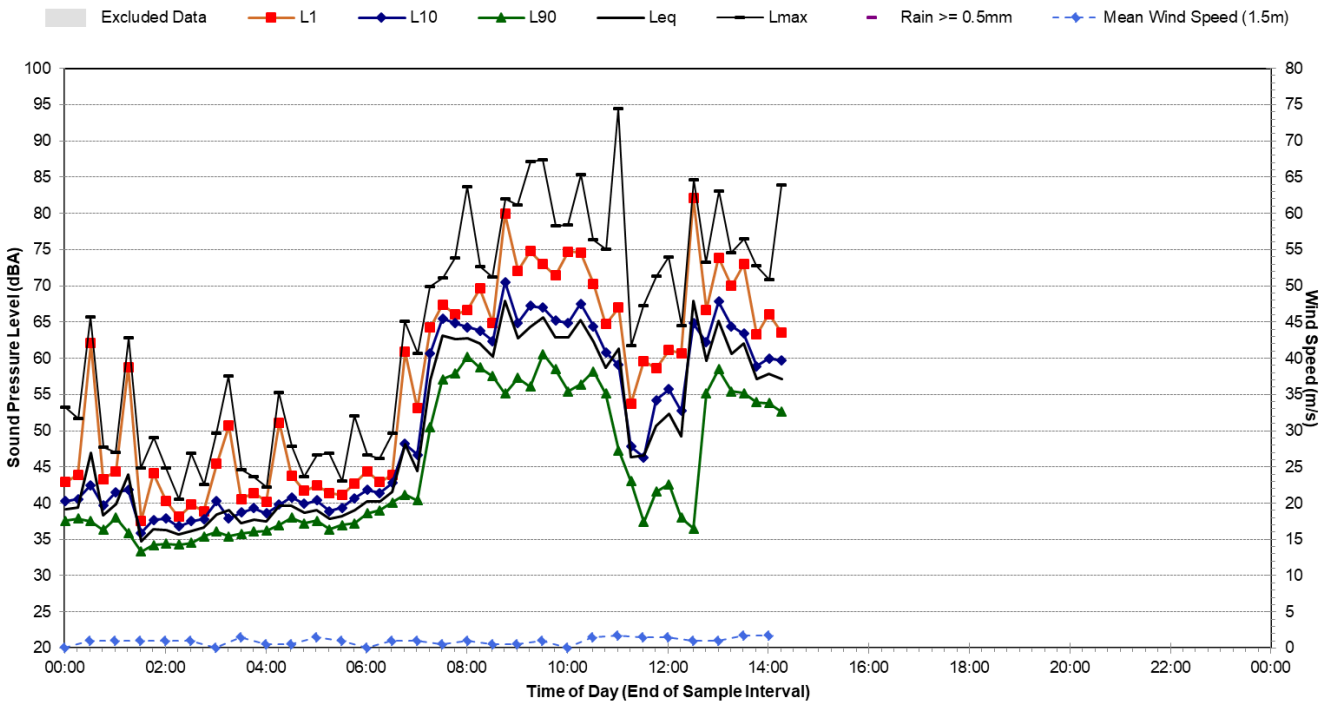
Statistical Ambient Noise Levels

L01 - Monday, 23 March 2020



Statistical Ambient Noise Levels

L01 - Tuesday, 24 March 2020



Noise Monitoring Location	L02	Map of Noise Monitoring
Noise Monitoring Address	**327-335 Burley Rd, Horsley Park**	

Logger Device Type: Svantek 957, Logger Serial No: 23244
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2414604

Ambient noise logger deployed at the southern boundary the site, approximately 900 m from Burley Road.

Attended noise measurements indicate the ambient noise environment at this location is dominated by activity from the quarry, distant traffic, birds and insects.

Recorded Noise Levels (LAmax):
10/03/2020: Quarry activity: 36- 41dBA, Aircraft: 42-58 dBA, Distant traffic: 35 - 38 dBA, Aircraft: 45-50 dBA, Birds: 43 - 57 dBA

Ambient Noise Logging Results – NPfI Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	35	66	51	60
Evening	39	57	51	57
Night-time	37	61	48	53

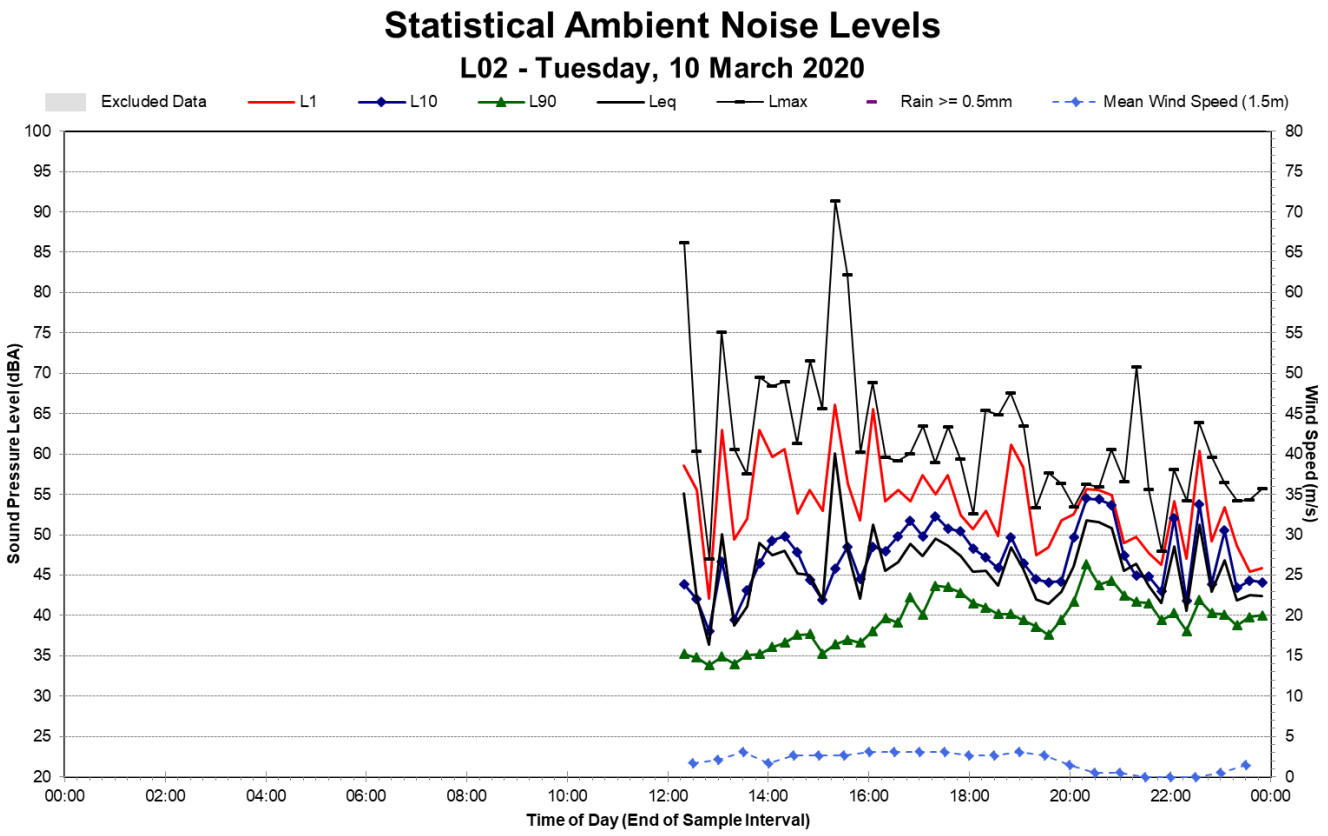
Ambient Noise Logging Results – RNP Defined Time Periods

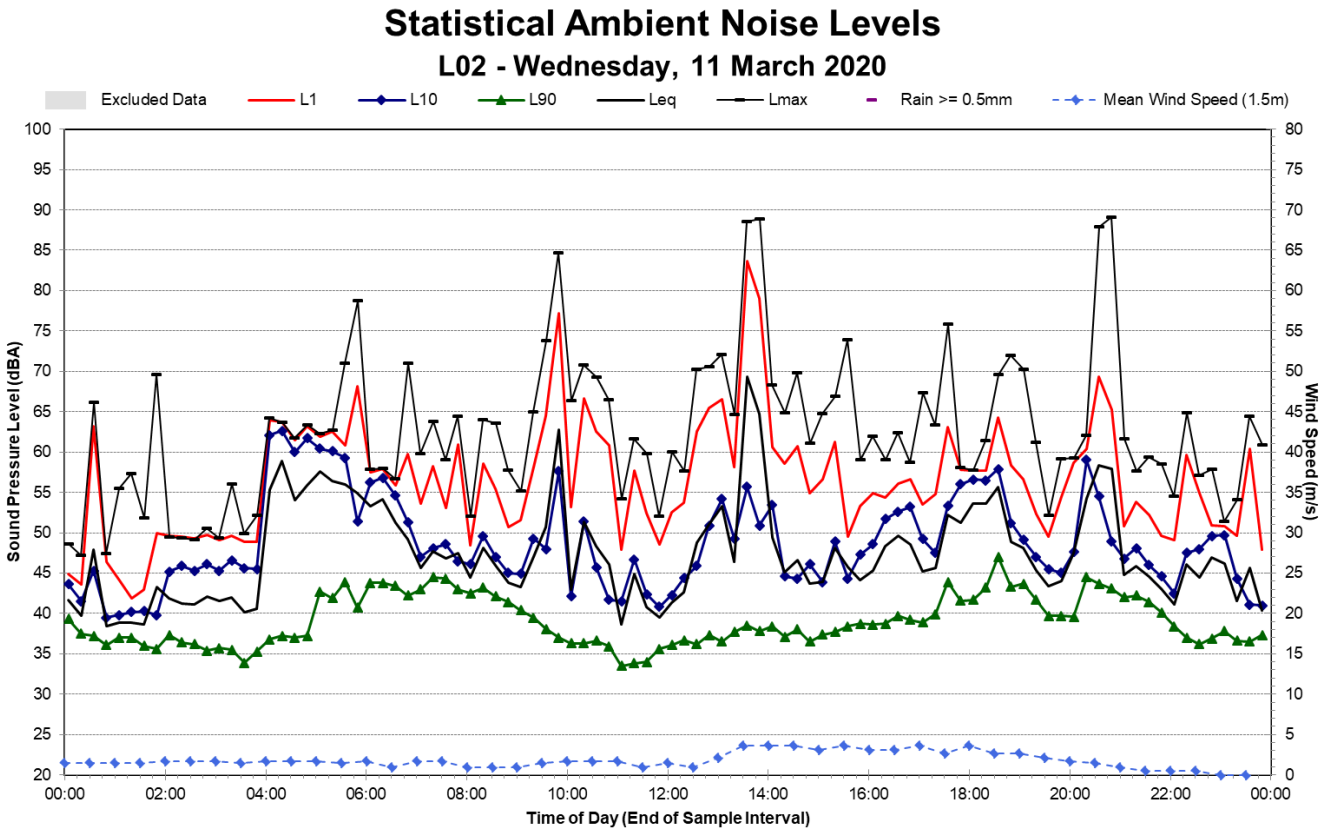
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	64	71
Night-time (10pm-7am)	62	61

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
10/03/2020	11:58 am	36	41	59

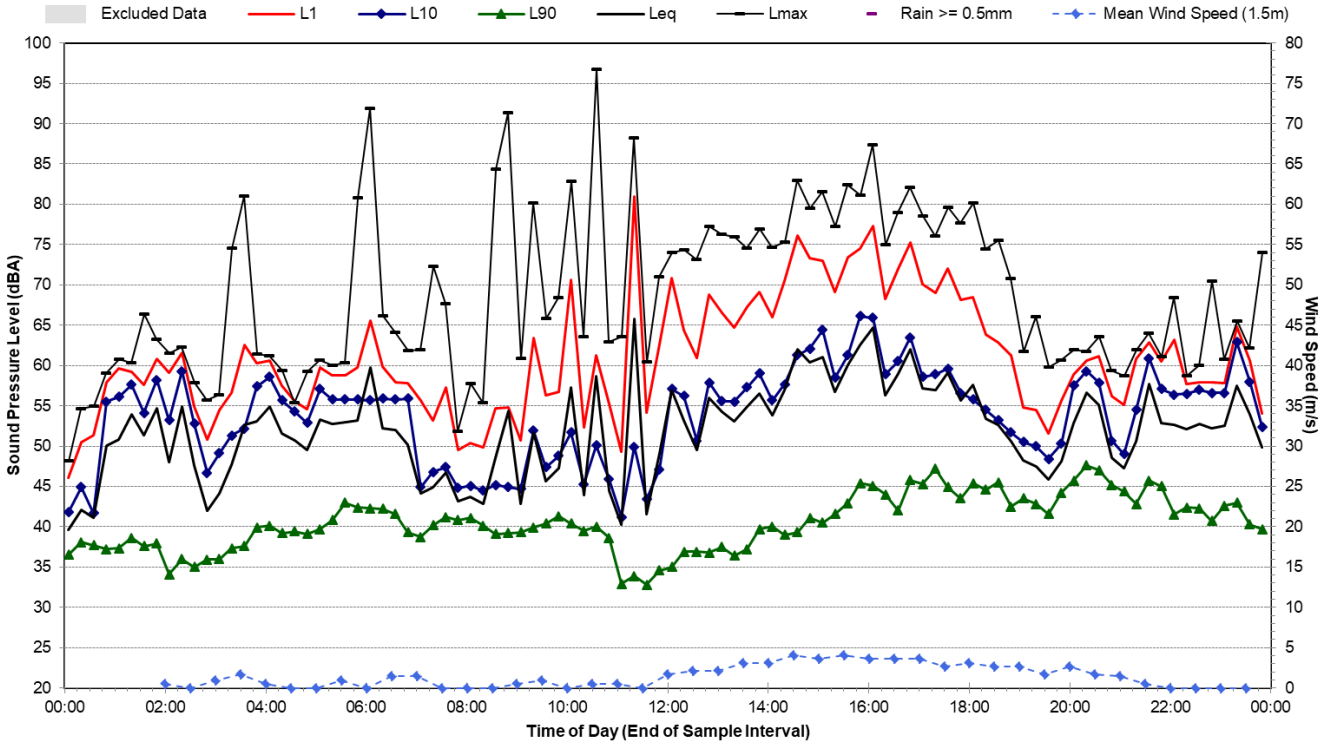
Photo of Noise Monitorin


Statistical Ambient Noise Levels
L02 - Tuesday, 10 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Wednesday, 11 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

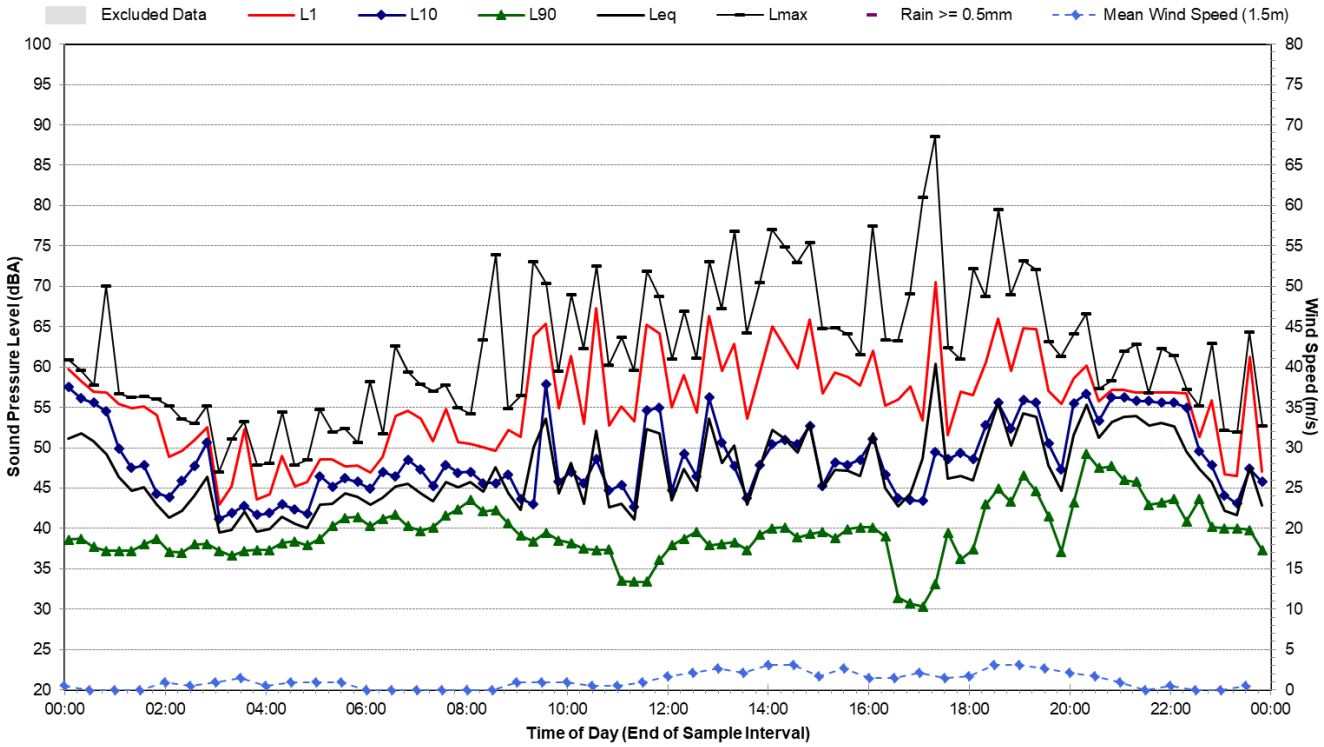
Statistical Ambient Noise Levels

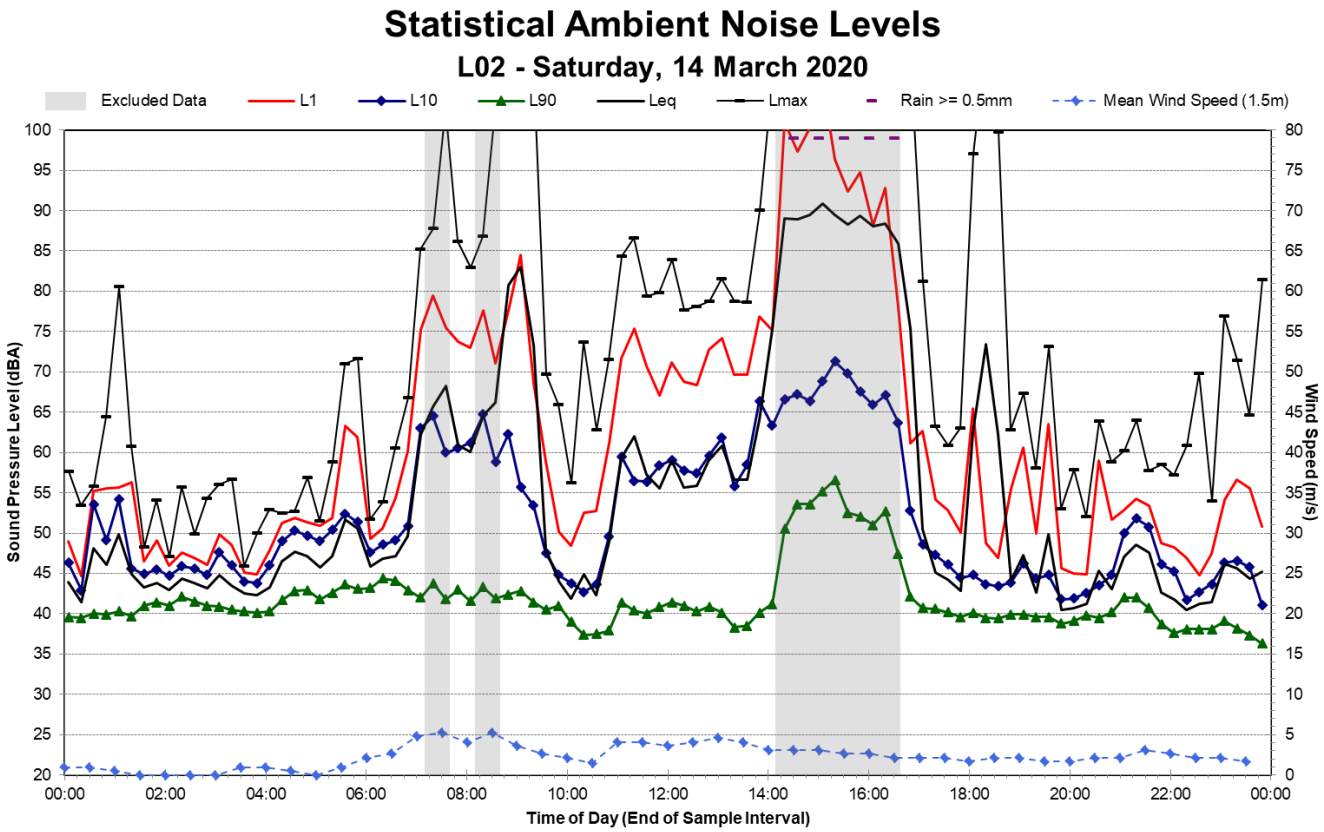
L02 - Thursday, 12 March 2020

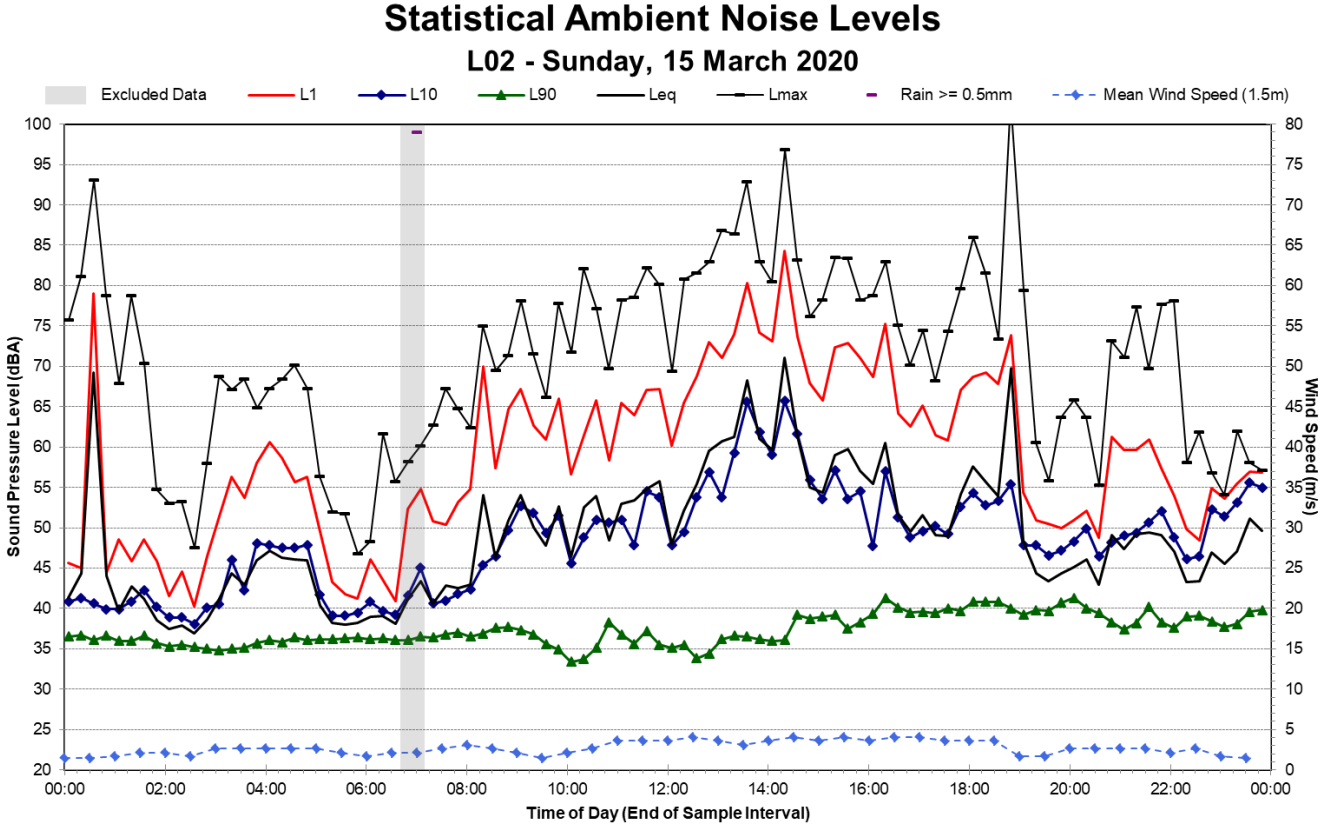


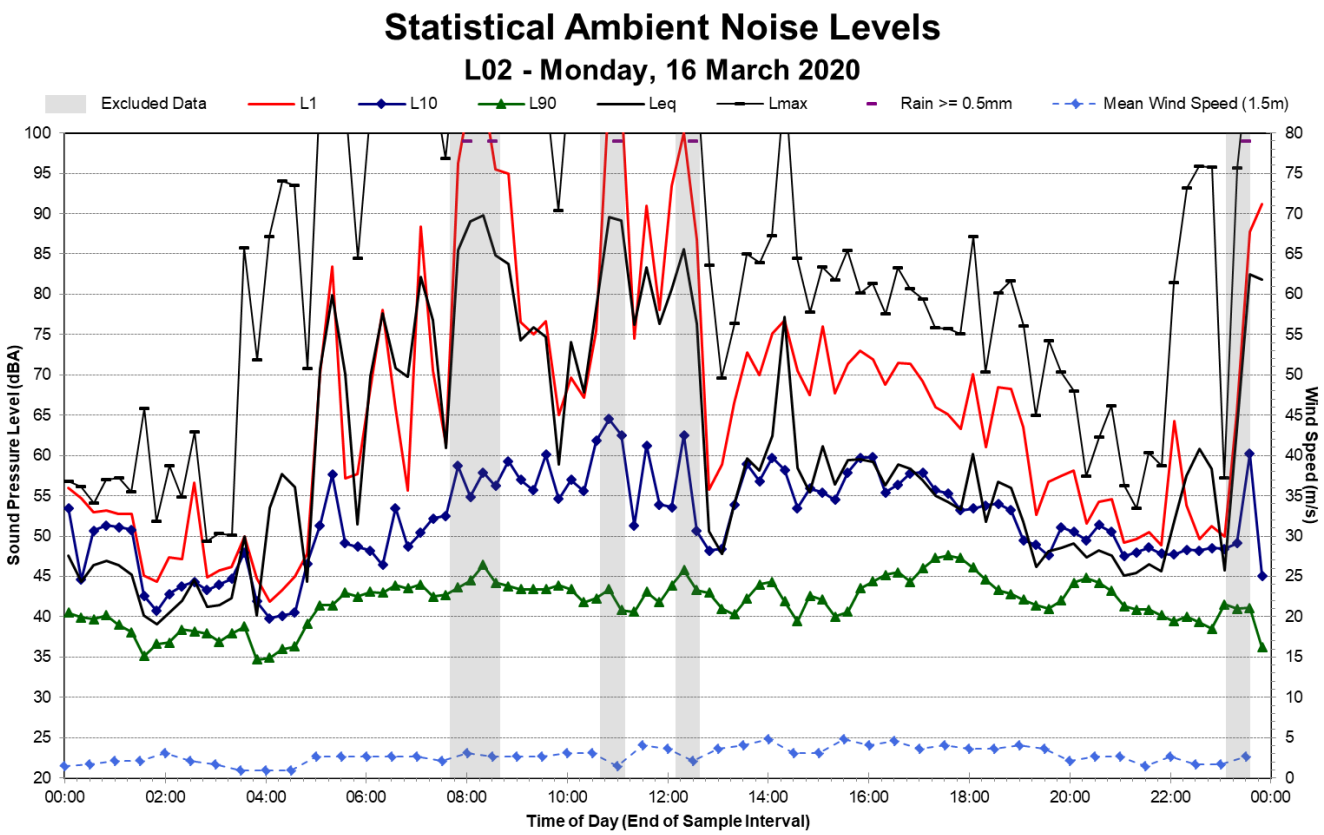
Statistical Ambient Noise Levels

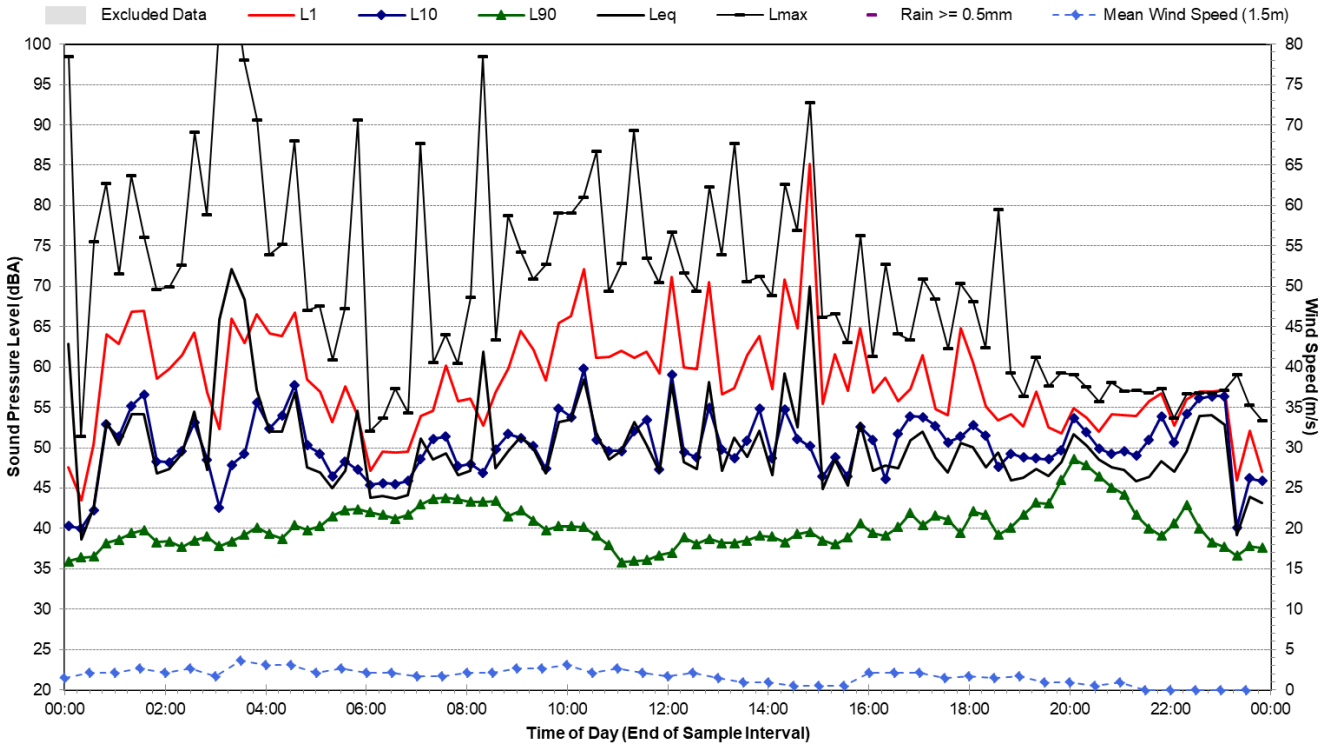
L02 - Friday, 13 March 2020

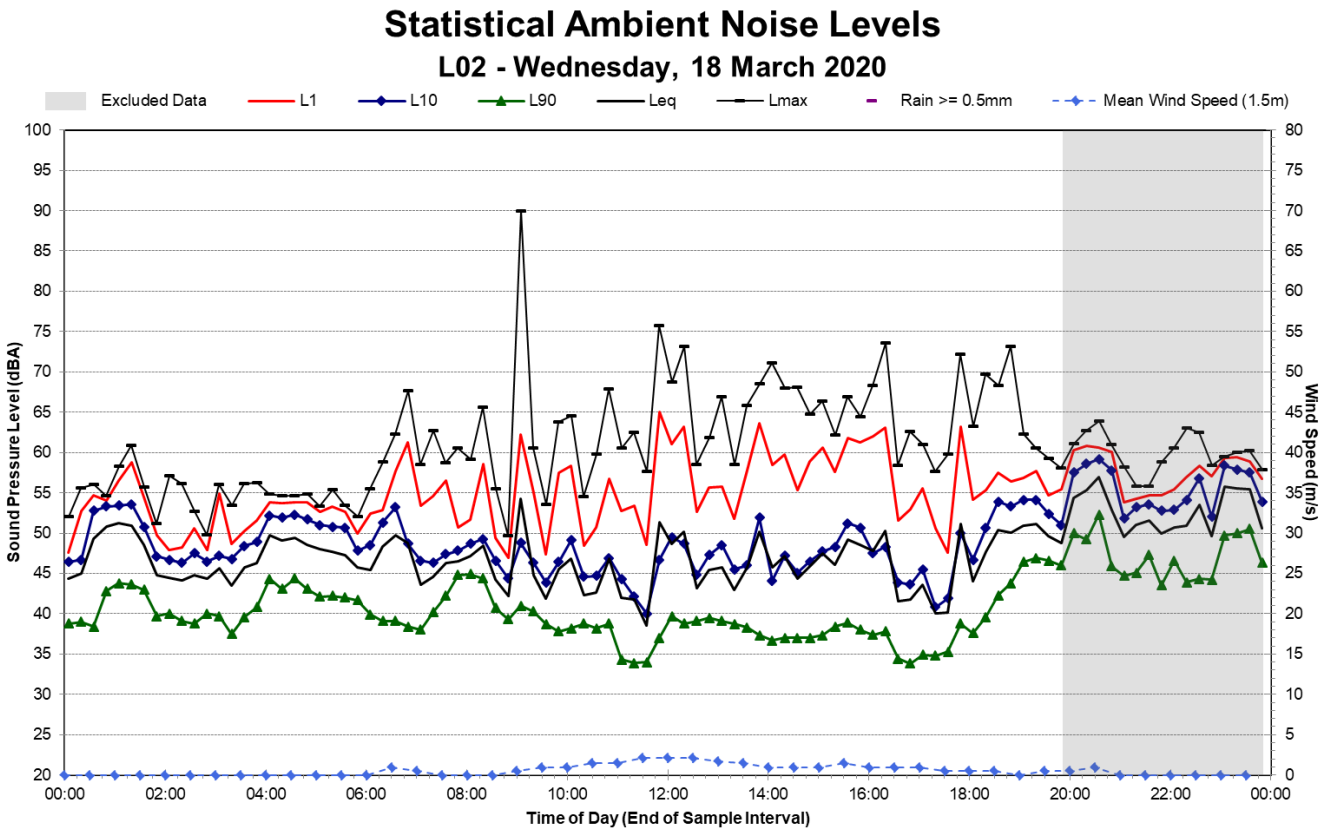


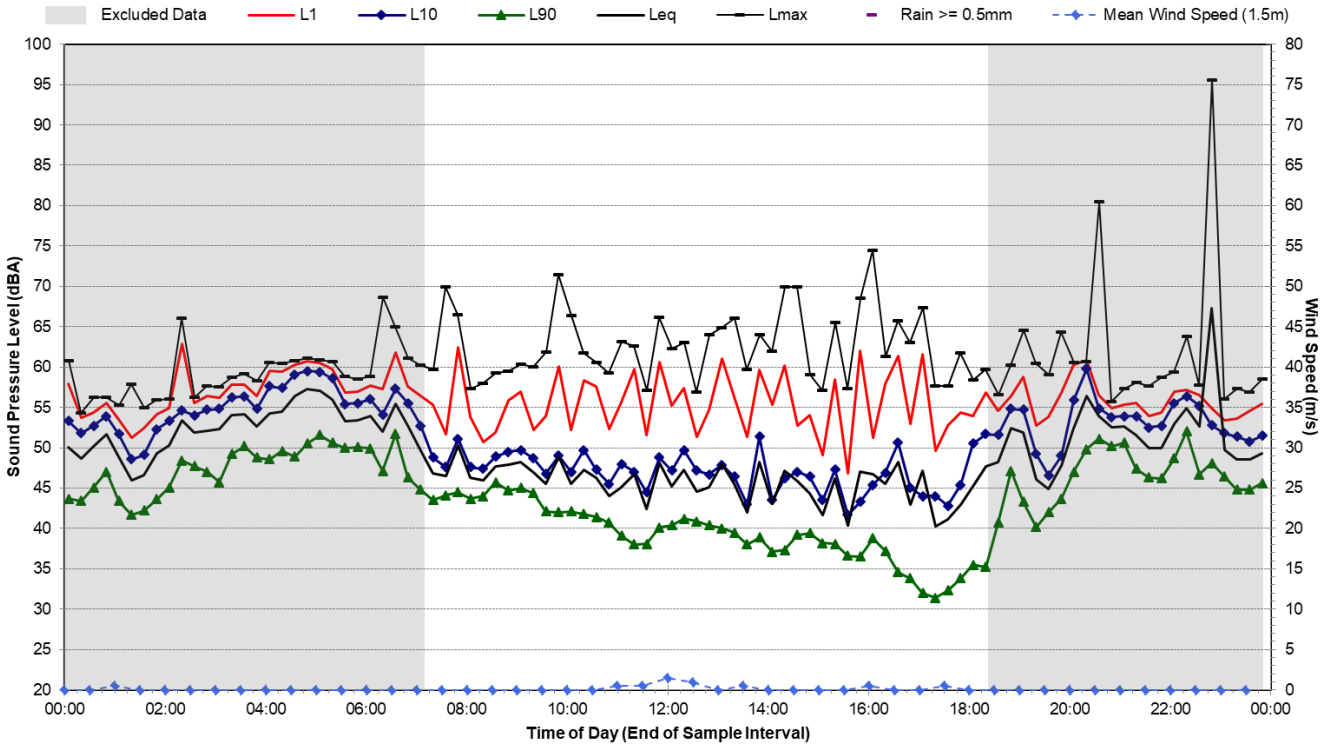

Statistical Ambient Noise Levels
L02 - Saturday, 14 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

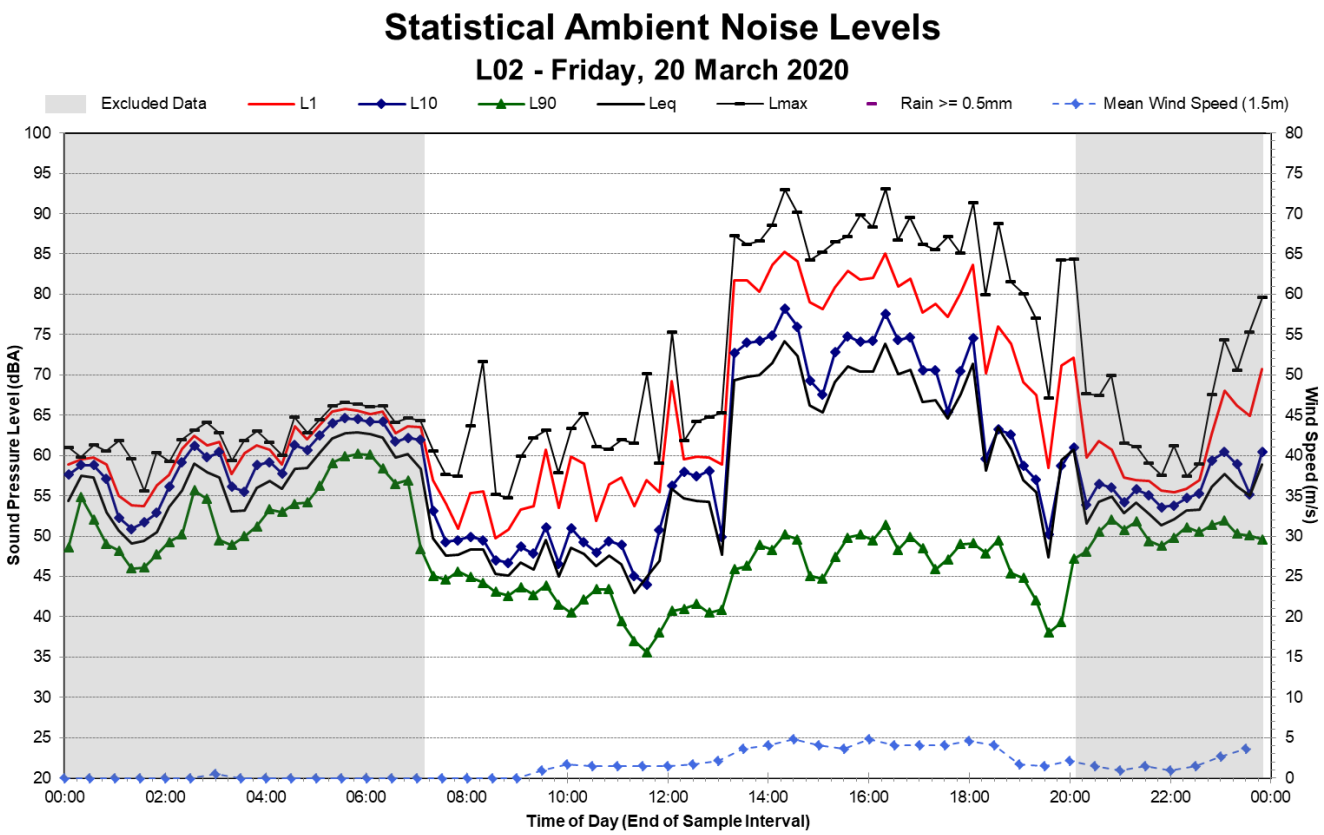

Statistical Ambient Noise Levels
L02 - Sunday, 15 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

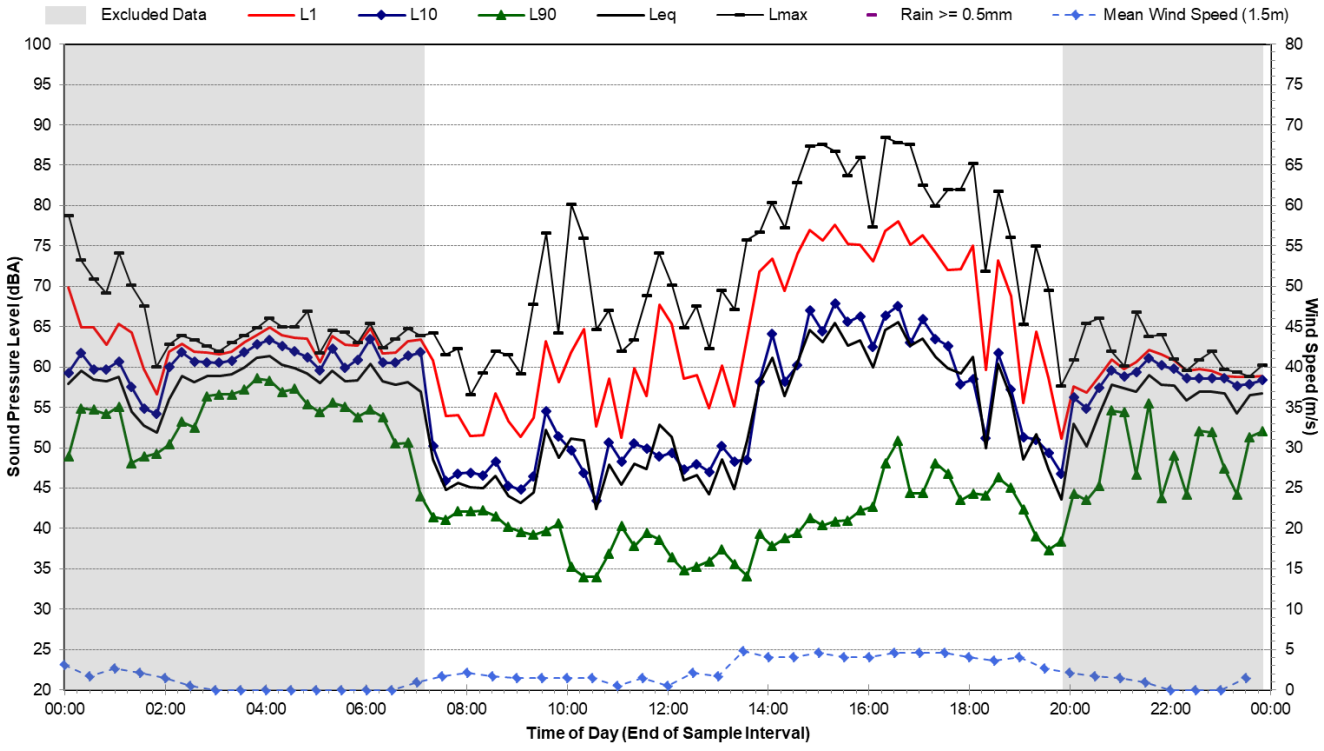

Statistical Ambient Noise Levels
L02 - Monday, 16 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

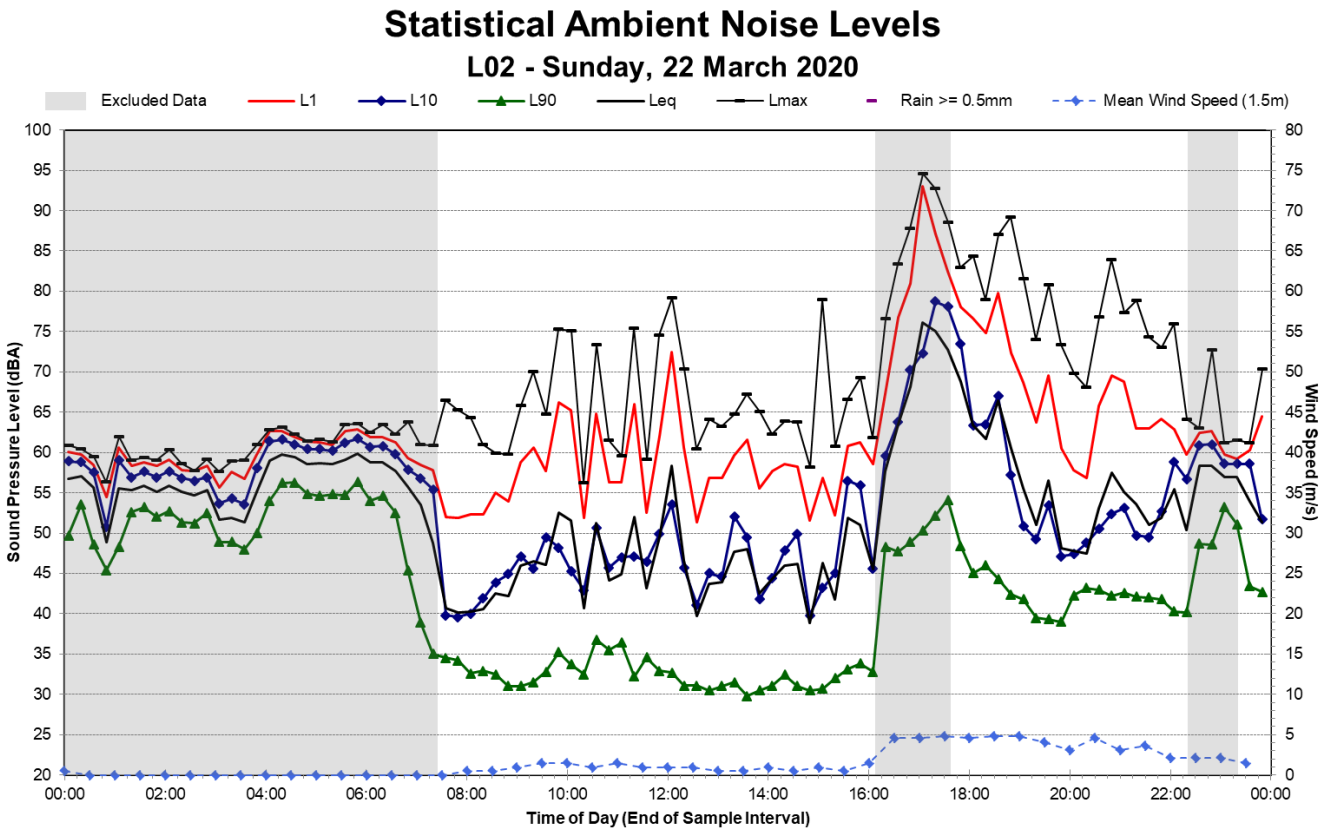

Statistical Ambient Noise Levels
L02 - Tuesday, 17 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

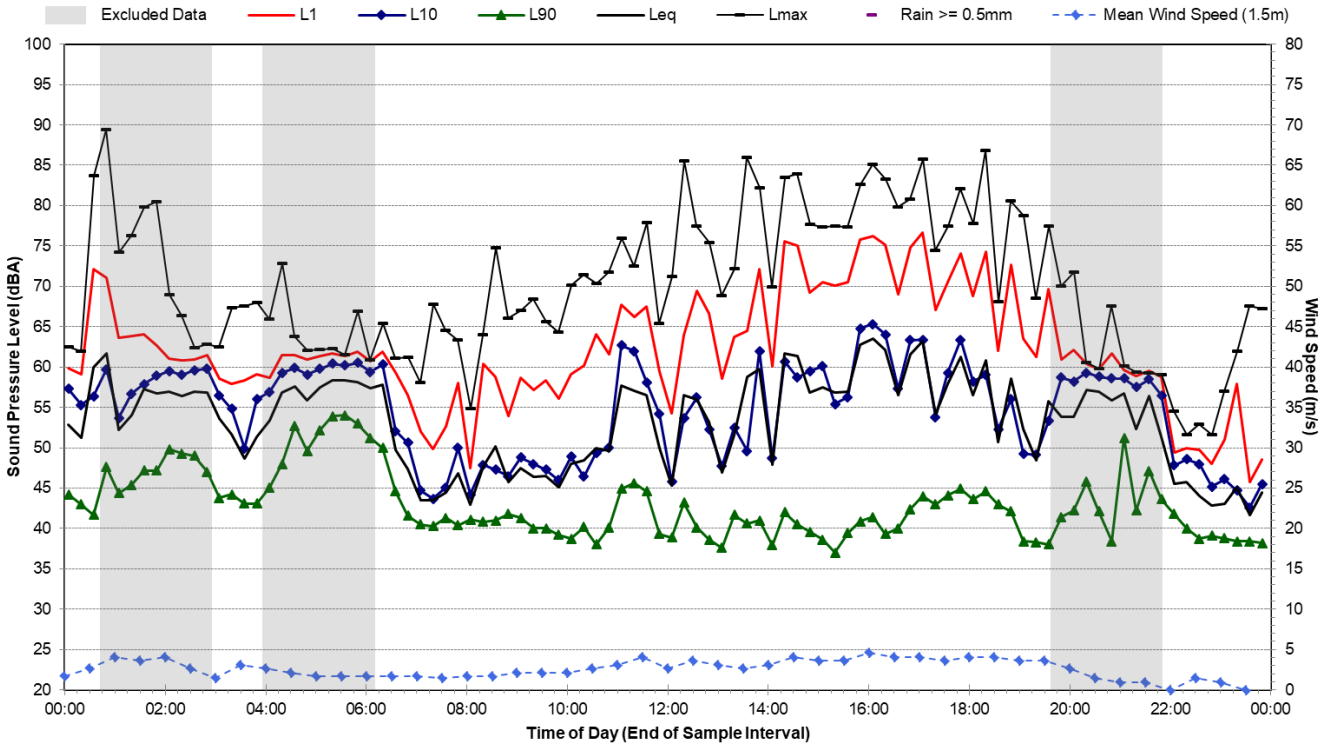

Statistical Ambient Noise Levels
L02 - Wednesday, 18 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

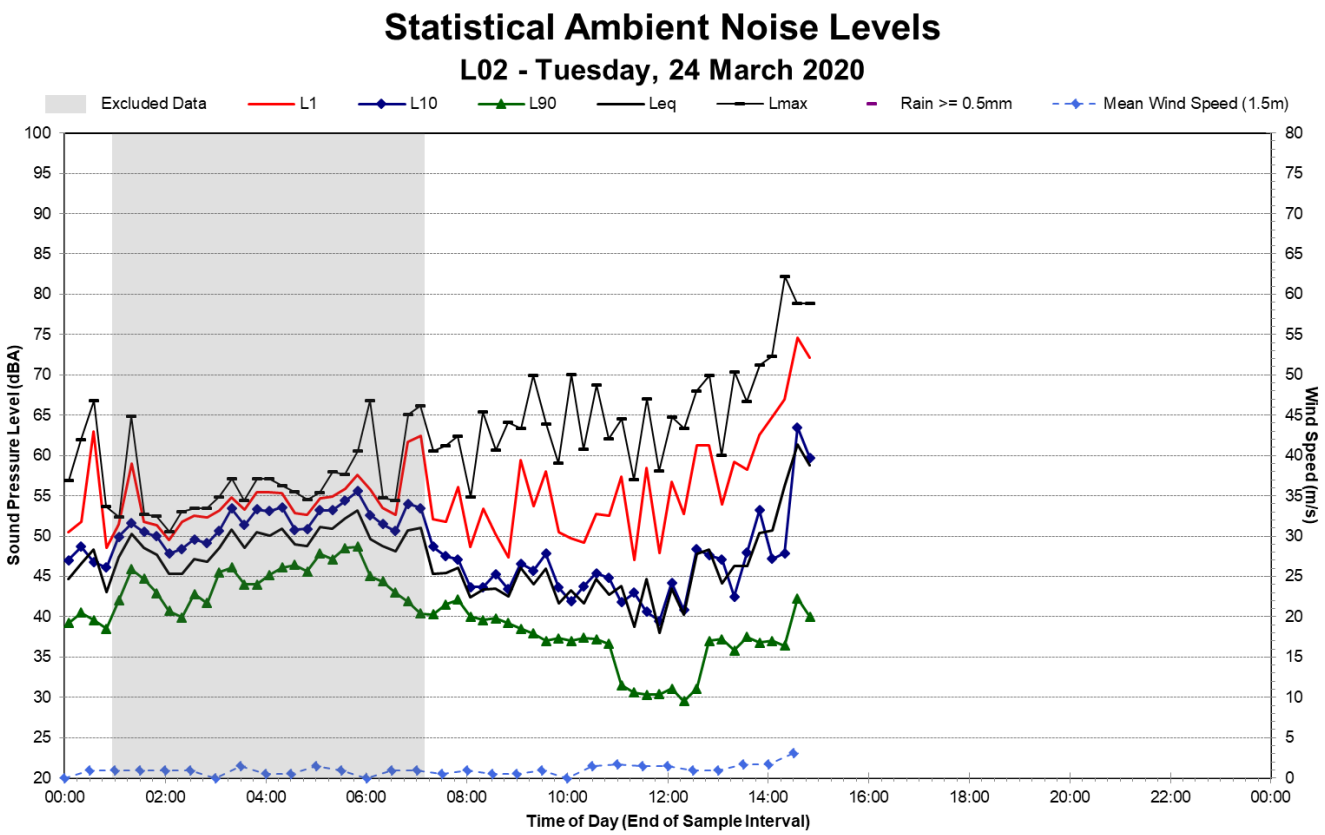

Statistical Ambient Noise Levels
L02 - Thursday, 19 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Friday, 20 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Saturday, 21 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Sunday, 22 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Monday, 23 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Tuesday, 24 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Noise Monitoring Location	L03	Map of Noise Monitoring
Noise Monitoring Address	**327-335 Burley Rd, Horsley Park**	

Logger Device Type: Svantek 957, Logger Serial No: 27578
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2414604

Ambient noise logger deployed at the southern boundary the site, approximately 950 m from Burley Road.

Attended noise measurements indicate the ambient noise environment at this location is heavily dominated by activity from the quarry.

Recorded Noise Levels (LAmax):
10/03/2020: Excavator (debris impact): 55 - 69dBA, Excavator (idle): 45- 46dBA, Excavator (tracks): 57 - 59dBA, Truck horn: 67 dBA, Accelerating truck: 57 - 59 dBA

Ambient Noise Logging Results – NPfI Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	39	63	50	61
Evening	39	64	53	66
Night-time	38	61	51	61

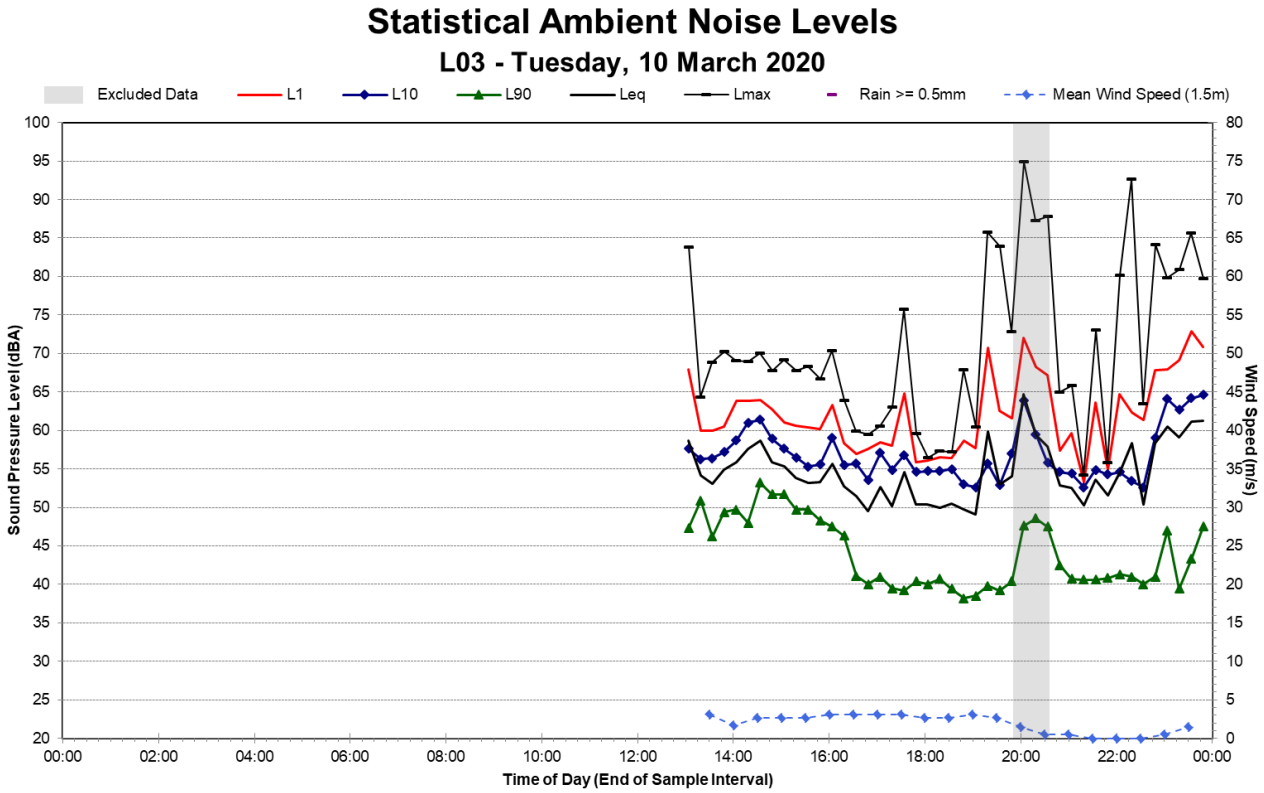
Ambient Noise Logging Results – RNP Defined Time Periods

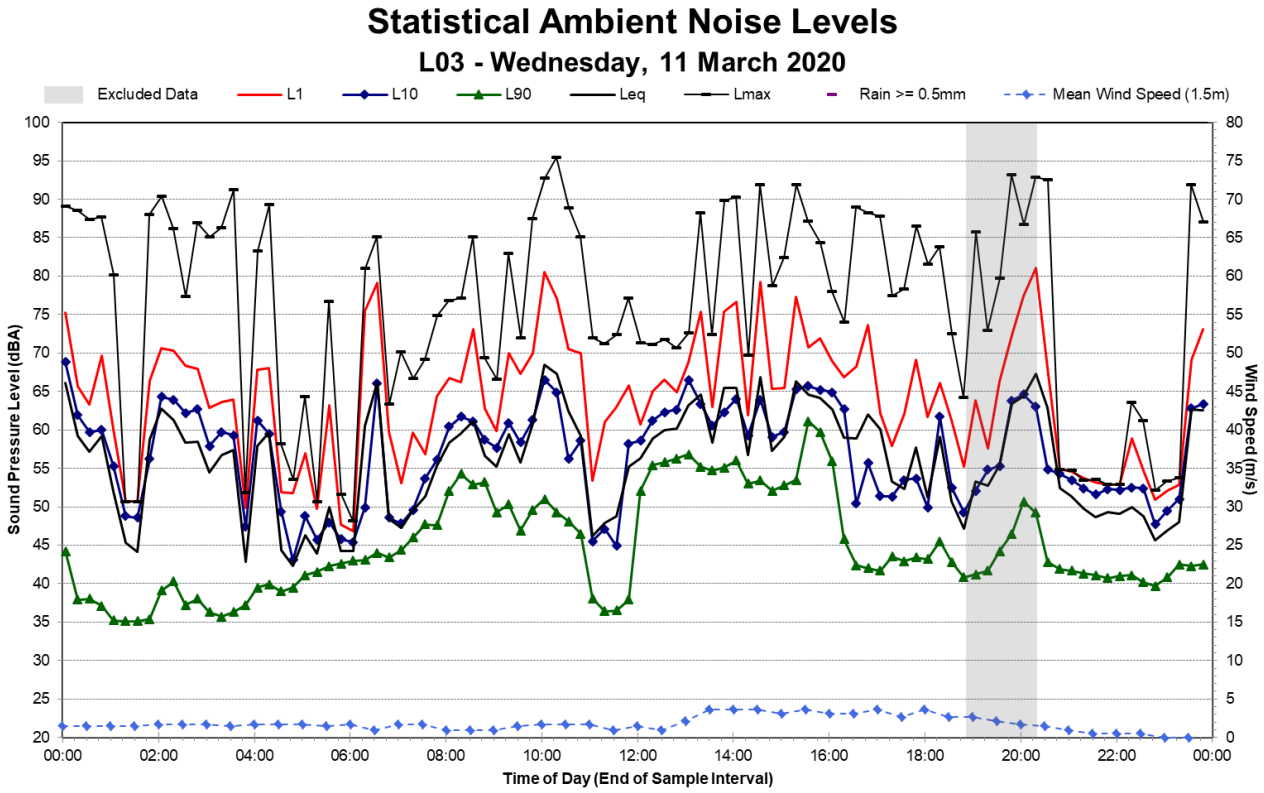
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	64	65
Night-time (10pm-7am)	60	60

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
10/03/2020	12:35 pm	46	53	69

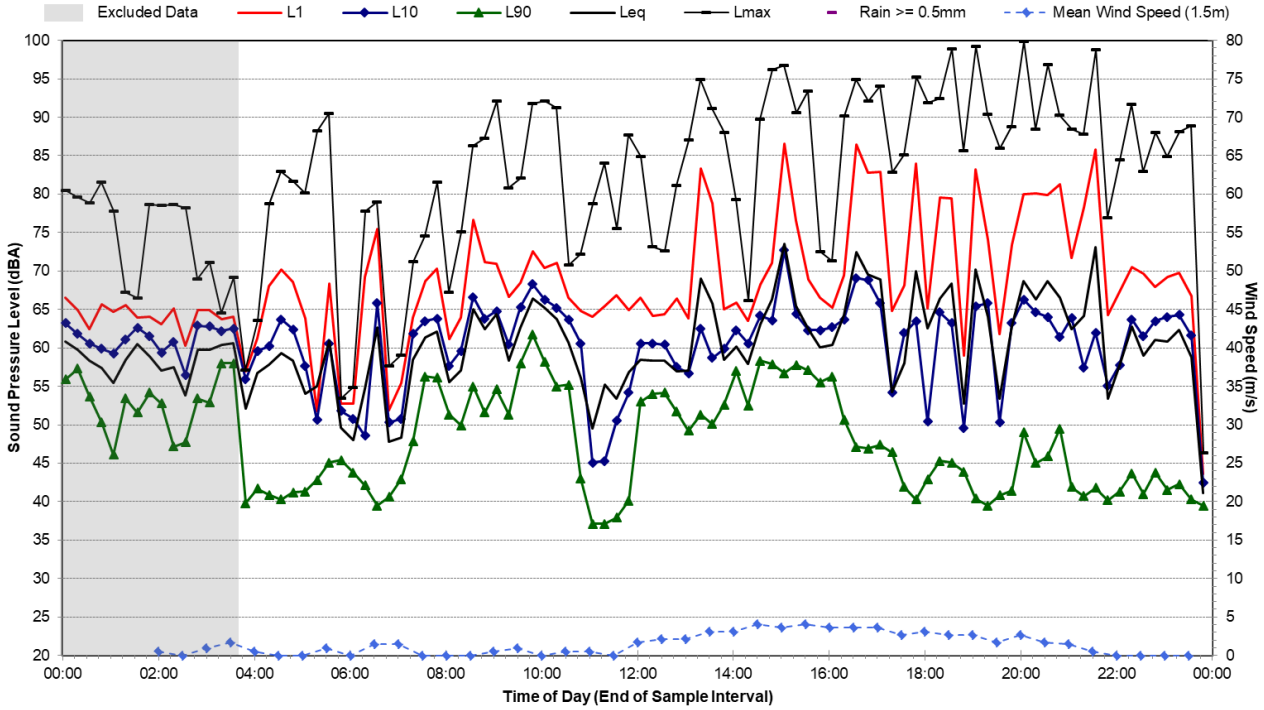
Photo of Noise Monitorin


Statistical Ambient Noise Levels
L03 - Tuesday, 10 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Wednesday, 11 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

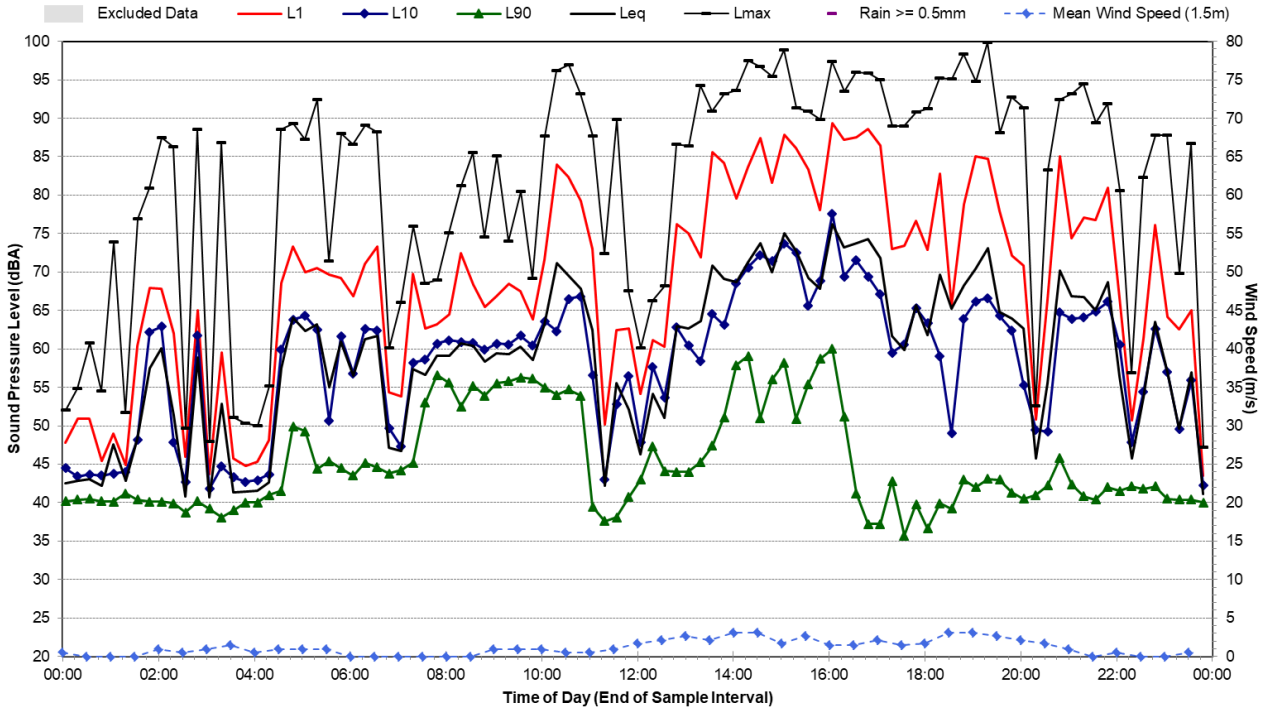
Statistical Ambient Noise Levels

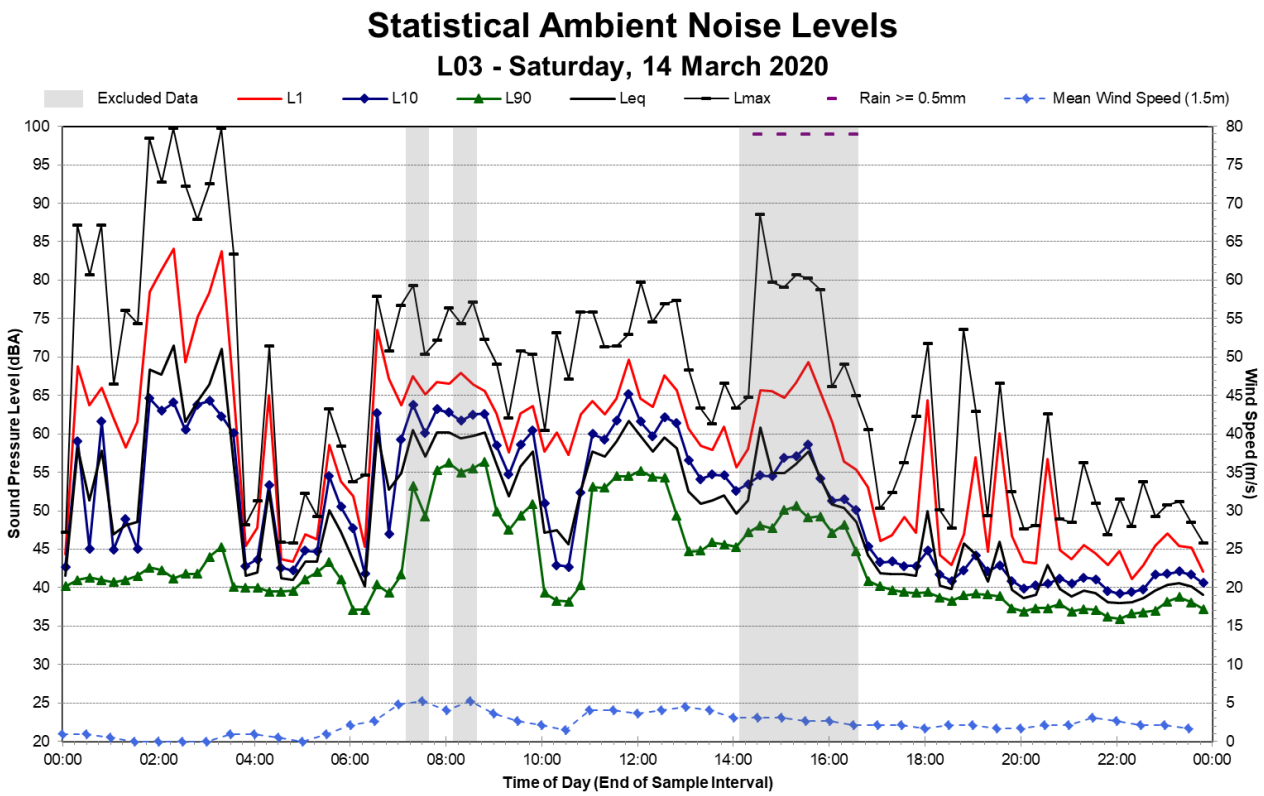
L03 - Thursday, 12 March 2020

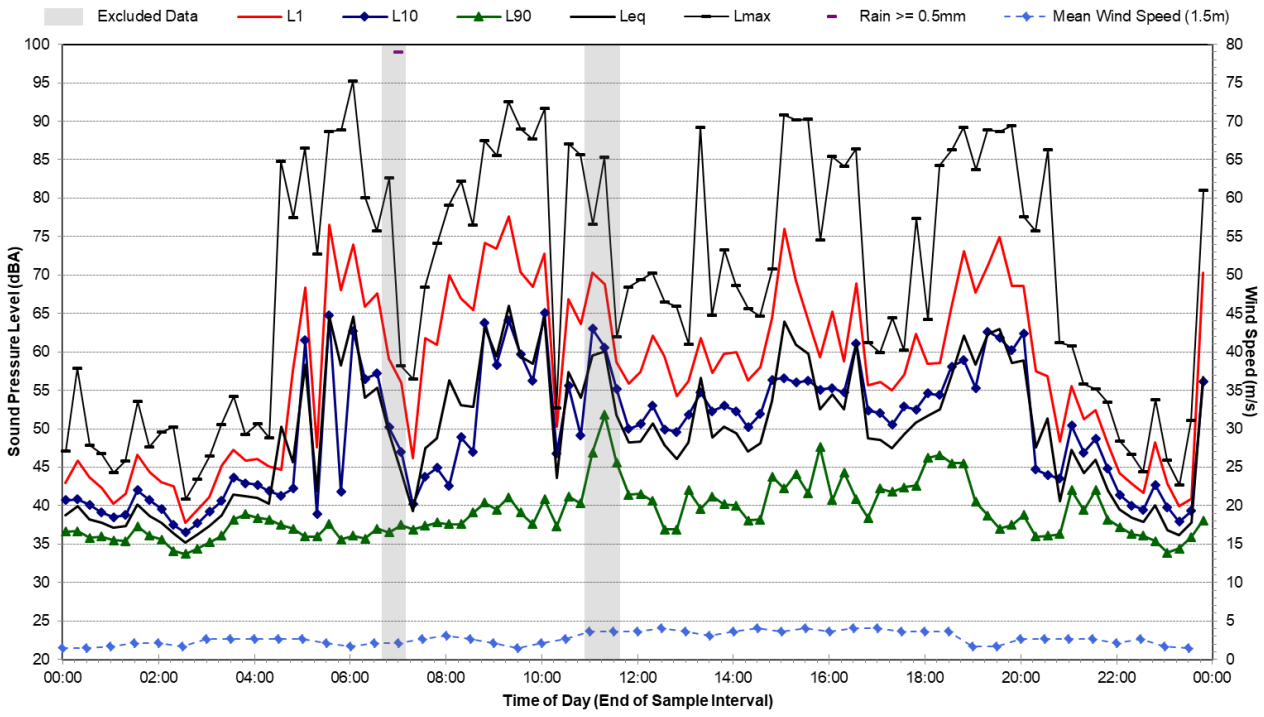


Statistical Ambient Noise Levels

L03 - Friday, 13 March 2020

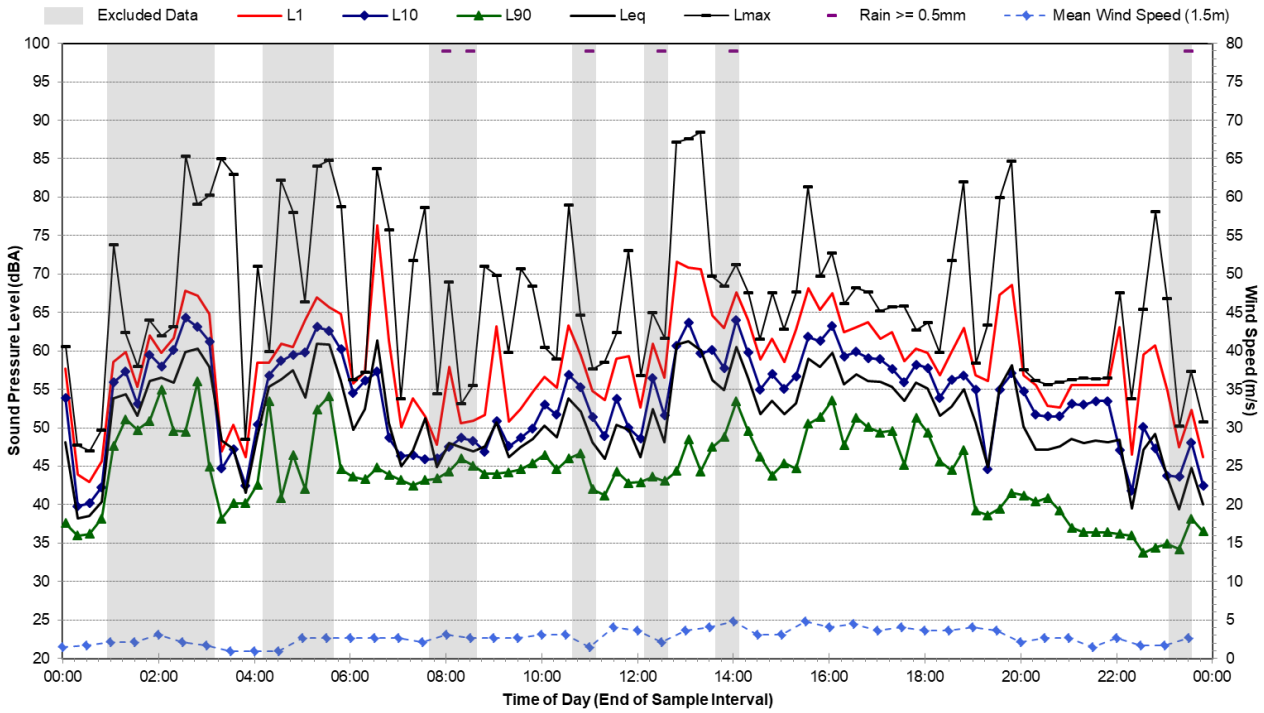



Statistical Ambient Noise Levels
L03 - Saturday, 14 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Sunday, 15 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

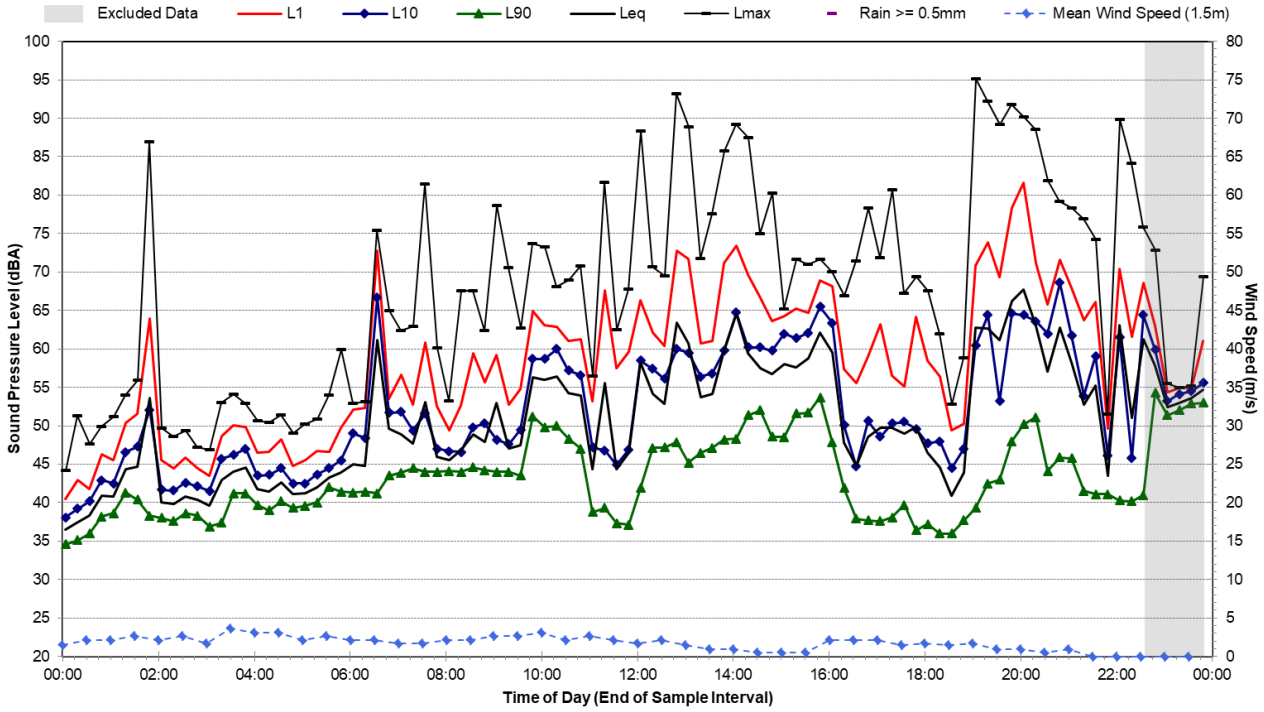
Statistical Ambient Noise Levels

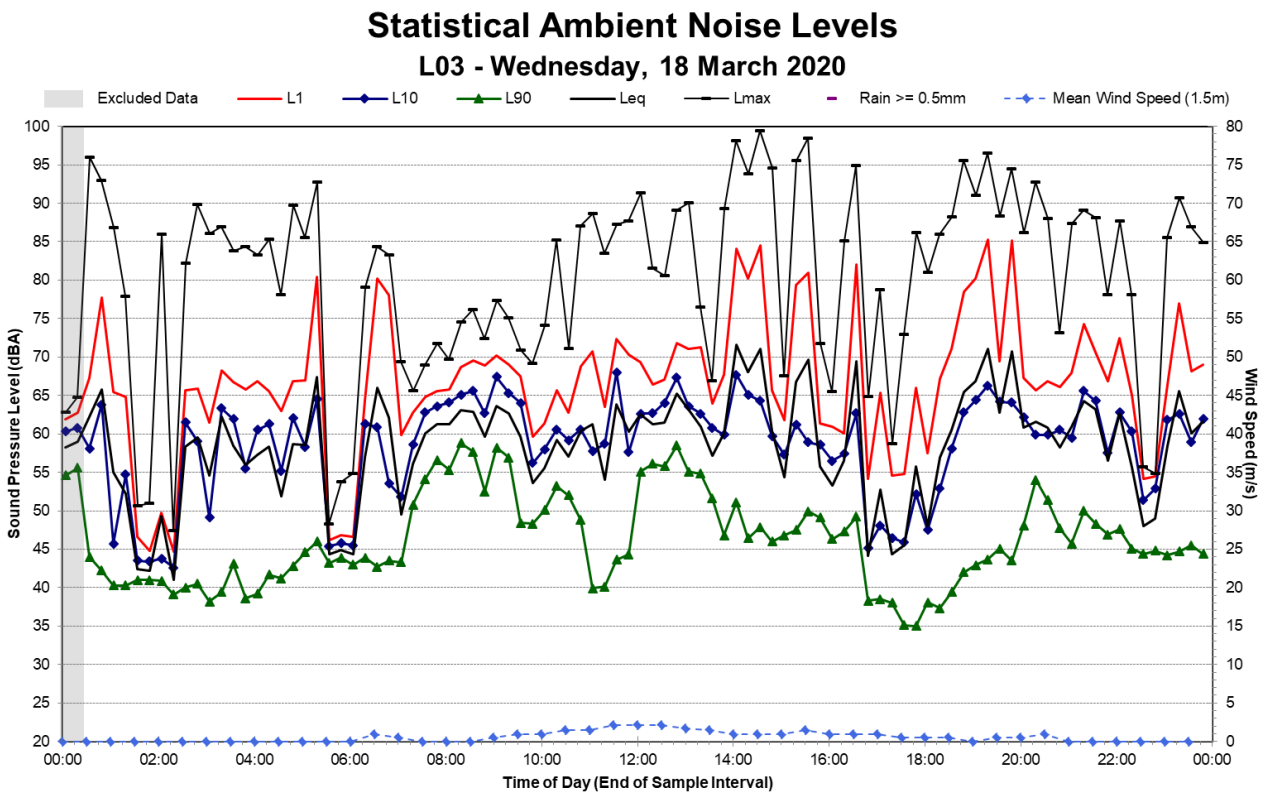
L03 - Monday, 16 March 2020

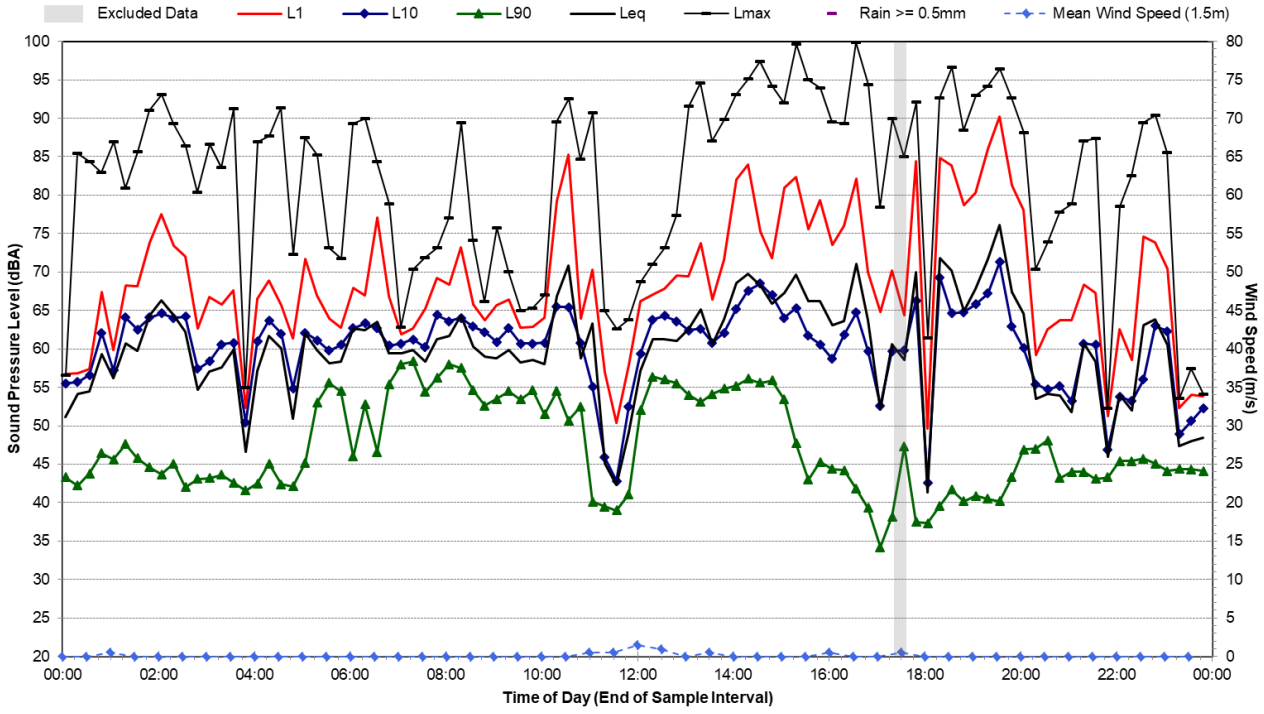


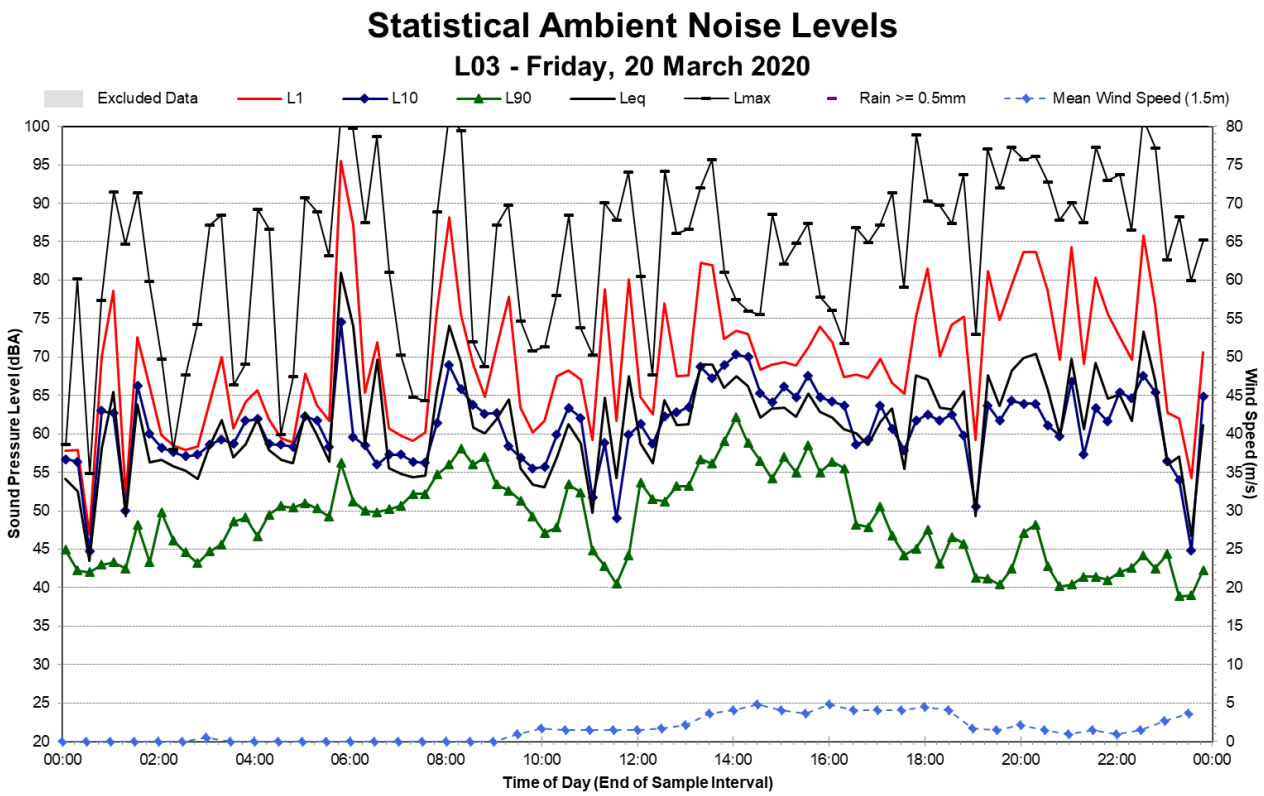
Statistical Ambient Noise Levels

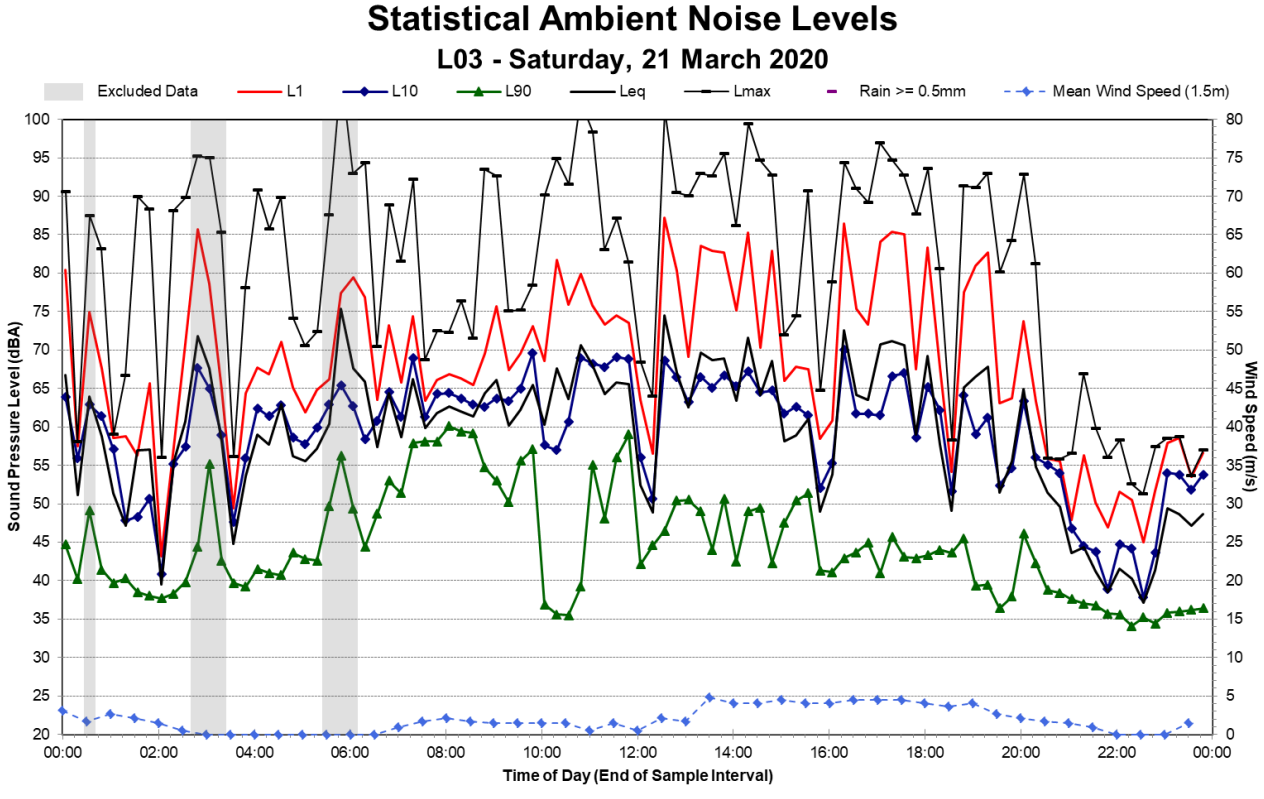
L03 - Tuesday, 17 March 2020

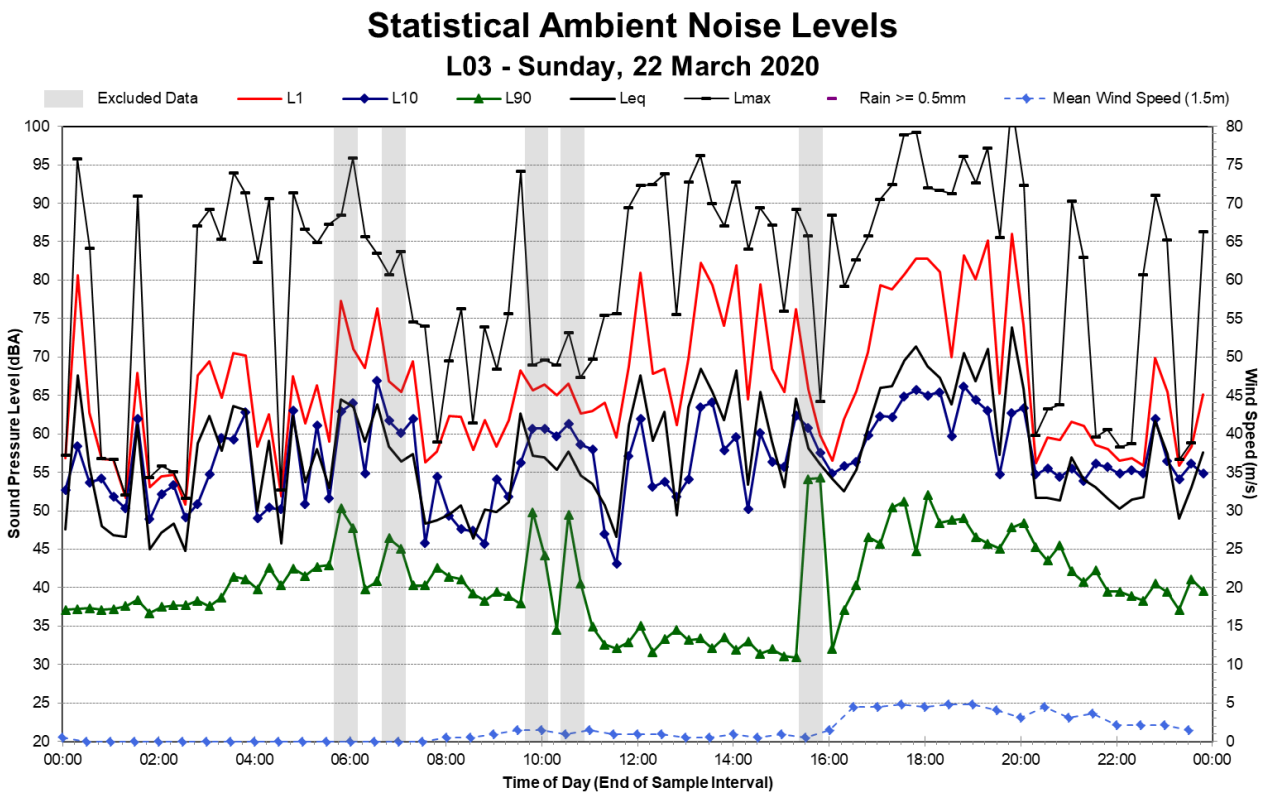


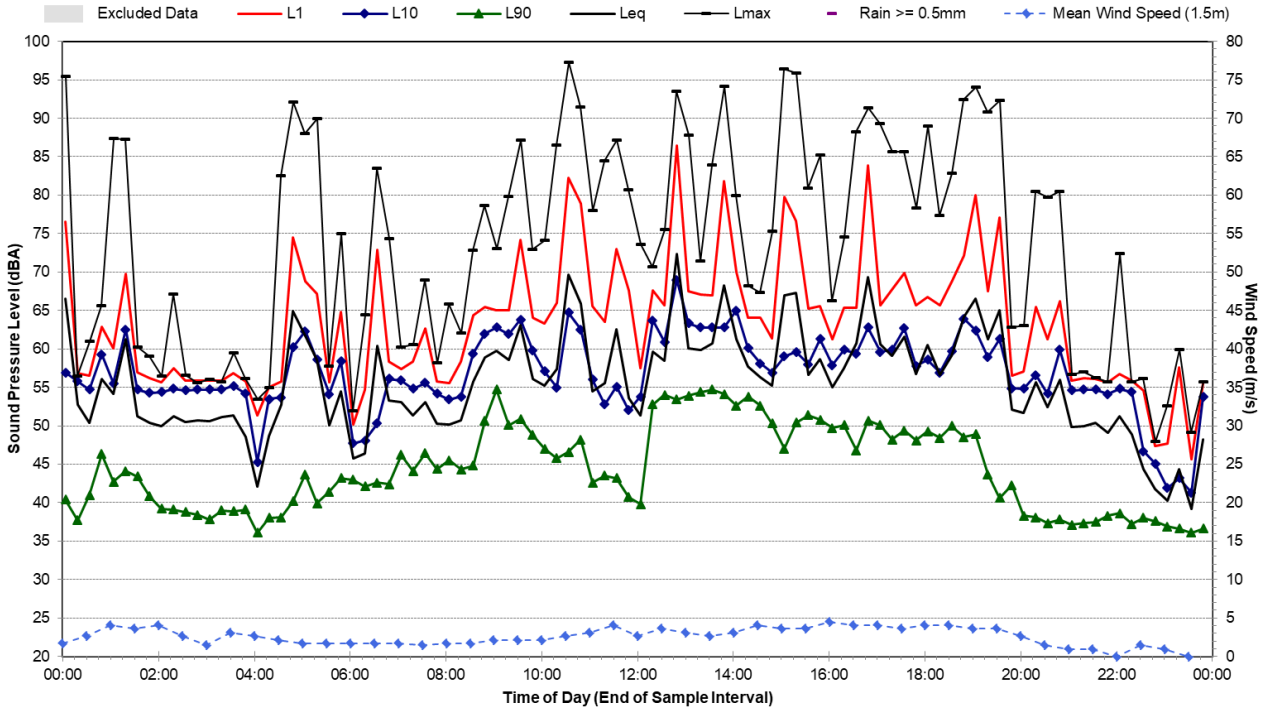

Statistical Ambient Noise Levels
L03 - Wednesday, 18 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

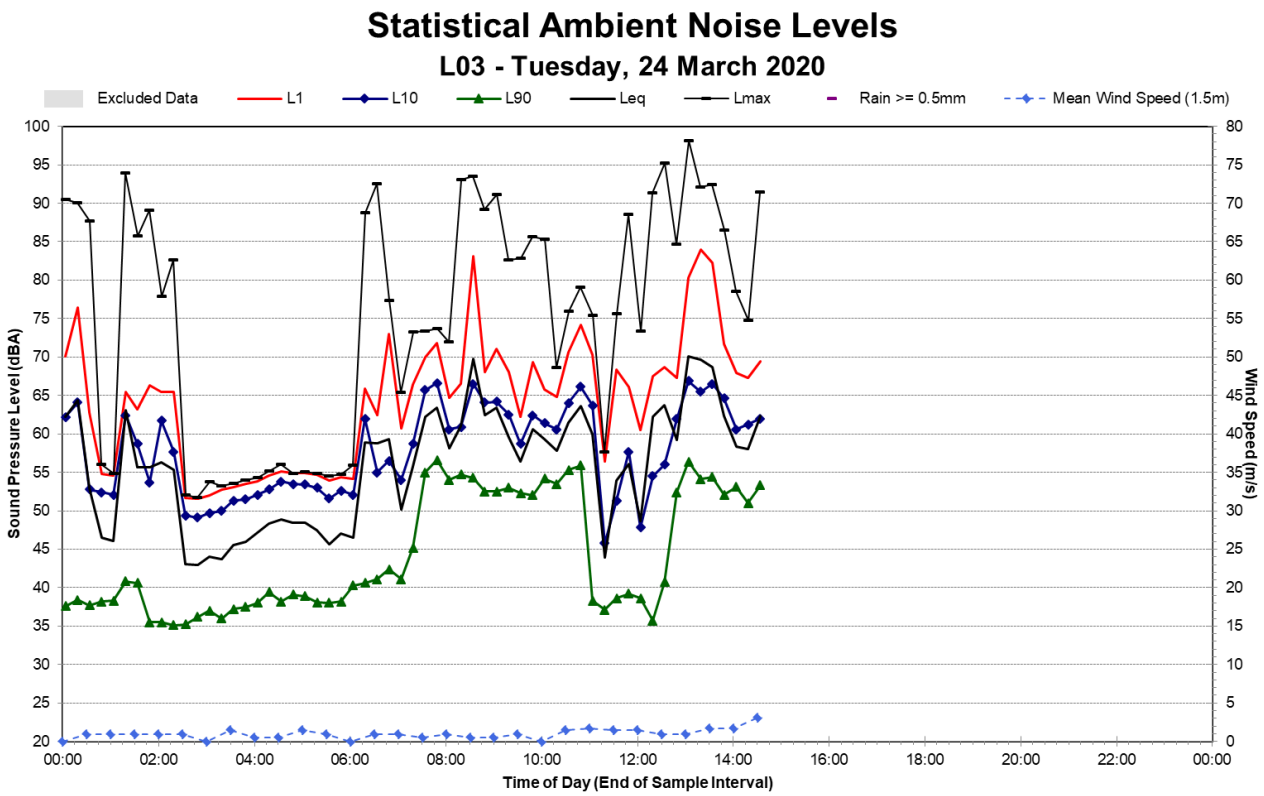

Statistical Ambient Noise Levels
L03 - Thursday, 19 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Friday, 20 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Saturday, 21 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Sunday, 22 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Monday, 23 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Tuesday, 24 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

Noise Monitoring Location	L04	Map of Noise Monitoring
Noise Monitoring Address	**327-335 Burley Rd, Horsley Park**	

Logger Device Type: Svantek 957, Logger Serial No: 21887
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2414604

Ambient noise logger deployed at the eastern boundary the site, approximately 730 m from Burley Road.

Attended noise measurements indicate the ambient noise environment at this location is dominated by activity from the quarry, birds and aircraft.

Recorded Noise Levels (L_{Amax}):
10/03/2020: Excavator (debris impact): 60 dBA, Excavator (idle): 50 - 54dBA, Haul truck: 45 - 56 dBA, Aircraft: 52 – 68 dBA, Birds: 57 dBA, Insects audible

Ambient Noise Logging Results – NPfI Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	40	53	52	58
Evening	38	46	45	50
Night-time	36	42	41	44

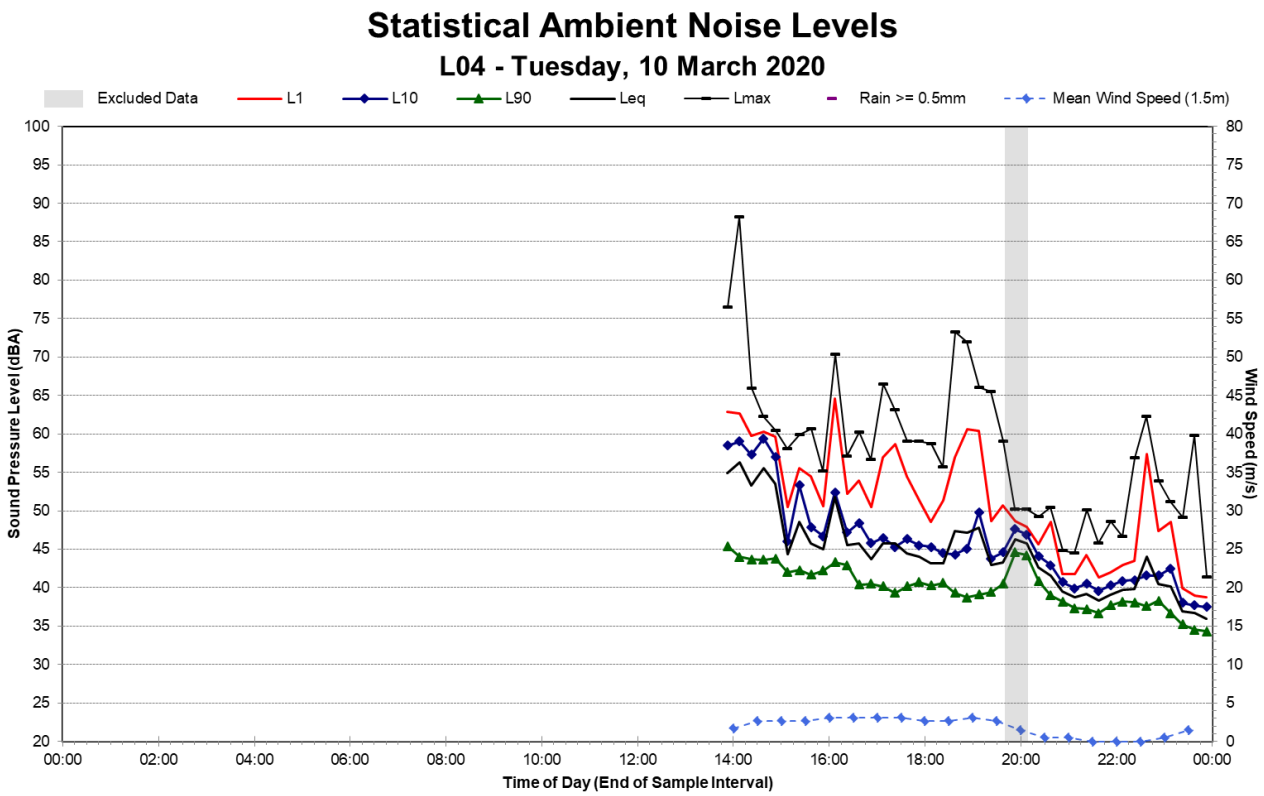
Ambient Noise Logging Results – RNP Defined Time Periods

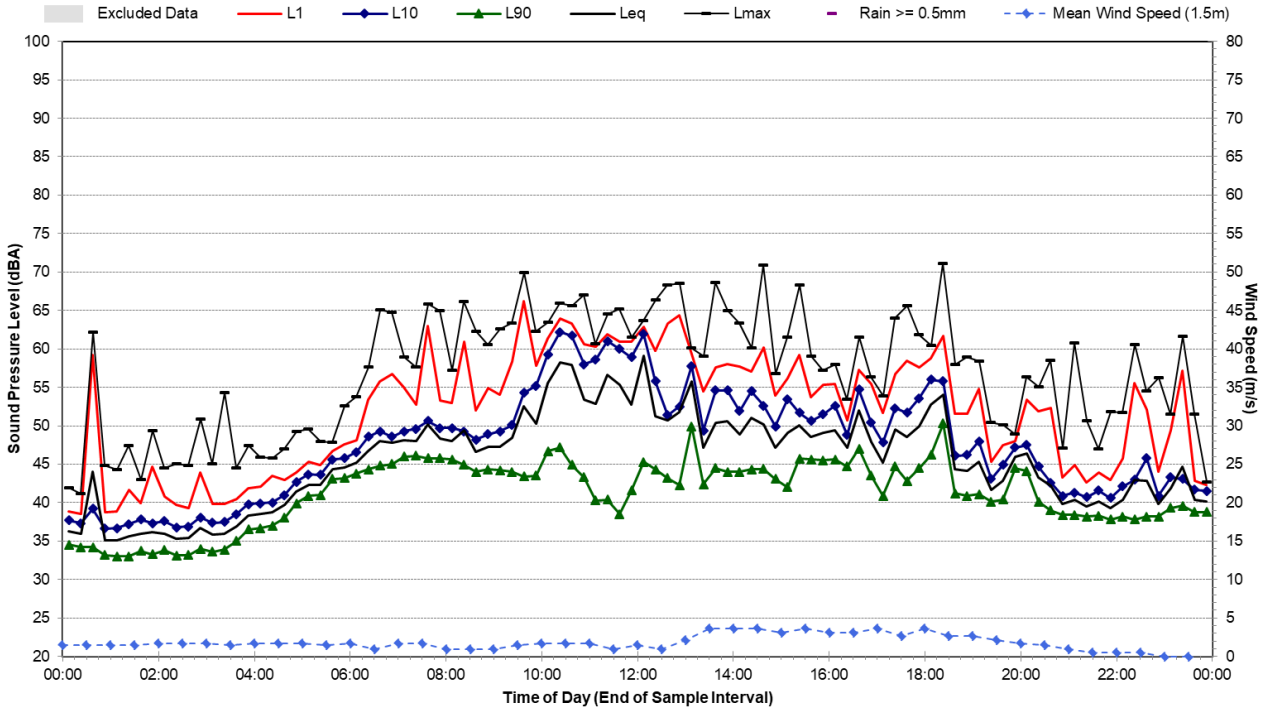
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	52	48
Night-time (10pm-7am)	42	41

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
10/03/2020	1:31 pm	45	51	68

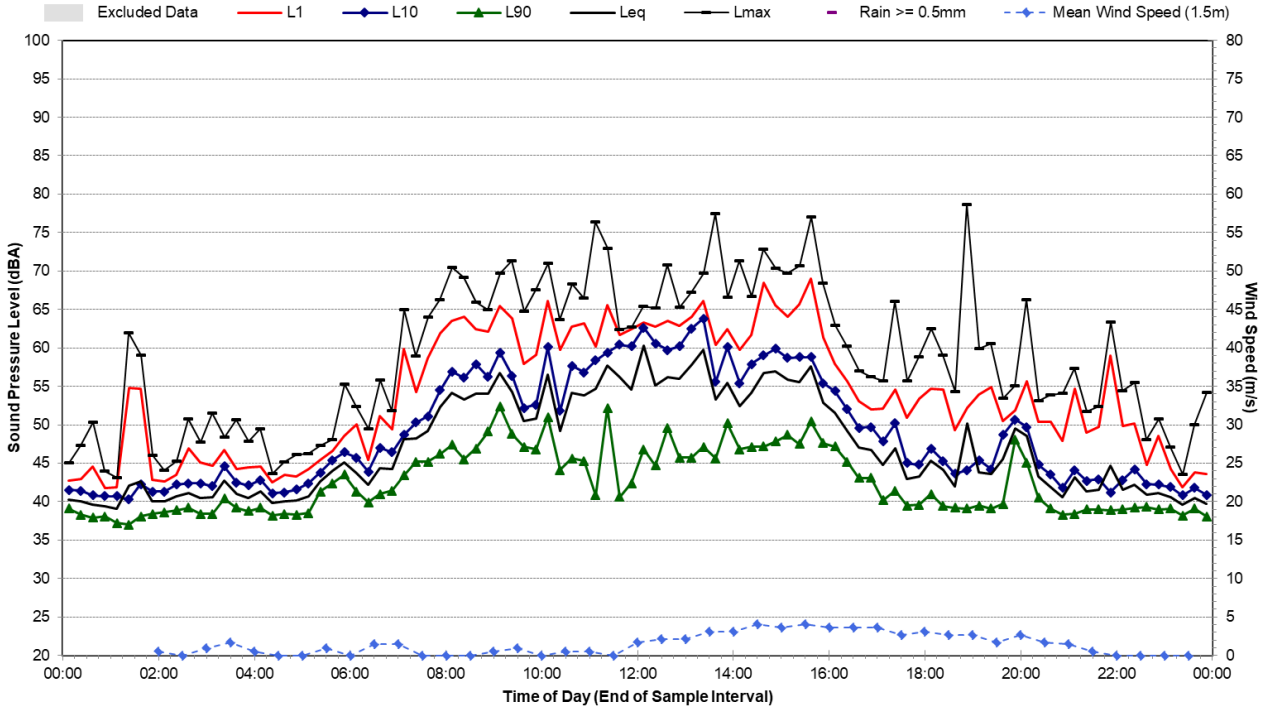
Photo of Noise Monitorin


Statistical Ambient Noise Levels
L04 - Tuesday, 10 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L04 - Wednesday, 11 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

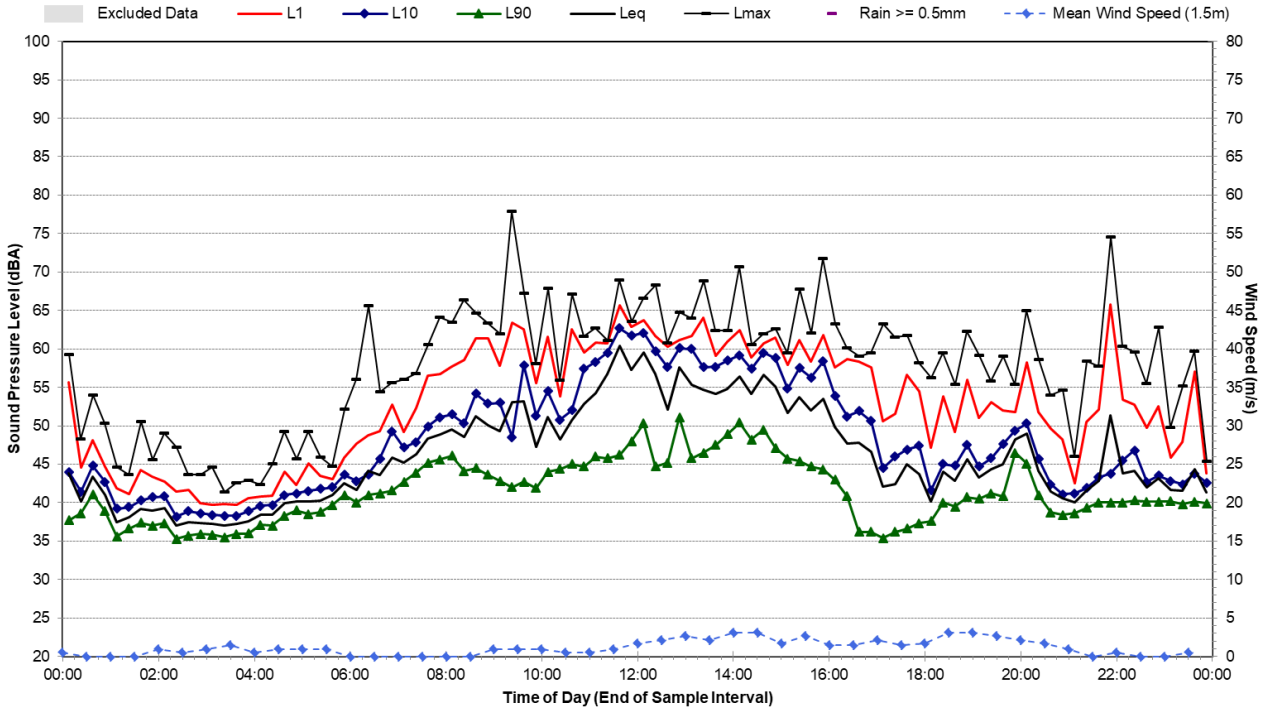
Statistical Ambient Noise Levels

L04 - Thursday, 12 March 2020



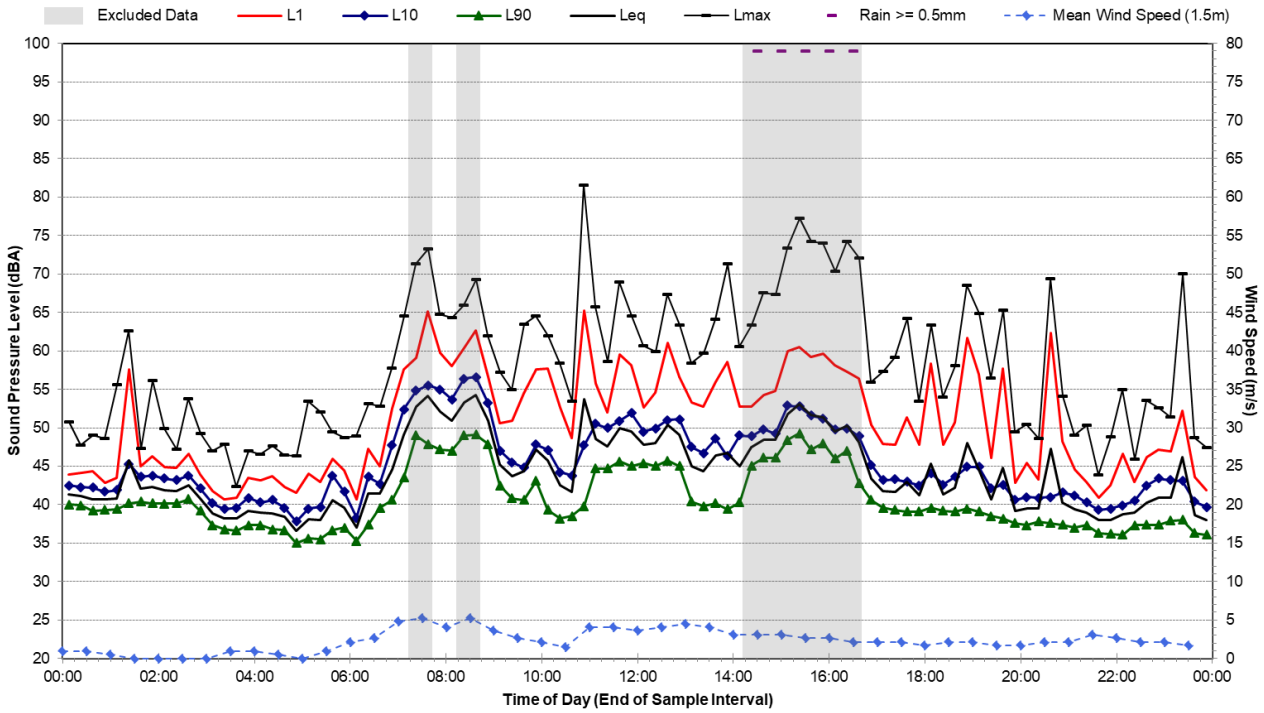
Statistical Ambient Noise Levels

L04 - Friday, 13 March 2020



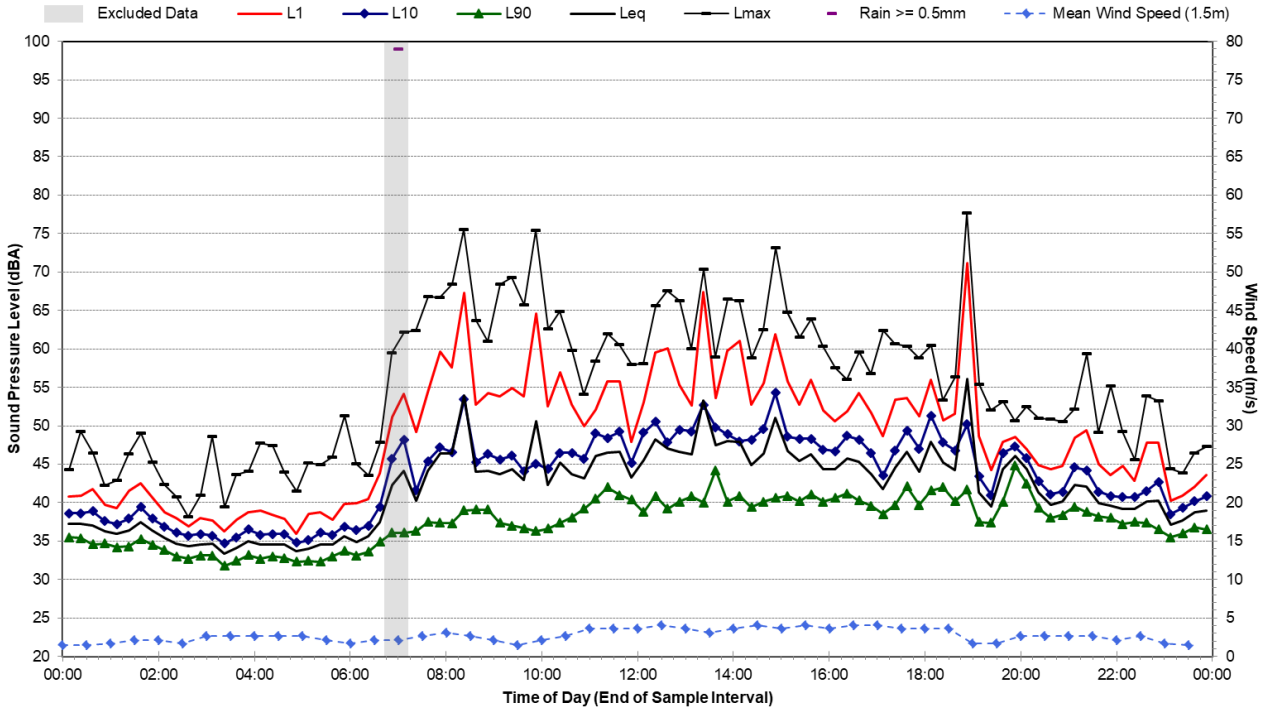
Statistical Ambient Noise Levels

L04 - Saturday, 14 March 2020



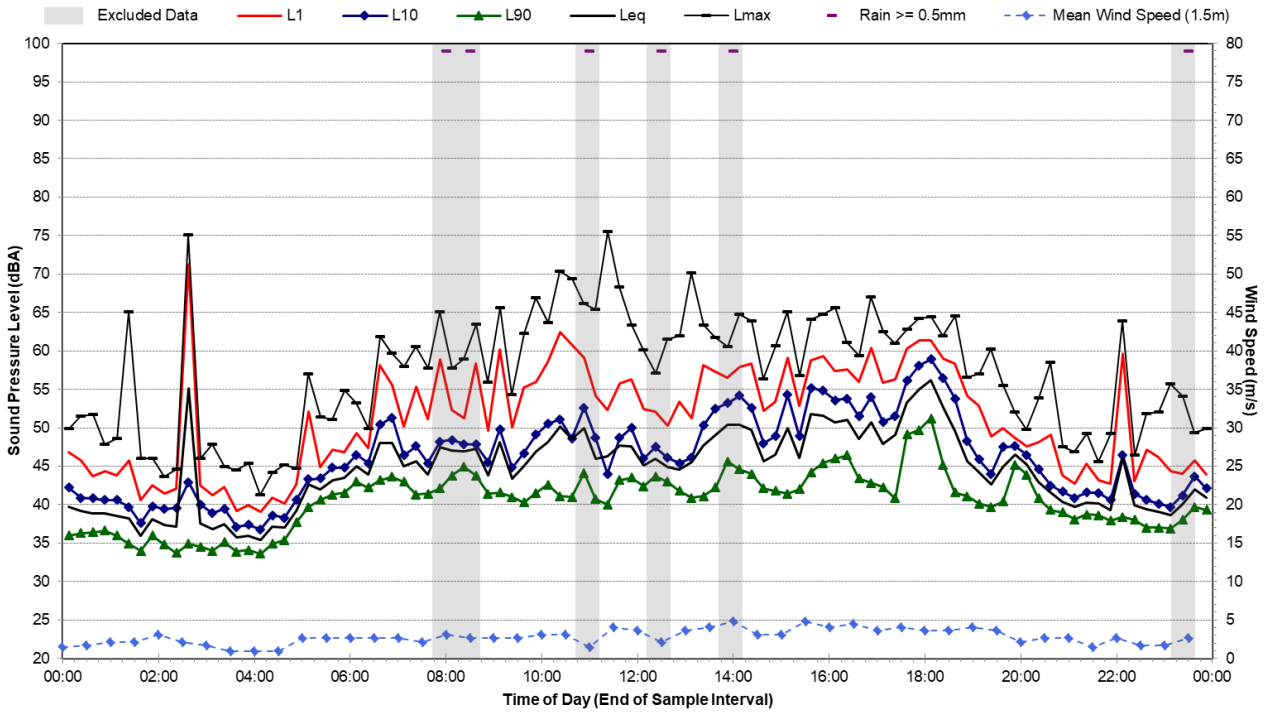
Statistical Ambient Noise Levels

L04 - Sunday, 15 March 2020



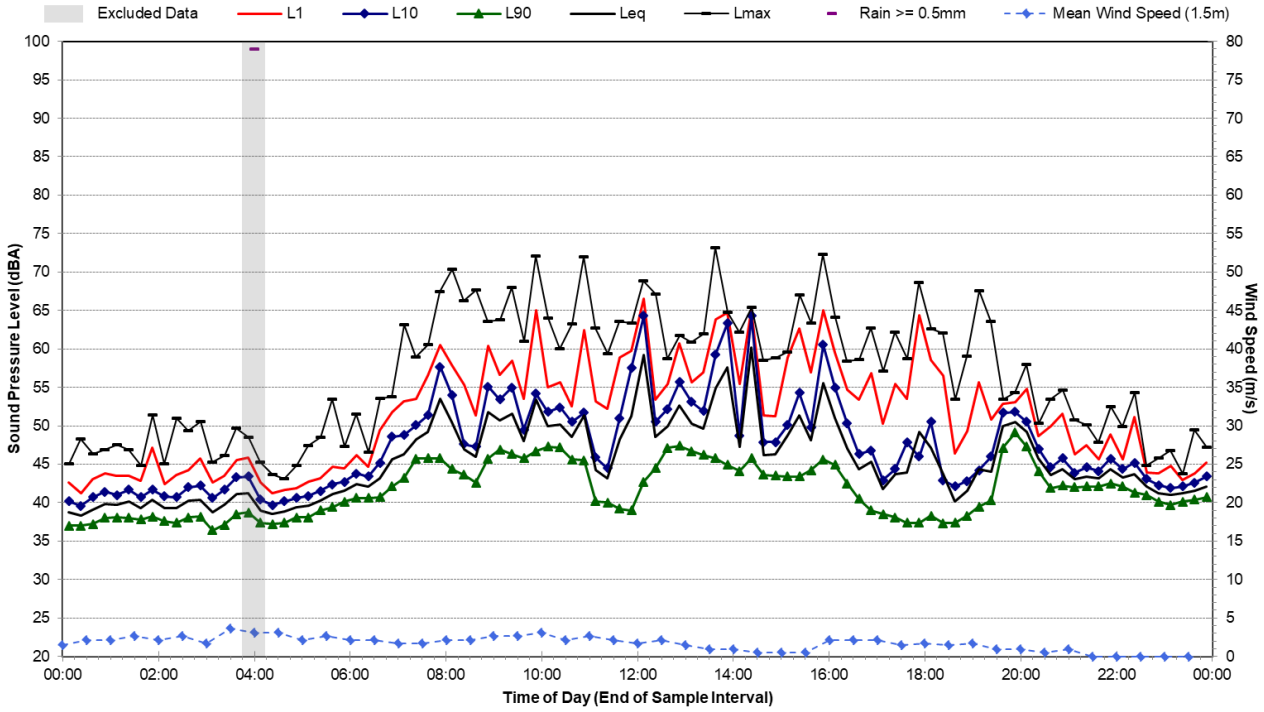
Statistical Ambient Noise Levels

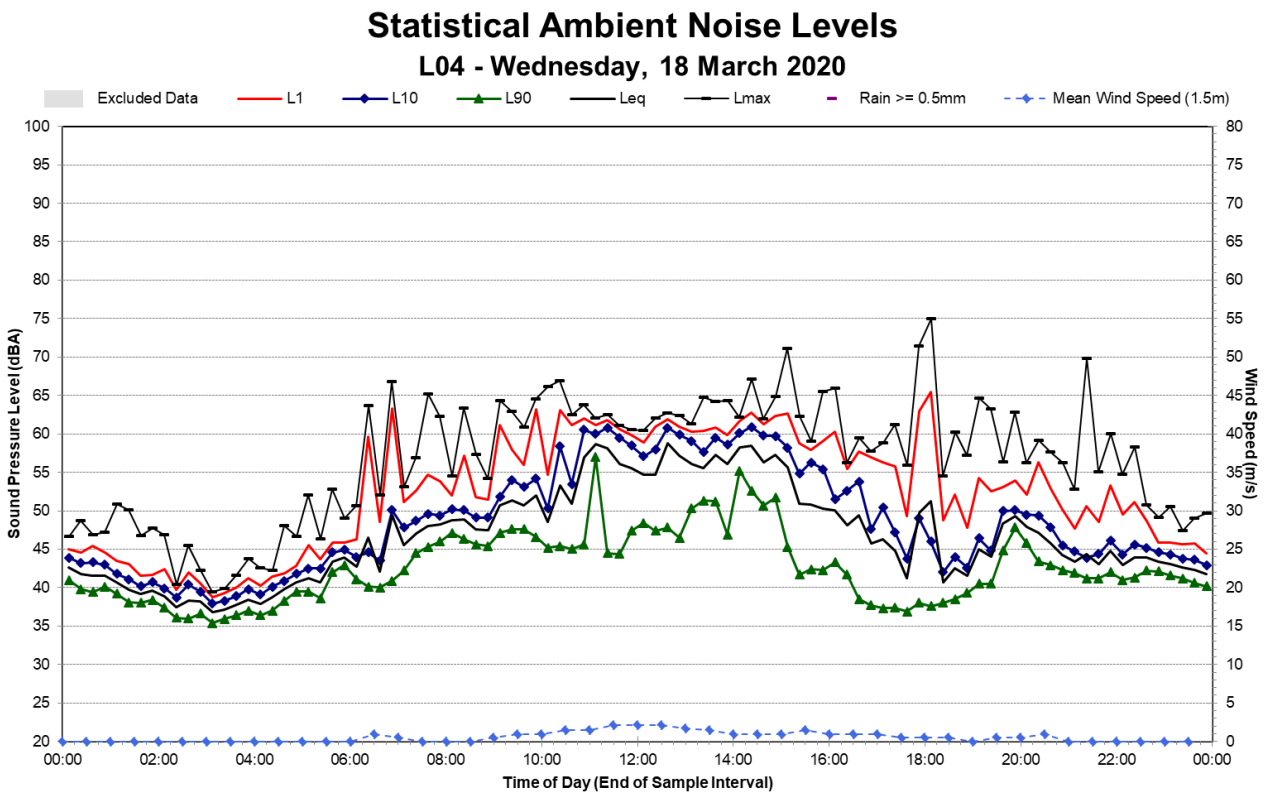
L04 - Monday, 16 March 2020

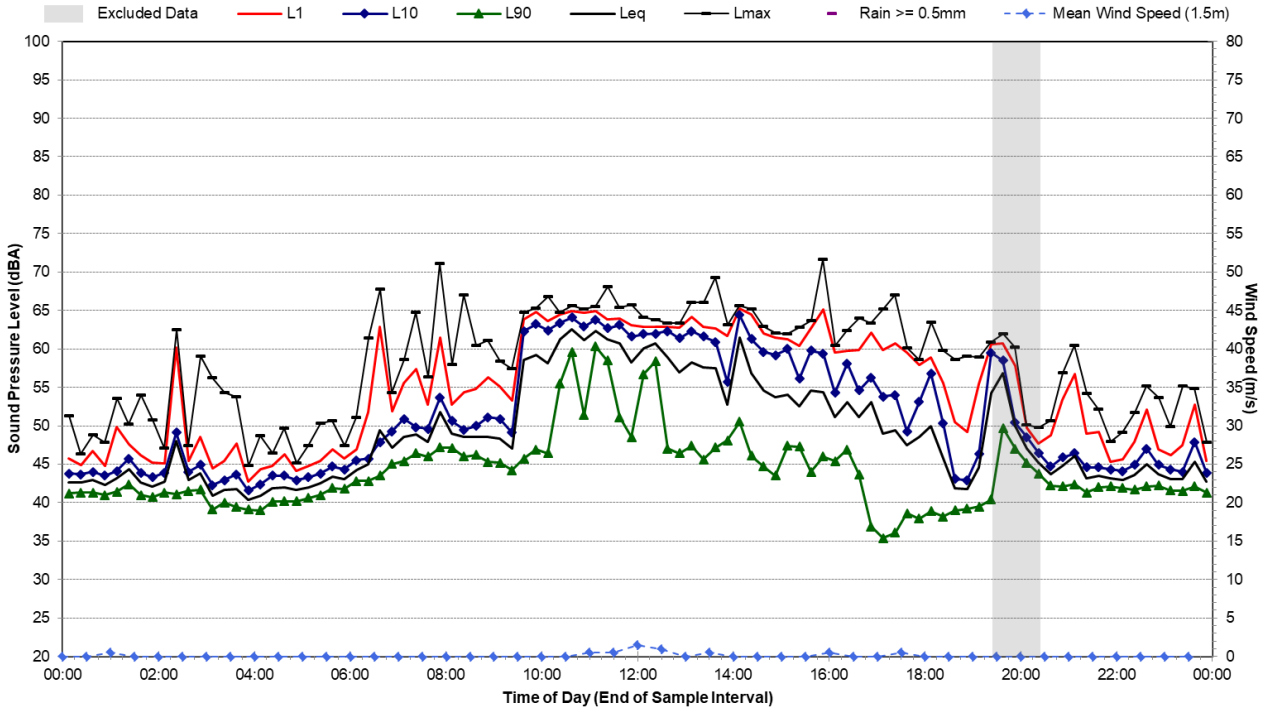


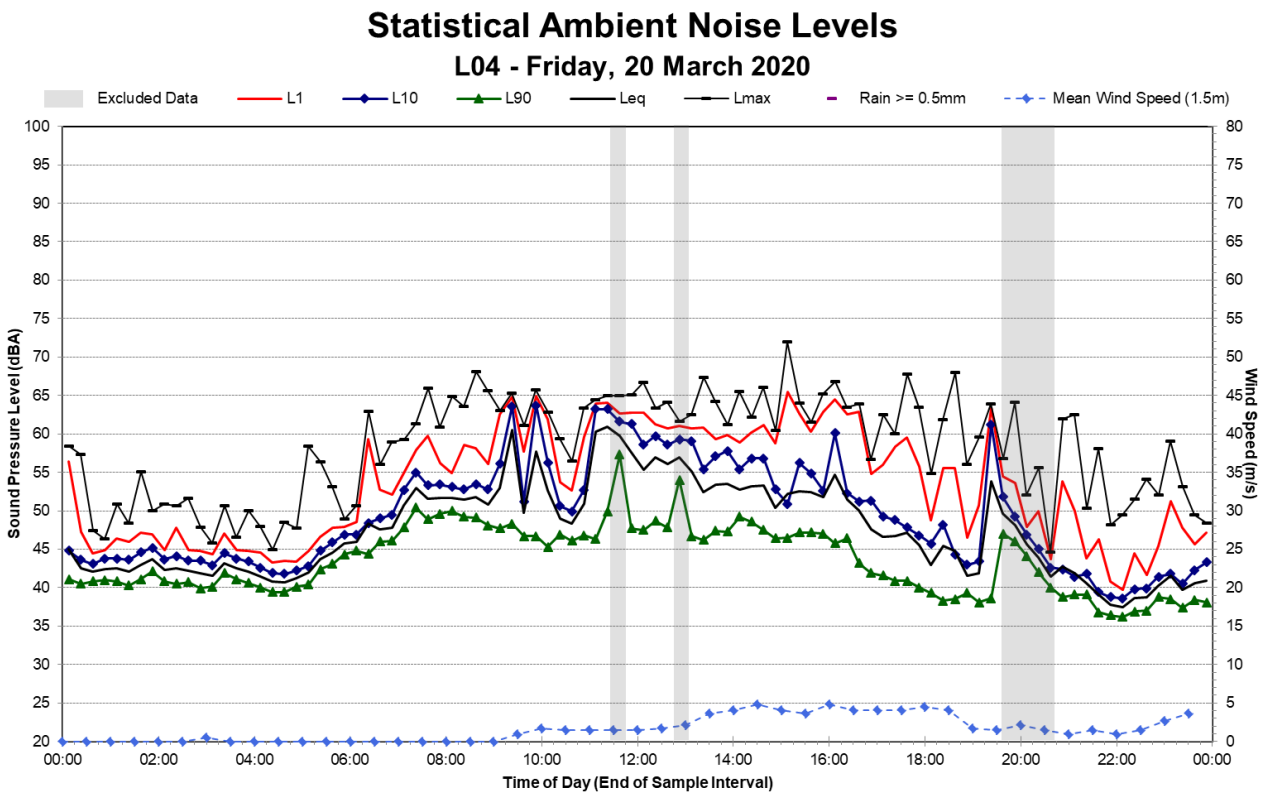
Statistical Ambient Noise Levels

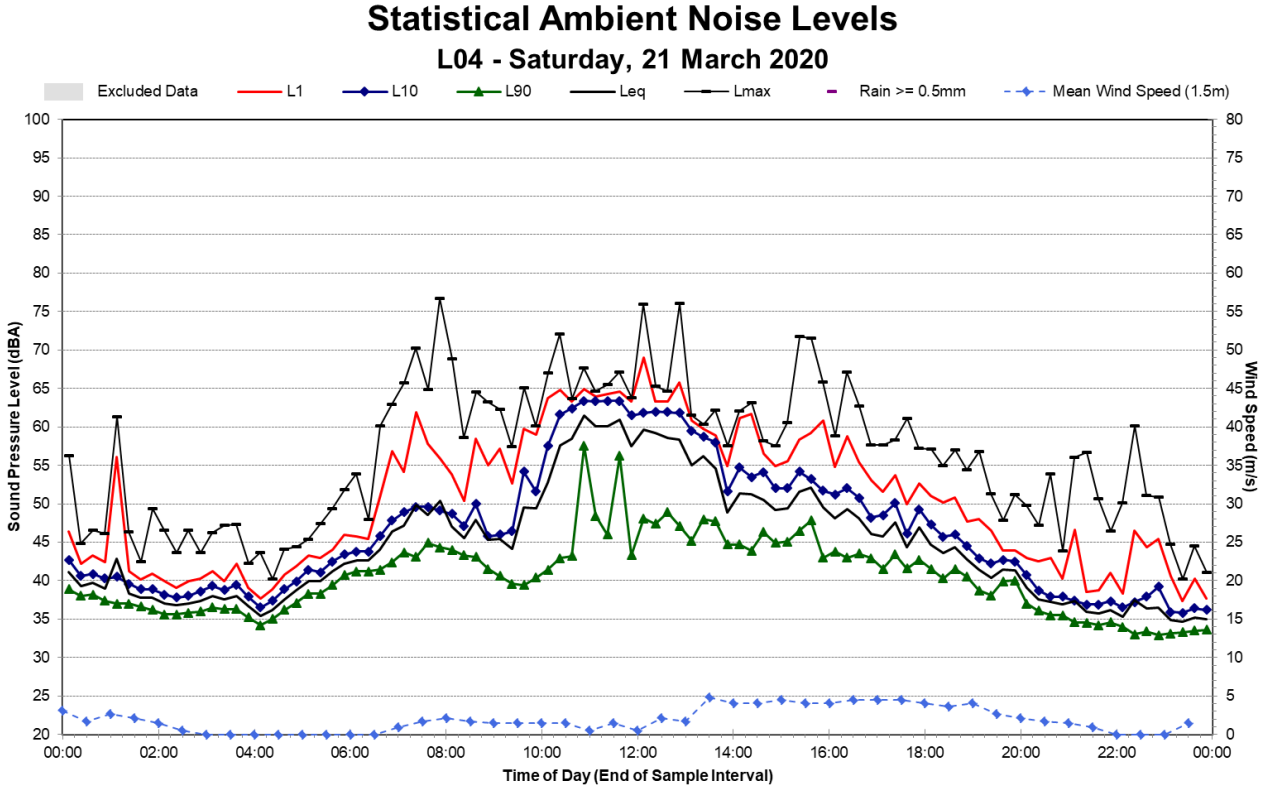
L04 - Tuesday, 17 March 2020




Statistical Ambient Noise Levels
L04 - Wednesday, 18 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

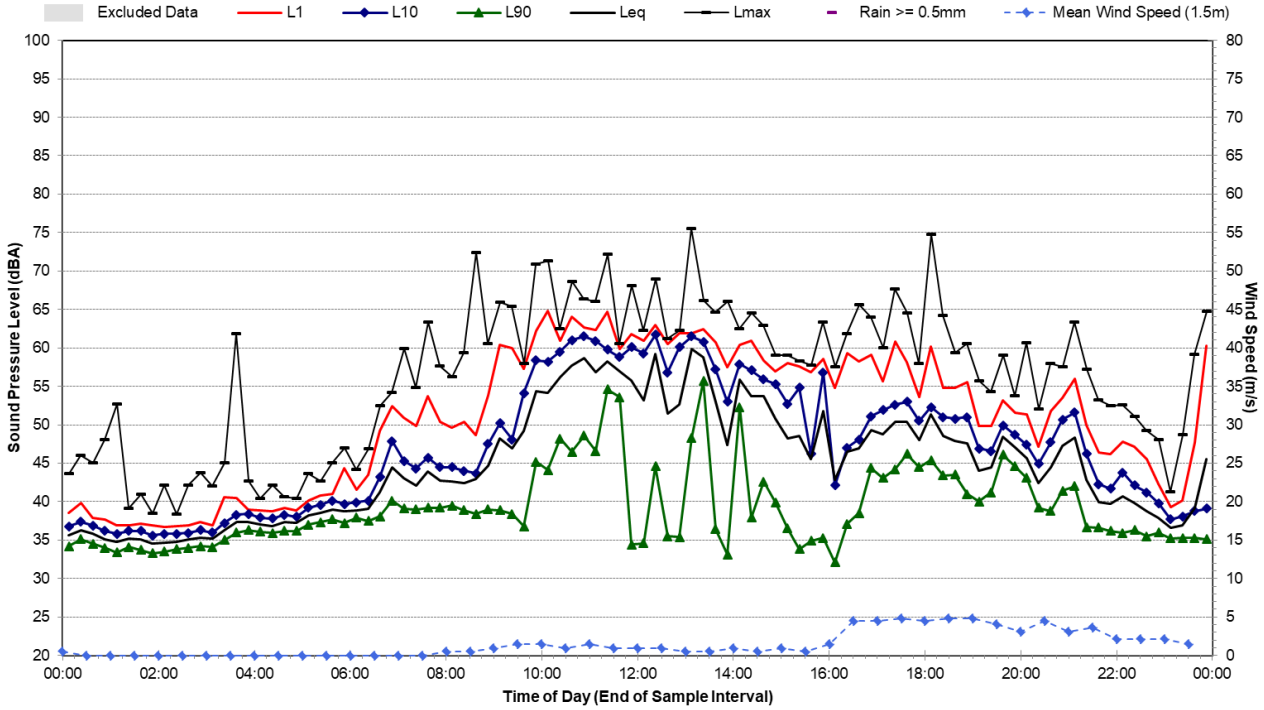

Statistical Ambient Noise Levels
L04 - Thursday, 19 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L04 - Friday, 20 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L04 - Saturday, 21 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

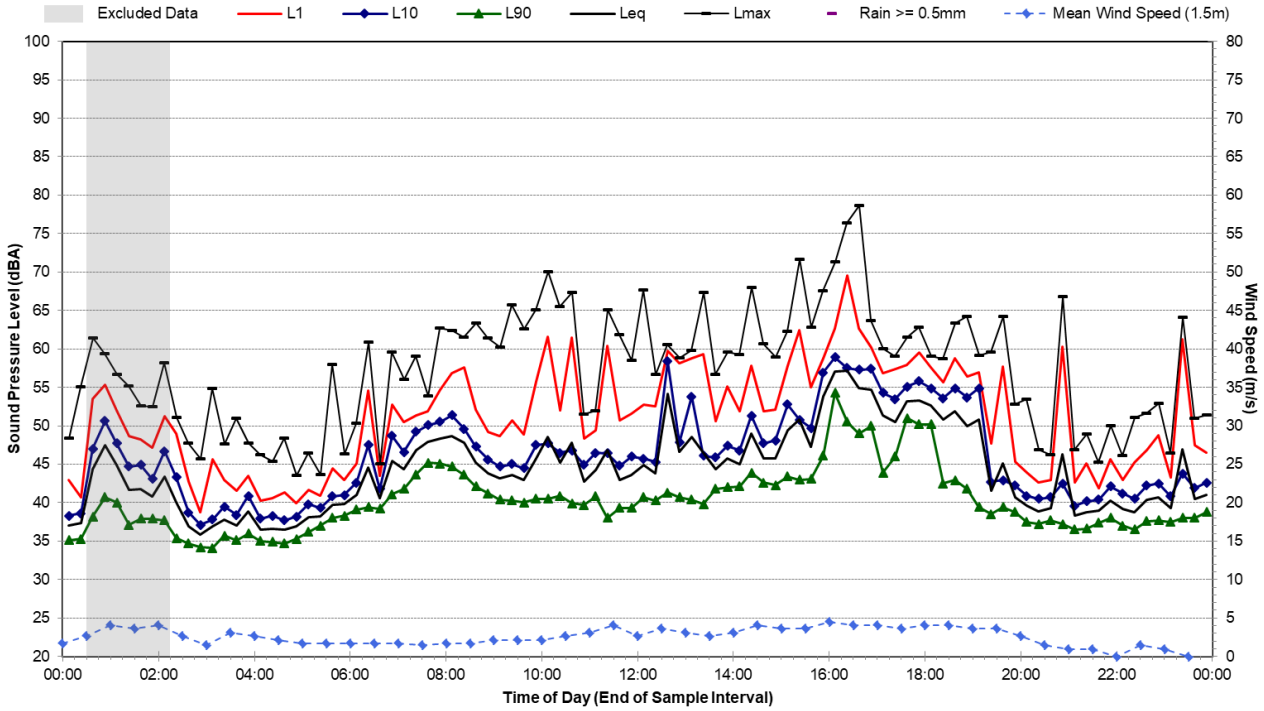
Statistical Ambient Noise Levels

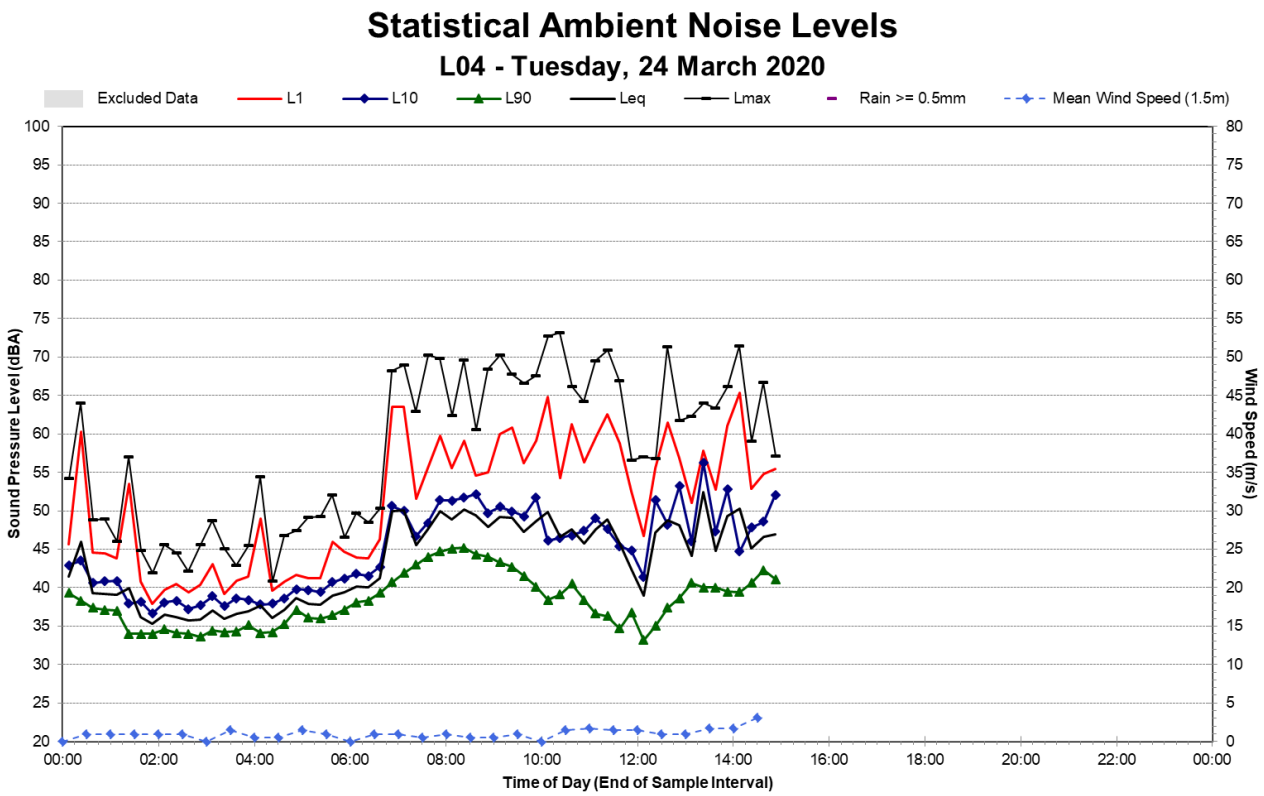
L04 - Sunday, 22 March 2020



Statistical Ambient Noise Levels

L04 - Monday, 23 March 2020




Statistical Ambient Noise Levels
L04 - Tuesday, 24 March 2020
Excluded Data
L1
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

APPENDIX C

Construction Scenarios and Equipment

Appendix C contents here

ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
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CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
Unit 5, 21 Parap Road
Parap NT 0820
Australia
T: +61 8 8998 0100
F: +61 8 9370 0101

GOLD COAST
Level 2, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

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Lane Cove NSW 2066
Australia
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F: +61 2 9427 8200

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Townsville QLD 4810
Australia
T: +61 7 4722 8000
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Townsville South QLD 4810
Australia
T: +61 7 4772 6500

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UoW Innovation Campus
North Wollongong NSW 2500
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Auckland 1010
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Richmond, Nelson 7020
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