STEELFORCE

Bringelly Business Hub
Noise Impact Assessment

Prepared for:

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PYRMONT NSW 2009

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BASIS OF REPORT

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

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Commercial & Industrial Property Pty Ltd (CIP Property) and Charter Hall (CH) to undertake a noise impact assessment of the proposed Steelforce facility, to be located at the intersection of Bringelly Road and Cowpasture Road at the Bringelly Business Hub. This assessment has been completed to accompany the Development Application for the proposal.

This report summarises the results of ambient noise measurements undertaken at the site and assesses the noise impacts on the surrounding receivers from predicted noise emissions from the proposal.

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

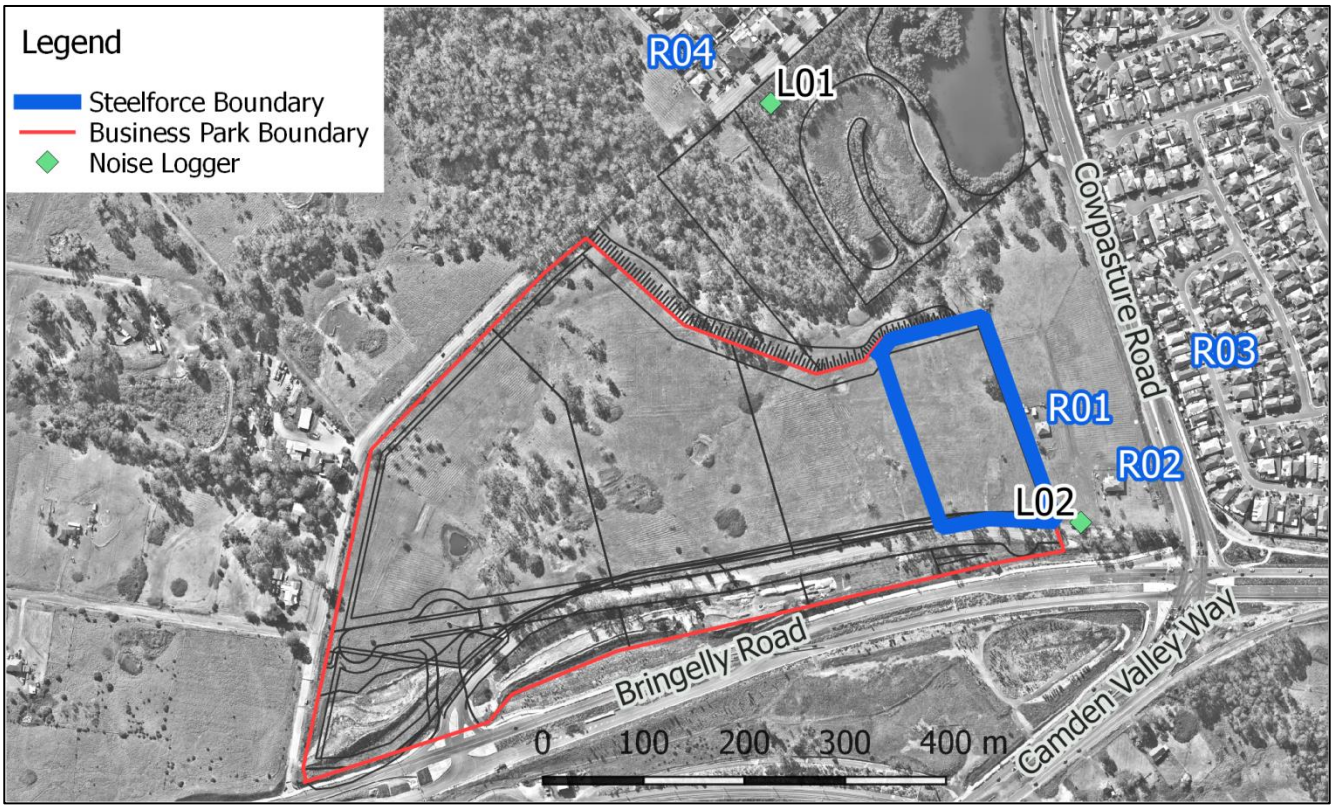
1.1 Proposal Description

The proposed facility would involve the delivery, storage, cutting and dispatching of steel products. Associated office and support facilities would also be provided with total staff numbers of around 38 employees.

The proposal forms part of the 19 hectare Bringelly Business Hub which was granted development consent in January 2016 and allows for predominantly light industrial and large format retail development.

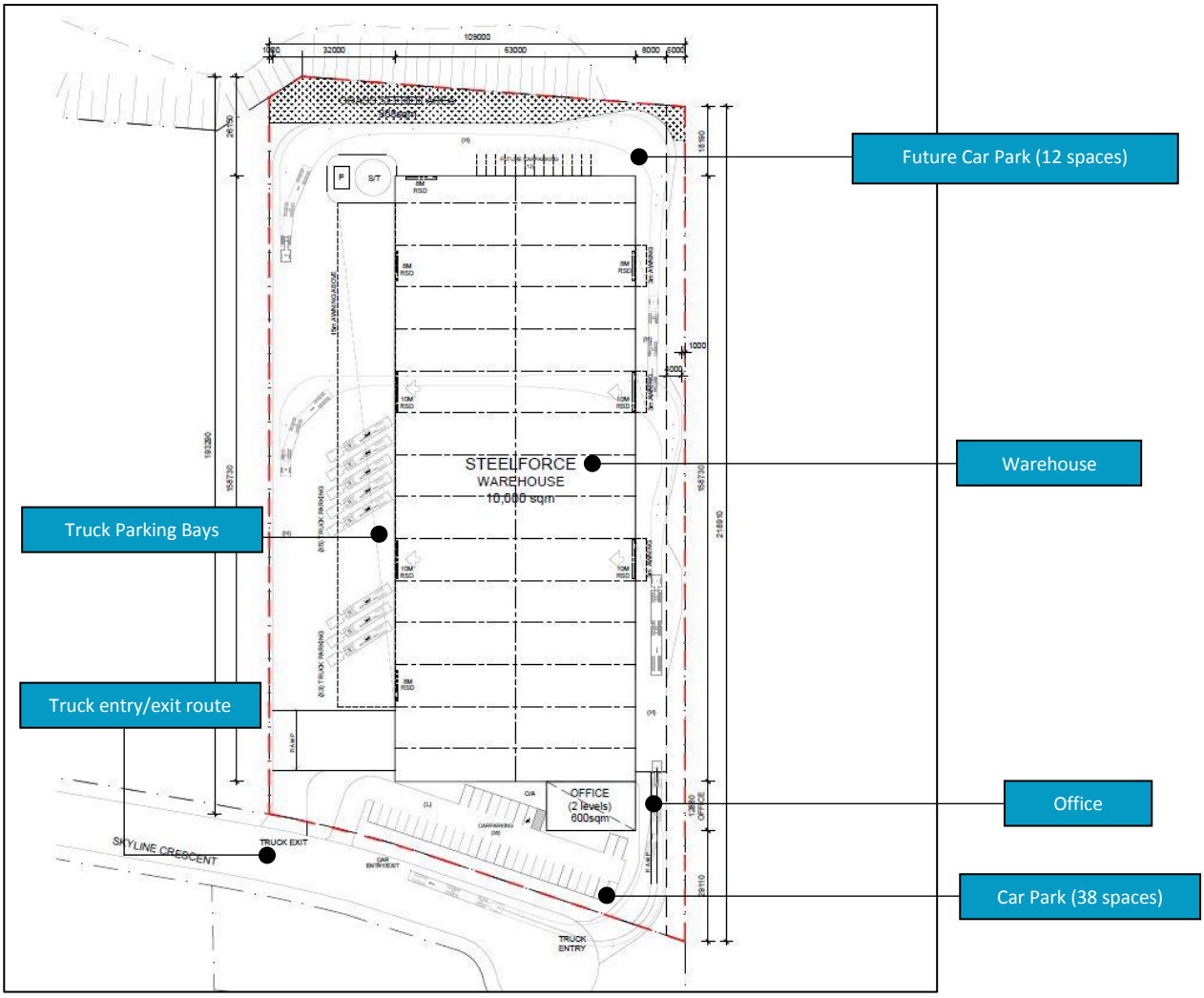
The site location is shown in **Figure 1** and proposed layout of the facility is shown in **Figure 2**.

Figure 1 Site Location, Surrounding Receivers and Noise Monitoring Locations



Note: Image courtesy of Nearmap

Figure 2 Proposed Layout



Warehouse operating hours would be 24 hours per day, Monday to Friday and generally 6:00 am – 3:00 pm on Saturday. Office operating hours would be 8:00 am – 5.30 pm Monday to Friday. Truck deliveries to and from the site would generally occur during daytime and evening hours.

The identified sources of noise from the proposed facility include:

- Internal warehouse operations
- Truck and light vehicle movements on internal access roads and in parking areas

Loading of trucks would occur within the warehouse, however the open roller doors provide a potential path for noise emissions.

A 36 space car park is situated to the south of the facility and a truck entry/exit route runs along the boundary of the site. There is potential for a future 12 space car cark which would be located in the north of the project site.

1.2 Nearest Receivers

The nearest sensitive receivers are two residential dwellings at 12 Bringelly Road, Horningsea Park, located to the east of the eastern boundary. The closest of these is around 15 m away, however it is noted that this dwelling appears to be in an abandoned condition. Whilst this dwelling is not considered noise sensitive at this time, it has been included in the assessment for completeness.

Residential areas are also located further to the east at a distance of around 150 m across Cowpasture Road and around 300 m to the north across Stuart Road. The nearest receivers are shown in **Figure 1**, with details of the nearest potentially affected sensitive receivers in **Table 1**.

Table 1 Surrounding Sensitive Receivers

ID	Address	Type	Distance (m)	Direction
R01	12 Bringelly Road, Horningsea Park (abandoned condition)	Residential	15 m	East
R02	12 Bringelly Road, Horningsea Park	Residential	60 m	East
R03	Properties across Cowpasture Road	Residential	150 m	East
R04	Properties to the north	Residential	>300 m	North

2 Existing Noise Environment

The acoustical environment surrounding the site is generally controlled by road traffic noise from the surrounding road network, with the nearest major roads being Cowpasture Road to the east and Bringelly Road and Camden Valley Way to the south. The South West Rail Link is also located around 250 m to the south of the site.

2.1 Unattended Ambient Noise Monitoring

Unattended noise monitoring was completed at the site in August 2018 to measure the existing ambient noise environment of the area.

The noise logger locations were selected with consideration of other noise sources which may influence the measurements, security of noise monitoring equipment and gaining permission for access from residents and landowners.

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 periods affected by adverse weather conditions, based on Bureau of Meteorology weather station data. A summary of the background noise monitoring locations and results are provided in **Table 2** and **Table 3**, and are shown in **Appendix B**.

Table 2 Ambient Noise Monitoring Locations

Noise Monitoring Location ID	Location Address	Location Details	Representative Receiver Area
L.01	18 Stuart Road, West Hoxton	Noise logger deployed in adjacent vacant land	Residences to the north in West Hoxton
L.02	12 Bringelly Road, Horningsea Park	Noise logger deployed in adjacent vacant land	Residences to the east in Horningsea Park

Table 3 Summary of Ambient Noise Levels

ID	Location	Measured Noise Levels (dBA)					
		RBL[1]			LAeq(period)[2]		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
L.01	18 Stuart Road, West Hoxton	39	36	31	53	51	48
L.02	12 Bringelly Road, Horningsea Park	46	45	37	55	53	52

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 contained in **Appendix B**. The graphs represent each 24 hour period during the survey and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels in 15 minute periods.

3 Assessment Criteria

3.1 Noise Policy for Industry

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

3.1.1 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 considered to be 'suburban'.

3.1.2 Project Specific Criteria

The noise emission trigger levels for industrial noise generated by the facility are provided in **Table 4**. The Project Specific Noise Trigger Level is the lowest value of the intrusiveness or amenity noise level for each period and these are shown in the table in bold.

Table 4 Project Specific Noise Trigger Levels

Receivers	Period	Recommended Amenity Noise Level L_{Aeq} (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
			RBL[1]	$L_{Aeq(period)}$	Intrusiveness	Amenity[2,3]
Residential to the north	Daytime	55	39	53	**44**	53
	Evening	45	36	51	**41**	43
	Night-time	40	31	48	**36**	38
Residential to the east	Daytime	55	46	55	**51**	53
	Evening	45	45	53	50	**43**
	Night-time	40	37	52	42	**40**[4]

Note 1: RBL = Rating Background Level.

Note 2: The recommended amenity noise levels have been reduced by 5 dB, where appropriate, to give the project amenity noise levels due to other sources of industrial noise likely to be built in the area in the future. It is noted that the NPfI defines a process in Section 2.4.2 for determining amenity noise levels where receivers are potentially affected by proposed 'clusters of industry'. However, given receivers surrounding the site would not be impacted by more than four individual sources of industrial noise, the recommended amenity noise level minus 5 dB approach is appropriate and adequately covers cumulative noise impacts from the Bringelly Road Business Hub.

Note 3: The project amenity noise levels have been converted to a 15 minute level by adding 3 dB.

Note 4: The measured L_{Aeq} noise level was dominated by road traffic noise and exceeds the recommended amenity noise level by 10 dB or more, therefore the 'high traffic project amenity noise level' is the existing $L_{Aeq(traffic)}$ noise level minus 15 dB.

3.1.3 Modifying Factors

Sources of industrial noise can cause greater annoyance where they contain certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content. The NPfI provides the following modifying factors, shown in **Table 5**, which are to be applied to the predicted receiver noise levels.

Table 5 NPfI Modifying Factors

Factor	Assessment/Measurement	When to Apply	Correction[1]
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by levels defined in the NPfI.	5 dB[2]
Low-frequency noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements	Measure/assess source contribution C and A weighted $L_{eq,t}$ levels over same time period. Correction to be applied where the C minus A level is 15 dB or more and the level to which thresholds defined in the NPfI are exceeded.	2 or 5 dB[2]
Intermittent noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level	The source noise heard at the receiver varies by more than 5 dB and the intermittent nature of the noise is clearly audible.	5 dB

Note 1: Corrections to be added to the measured or predicted levels.

Note 2: Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

Sleep Disturbance

In accordance with the NPfI, a detailed maximum noise level assessment should be undertaken where a development results in night-time noise levels which exceed:

- $L_{Aeq(15minute)}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is the greater.

The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL and the number of times this happens during the night-time.

The NPfI refers to the *Road Noise Policy* (RNP) for additional information regarding sleep disturbance. From the research to date, the RNP concludes that:

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

4 Assessment of Noise Impact

4.1 Operational Noise Sources

A summary of the potential noise sources associated with the operation of the facility is provided below.

4.1.1 On-Site Traffic

The modelling of on-site vehicles has been based on the traffic data presented in **Table 6**. The volumes are assumed to be representative of the worst-case 15-minute period for the daytime, evening and night-time.

Table 6 Vehicle Volumes – Worst-case 15 Minute Period

Vehicle Type	Number of Vehicles (per Worst-case 15 Minute)		
	Daytime	**Evening**	**Night-time**
Semi-trailer Truck	2	2	1[1]
Light Vehicle Traffic	15	15	5

Note: No deliveries to or from the site would occur during the night-time, however Steelforce may load trucks during this period.

On-site vehicles have been modelled as line sources based on the sound power levels and assumed speeds presented in **Table 7**.

Table 7 Vehicle Speeds & Sound Power Levels

Noise Source	Sound Power Level (dBA)	Vehicle Speed	Location
Semi-trailer Truck	105	10 – 20 km/h	Perimeter of site
Semi-trailer Truck	105	5 – 10 km/h	Truck parking bay
Light Vehicle Traffic	95	10 – 20 km/h	Car park

The following typical noise sources associated with the truck parking bay are presented in **Table 8**.

Table 8 Typical Truck Parking Noise Levels and Duration of Operation

Noise Source	Sound Power Level (dBA)	Typical Duration of Operation	Source Height
Reversing Alarm[1]	110	10 Seconds	1.5 m
Semi-trailer Truck	105	120 seconds	1.5 m

Note 1 It is noted that the operation of this plant is typically intermittent in nature. A +5 dB modifying correction factor is therefore applied to the noise level to account for its potential to cause annoyance, in accordance with the INP.

4.1.2 Warehouse Internal Activities

The internal noise generating activities within the warehouse include the cutting of steel and the loading and unloading of trucks. During the worst-case 15 minute period one truck would be simultaneously loaded or unloaded with sawing activities also occurring.

The following typical reverberant noise level for the internal area of the warehouse shown in **Table 9** has been used in the modelling.

Table 9 Reverberant Noise Level for Internal Warehouse Areas

Noise Source	Reverberant Noise Level (dBA)
Internal Warehouse	75

Note: Internal noise levels were based on measurements of a similar Steelforce facility.

4.1.3 Noise Sources with Potential for Sleep Disturbance

As the facility operates 24 hours per day, noise emissions during the night time period require an assessment for potential sleep disturbance at the nearest noise sensitive receivers. A summary of the L_{Amax} sound power levels of typical activities that may occur at the facility with the potential to cause sleep disturbance is presented in **Table 10**.

Table 10 Sleep Disturbance – L_{Amax} Sound Power Levels

Noise Source	L_{Amax} SWL (dBA)	Source height
Truck Movement in Truck Parking Area	108	1 m
Airbrake in Truck Parking Area	120	1 m
Reversing Alarm	110	1 m
Roller Door	94	4 m

4.2 Noise Level Predictions

SoundPLAN V8 has been used for modelling the noise emissions from the proposal using the ISO 9613-2 industrial noise algorithm. The model includes ground topography, buildings and representative noise sources as discussed in **Section 4.1**.

The predicted noise levels at the nearest receivers from industrial noise emissions are presented in **Table 11**.

Table 11 Industrial Noise Assessment

Scenario	Receiver Location	Period	$L_{Aeq(15\ minutes)}$ Noise Level (dBA)			Compliance?
			Project Trigger Level	**Predicted**	**Exceedance**	
Cumulative Industrial Noise Sources	R1 – 12 Bringelly Road, Horningsea Park (abandoned property)	Daytime	51	51	-	Yes
		Evening	43	51	8	**No**
		Night-time	40	42	2	**No**
	R2 – 12 Bringelly Road, Horningsea Park	Daytime	51	42	-	Yes
		Evening	43	42	-	Yes
		Night-time	40	33	-	Yes
	R3 – Cowpasture Road Receivers	Daytime	51	35	-	Yes
		Evening	43	35	-	Yes
		Night-time	40	>30	-	Yes
	R4 – Receivers to the north	Daytime	44	36	-	Yes
		Evening	41	36	-	Yes
		Night-time	36	>30	-	Yes

The above assessment indicates that predicted daytime noise from the proposal complies with the Project Trigger Level at all receivers.

During the evening and night time period compliance is also predicted at all receivers with the exception of receiver R1 (abandoned dwelling to the east of the site).

The exceedance at this receiver during the evening period is caused by truck movements on the eastern access road and the exceedance during the night-time is from internal warehouse activity. Compliance is predicted at all surrounding habitable dwellings during the evening and night-time.

4.2.1 Sleep Disturbance

The predicted night-time L_{Amax} noise levels at the nearest habitable receivers to the development are presented in **Table 12**.

Table 12 Summary of Predicted Sleep Disturbance Noise Levels (dBA)

Receiver Location	Source	L_{AFmax} Noise Level (dBA)			Compliance?
		Criteria	**Predicted**	**Exceedance**	
R2 – 12 Bringelly Road	Airbrake in Truck Parking Area	52	44	-	Yes
	Reversing Alarm		<40	-	Yes
	Roller Door		43	-	Yes
	Internal Workshop Activities		49	-	Yes
R4 – Receivers to the north	Truck Movement in Parking Area	52	<40	-	Yes
	Airbrake in Truck Parking Area		55	3	**No**
	Reversing Alarm		44	-	Yes
	Roller Door		<40	-	Yes
	Internal Workshop Activities		<40	-	Yes

The above shows a minor exceedance of the night-time sleep disturbance goal at the residences to the north of the proposed facility from with use of truck airbrakes. The use of truck airbrakes is expected to be an infrequent event (during loading of trucks only) and the impacts from this exceedance are considered minor.

4.2.2 Mechanical Plant

The mechanical plant at the site would likely be limited to air-conditioning equipment, a back-up generator, pumps and small supply/extraction fans. The specification and location of equipment has not yet been confirmed at this early stage of the project.

Mechanical plant at the site should be reviewed during detailed design and an assessment of industrial noise emissions against the NPfI criteria detailed in **Table 4** should be completed. Compliance with the nominated criteria is expected to be achievable with standard noise attenuation measures.

4.3 Noise Mitigation

Noise emissions from the proposal are predicted to be compliant at most of the surrounding receivers with the exception of the evening and night time period at the unoccupied receiver at 12 Bringelly Road (R1).

As the unoccupied receiver at 12 Bringelly Road appears to be in an abandoned condition it is therefore not considered noise sensitive.

Minor sleep disturbance impacts are predicted for the residences located to the north. The sleep disturbances are a result of infrequent use of airbrakes in the truck parking bays.

It is noted that the existing noise environment of the area is controlled by road traffic noise from the nearby Cowpasture Road. As a result the predicted night-time exceedance is considered to be of minor significance as noise levels would most likely be dominated by existing road traffic emissions.

4.4 Traffic Increases on the Surrounding Road Network

Light and heavy vehicles associated with the facility would access the site directly from Bringelly Road. Given the high existing volumes on this route, the potential noise impacts from additional traffic generated by the development is considered negligible.

4.5 Construction Noise

The activities likely to be required to construct the project involve conventional construction equipment such as earth moving equipment, concreting equipment, piling plant and cranes.

4.5.1 Construction Hours

Construction of the proposal would occur during the standard construction hours of:

- Monday to Friday: 7 am to 6 pm
- Saturday: 8 am to 1 pm
- Sunday and Public Holidays: No work.

4.5.2 Potential Impacts and Mitigation

Noise impacts may be apparent at the nearest receivers during construction of the project. The project should apply all feasible and reasonable mitigation measures to minimise the impacts, particularly during highly noise intensive works.

The following example measures should be considered to minimise the potential impacts from the works:

- Use of site inductions and work team briefings to create awareness of nearby sensitive receivers and the importance of minimising noise emissions.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Establishing load points as far as practicable from sensitive receivers.
- Use of less noise-intensive equipment, where feasible and reasonable.

5 Conclusion

Noise emissions associated with the proposed Steelforce facility at the Bringelly Business Hub have been assessed against the appropriate *Noise Policy for Industry* trigger levels.

The assessment generally indicates compliance with the trigger levels at the nearest residential properties, with the exception of one unoccupied residence located at 12 Bringelly Road. As the dwelling appears to be abandoned it is therefore not currently noise sensitive.

Minor sleep disturbance impacts are predicted for the residence located to the north. The sleep disturbance is a result of infrequent truck airbrakes in the truck parking bays. The predicted sleep disturbance exceedances are considered to be of minor significance, as noise levels would most likely be dominated by existing road traffic emissions.

Final details of mechanical plant at the site are not currently available and the potential noise impacts should be reviewed during detailed design. Compliance with the nominated criteria is expected to be achievable with standard noise attenuation measures.

APPENDIX A

Acoustic Terminology

1 Sound Level or Noise Level

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

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

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A 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. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 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

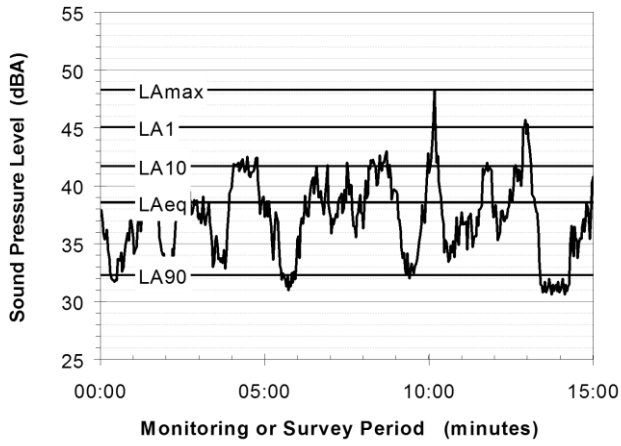
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or Lw, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} 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:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} 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.

L_{Aeq} 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.

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

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

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

6 Impulsiveness

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

7 Frequency Analysis

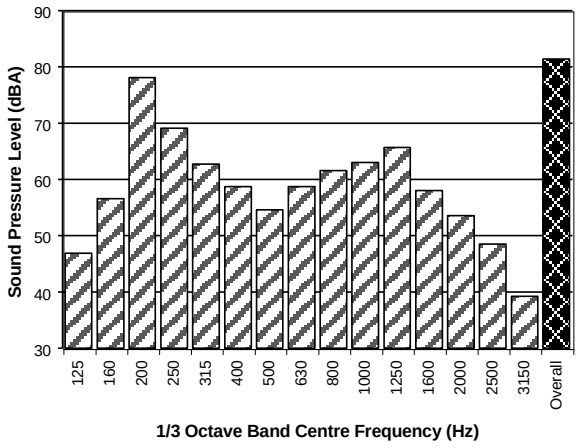
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter 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. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organisations.

9 Human Perception of Vibration

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

10 Over-Pressure

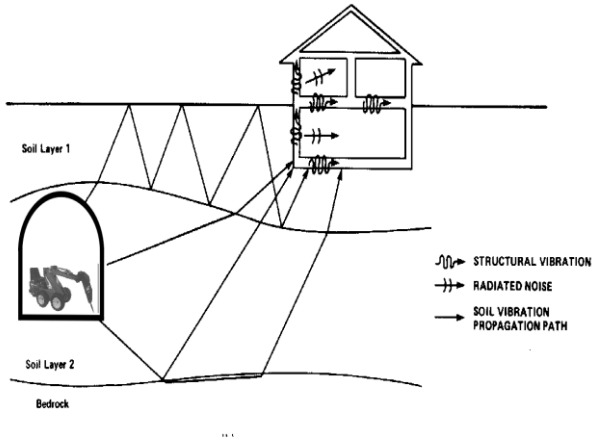
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 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.



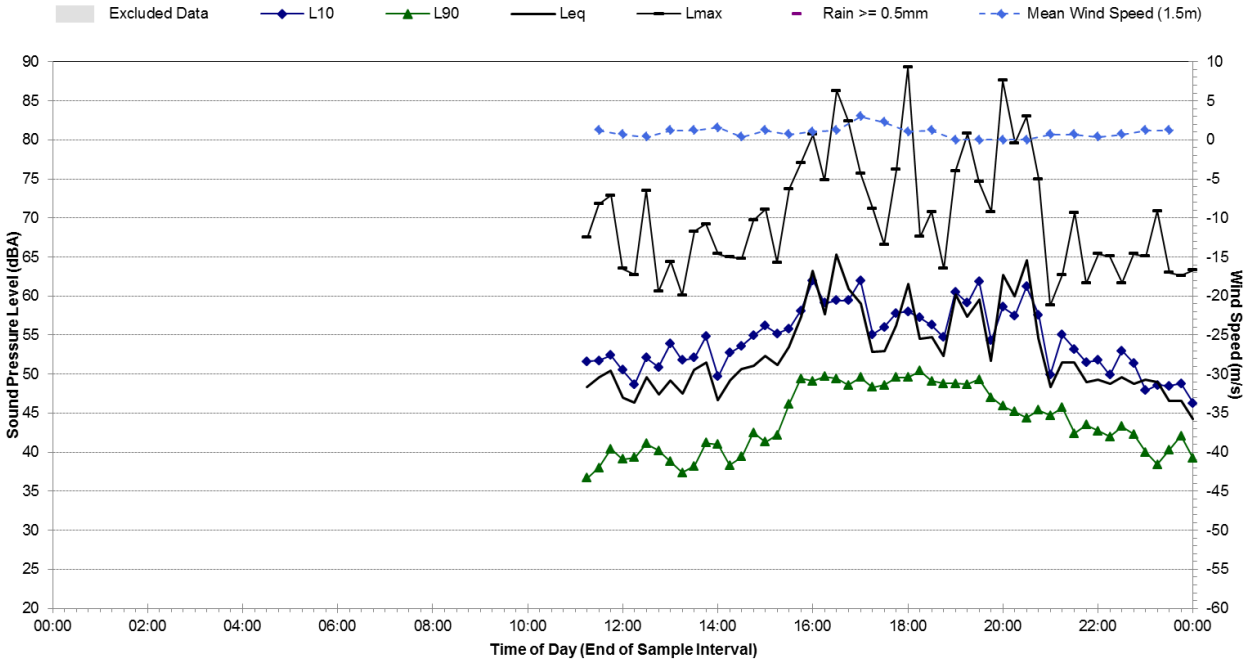
The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect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

APPENDIX B

Noise Logging Results

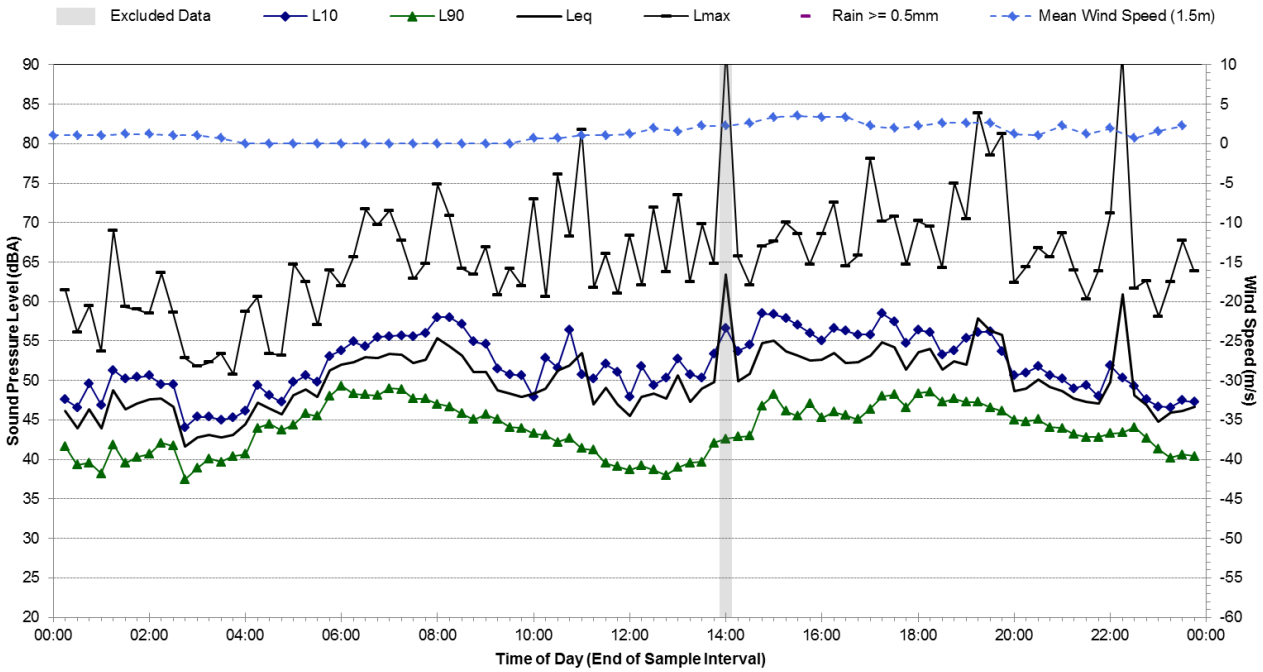
Statistical Ambient Noise Levels

Location One - Thursday, 9 August 2018



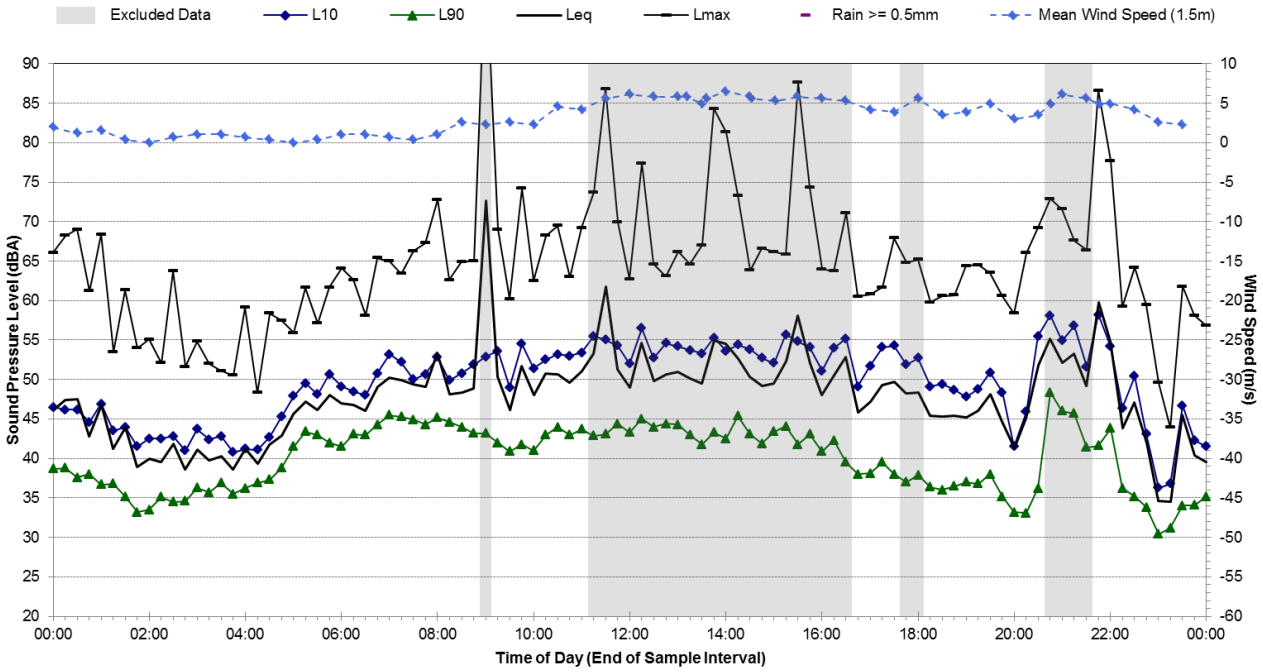
Statistical Ambient Noise Levels

Location One - Friday, 10 August 2018



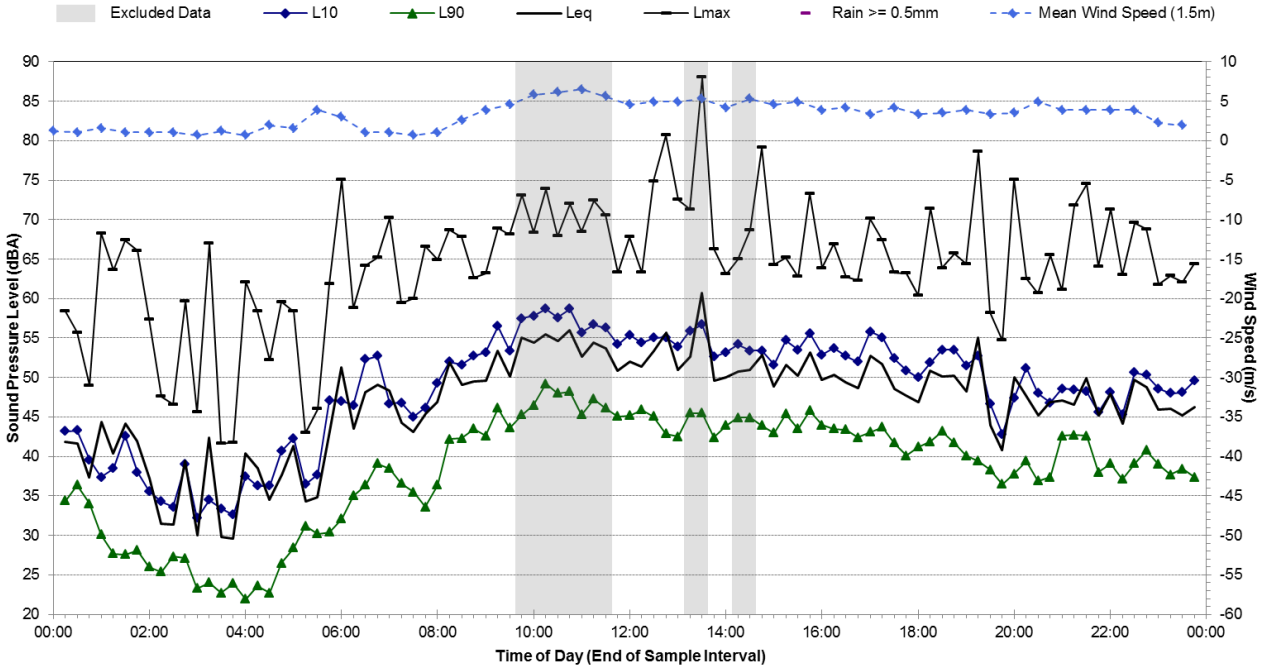
Statistical Ambient Noise Levels

Location One - Saturday, 11 August 2018



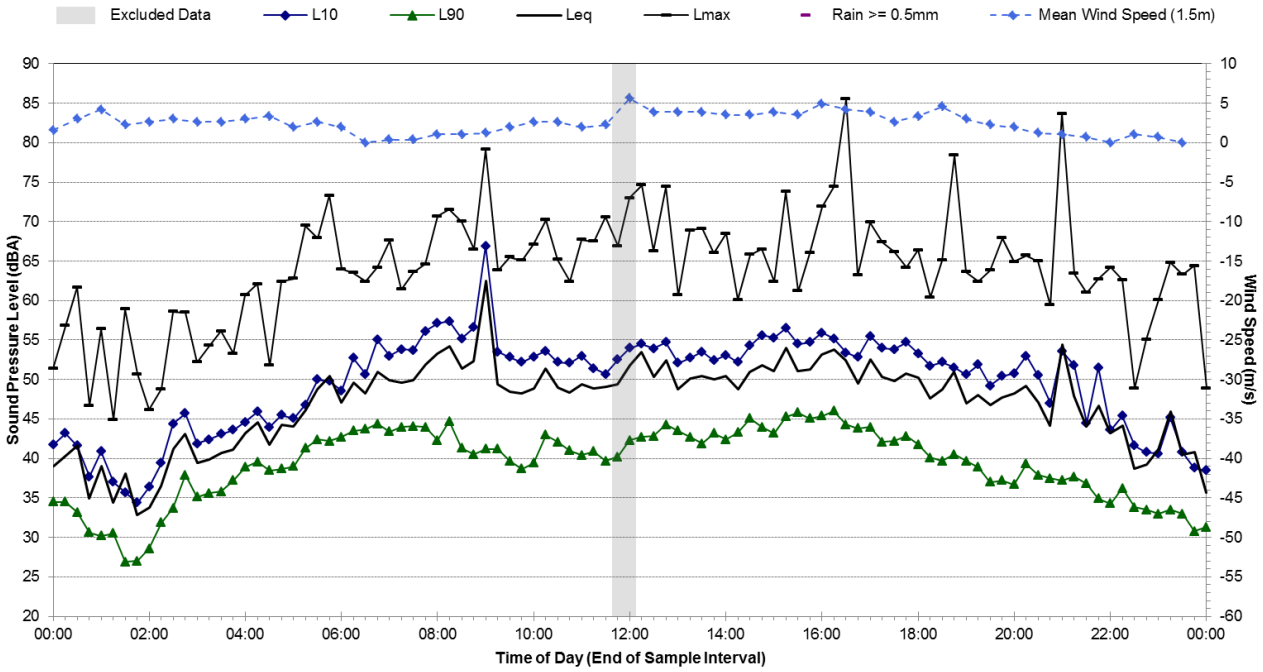
Statistical Ambient Noise Levels

Location One - Sunday, 12 August 2018



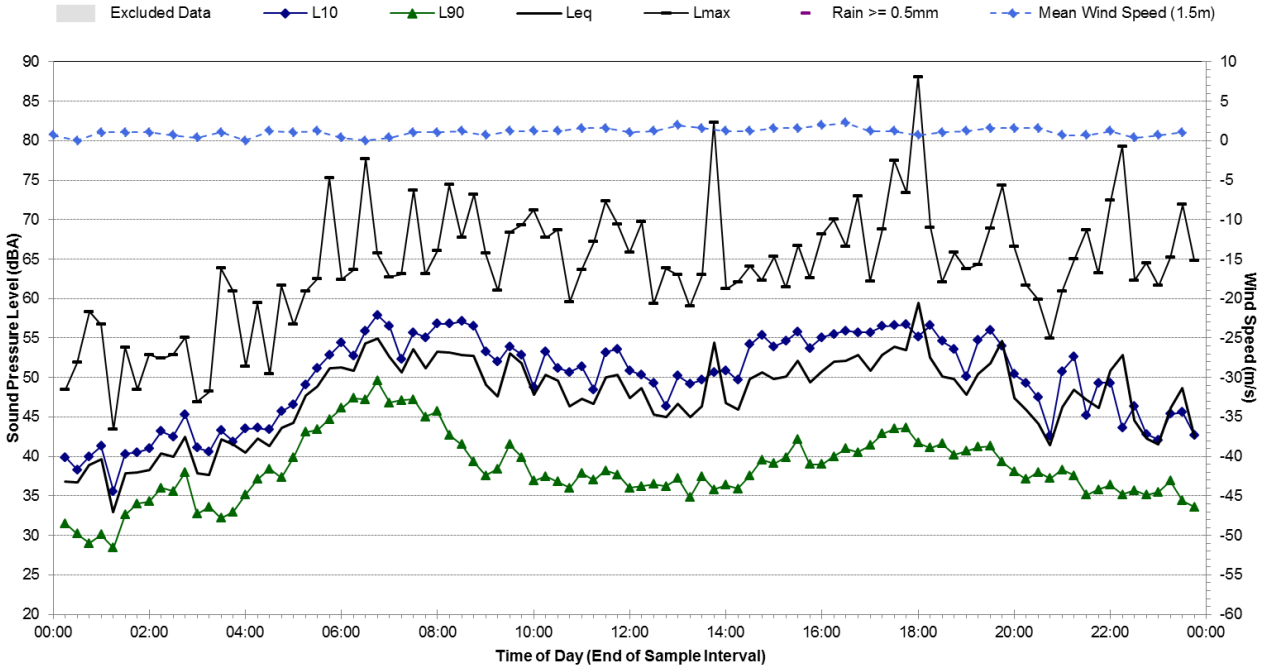
Statistical Ambient Noise Levels

Location One - Monday, 13 August 2018



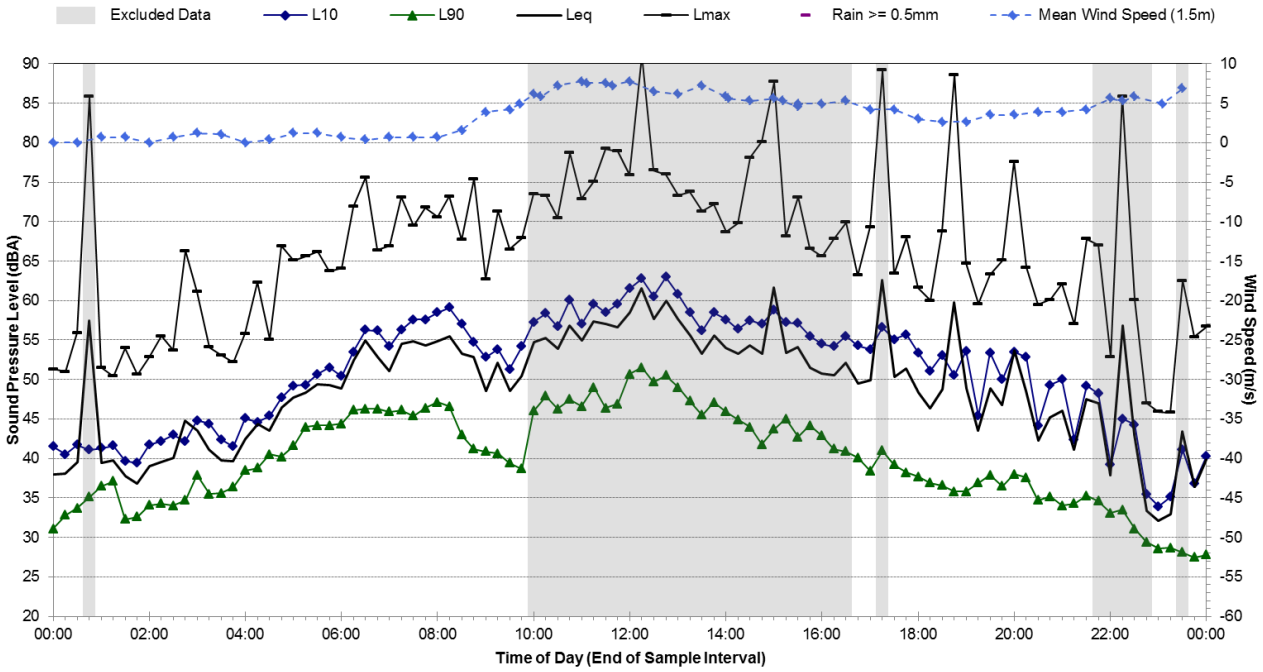
Statistical Ambient Noise Levels

Location One - Tuesday, 14 August 2018



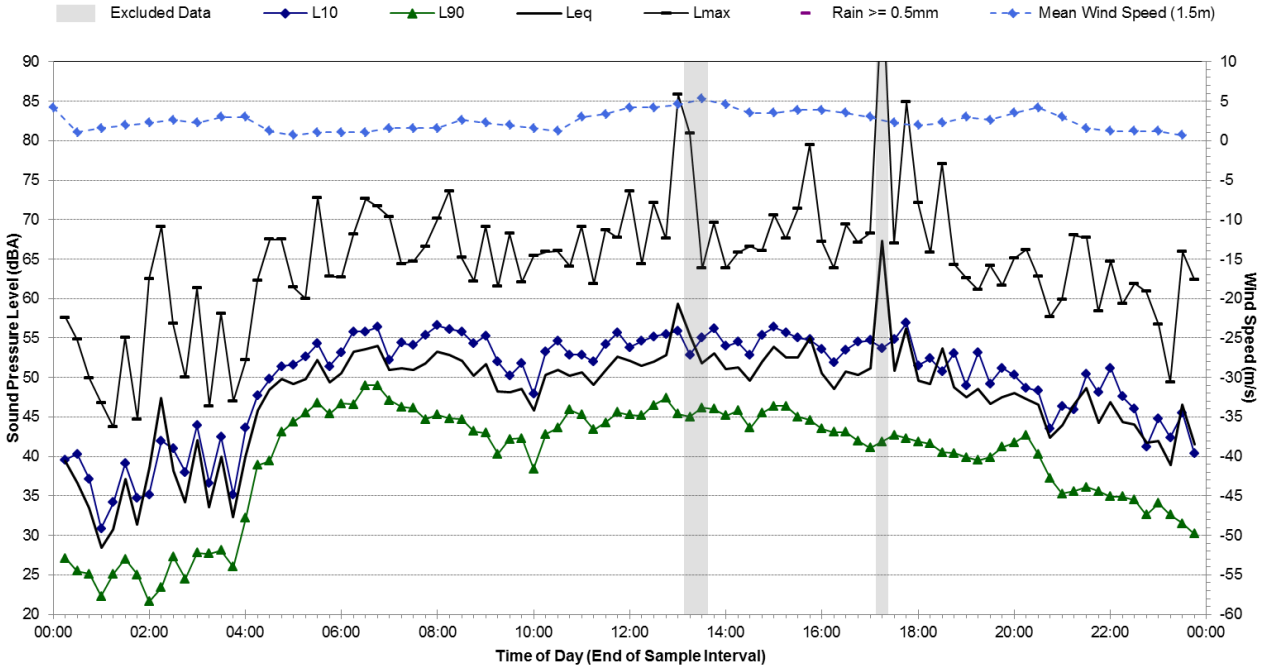
Statistical Ambient Noise Levels

Location One - Wednesday, 15 August 2018



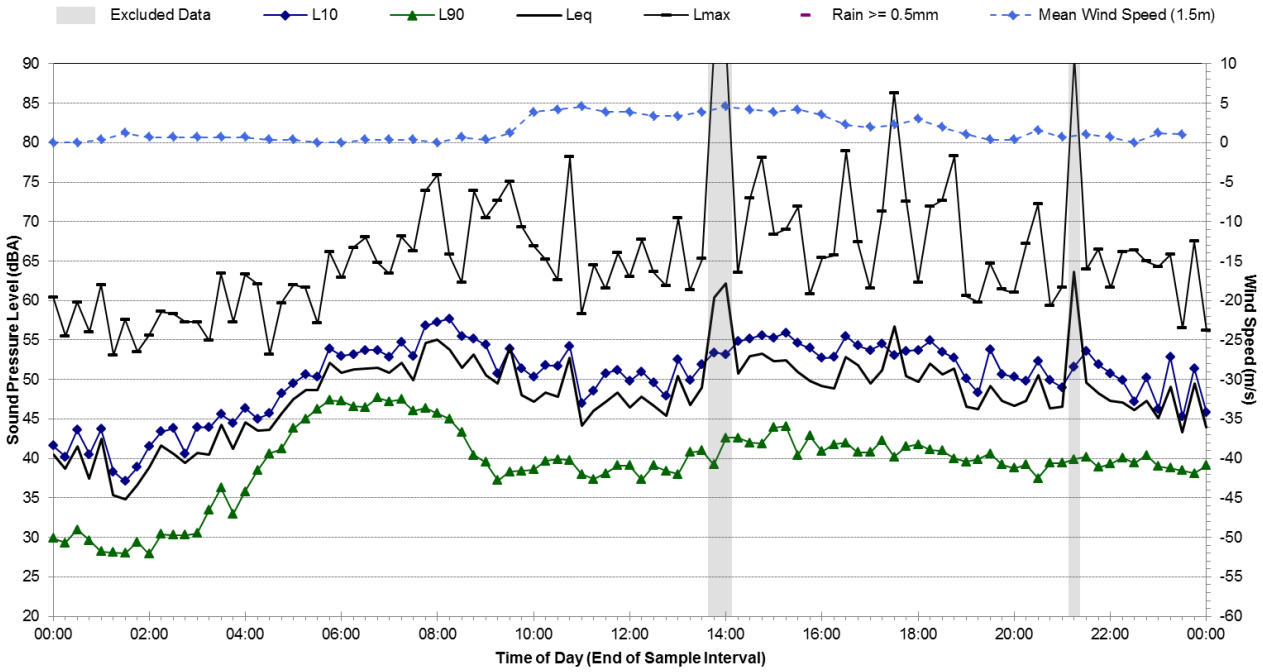
Statistical Ambient Noise Levels

Location One - Thursday, 16 August 2018



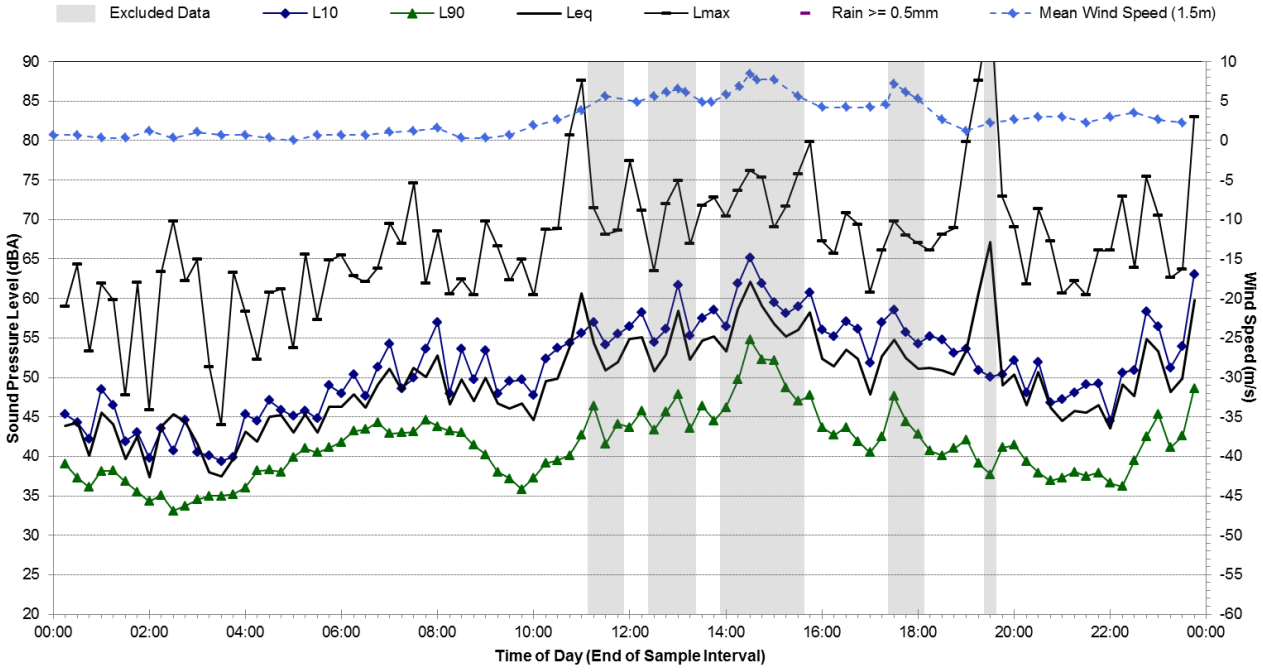
Statistical Ambient Noise Levels

Location One - Friday, 17 August 2018



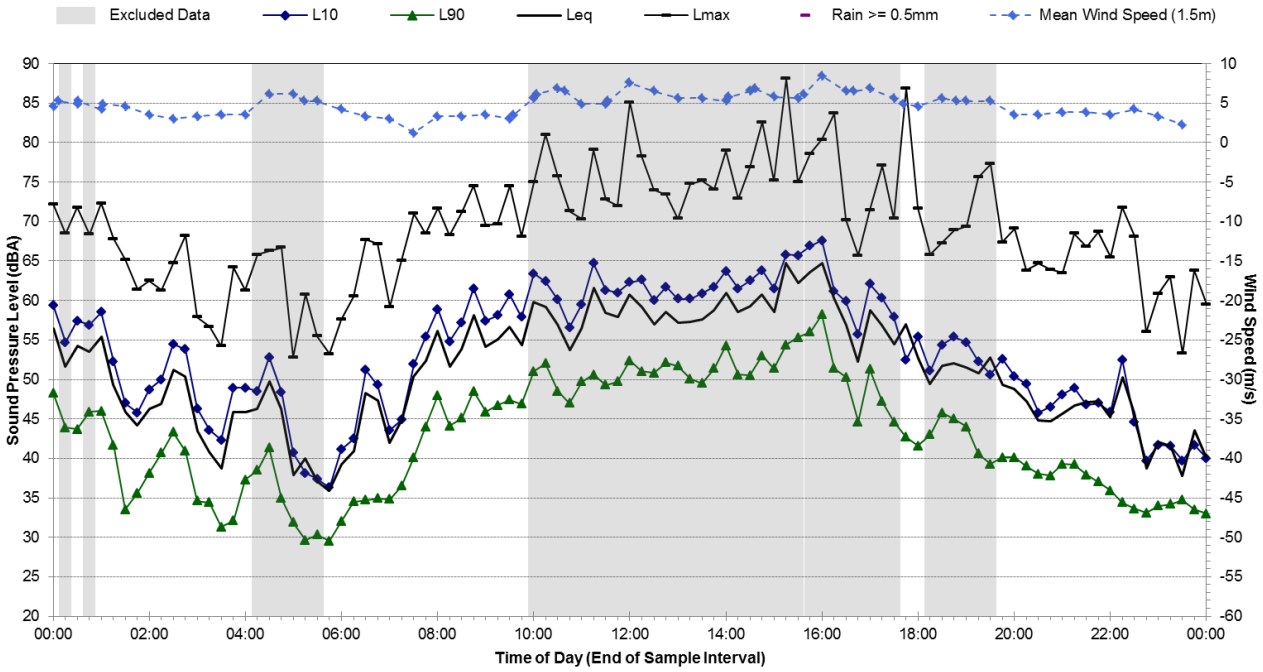
Statistical Ambient Noise Levels

Location One - Saturday, 18 August 2018



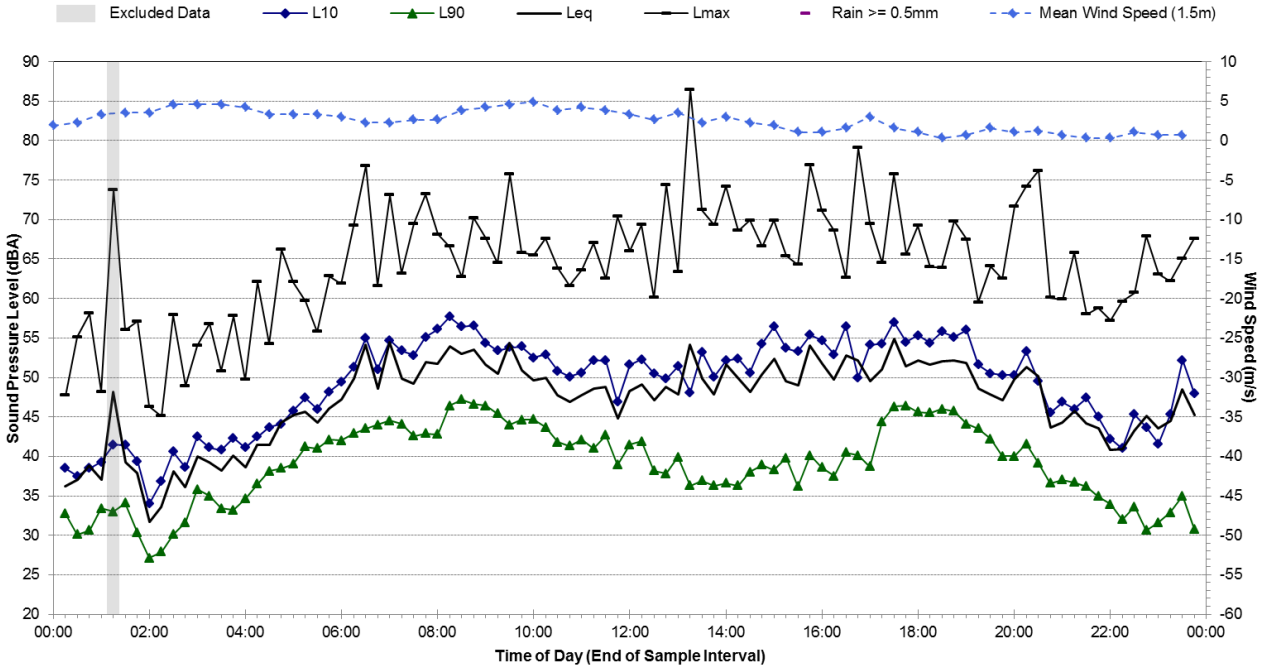
Statistical Ambient Noise Levels

Location One - Sunday, 19 August 2018



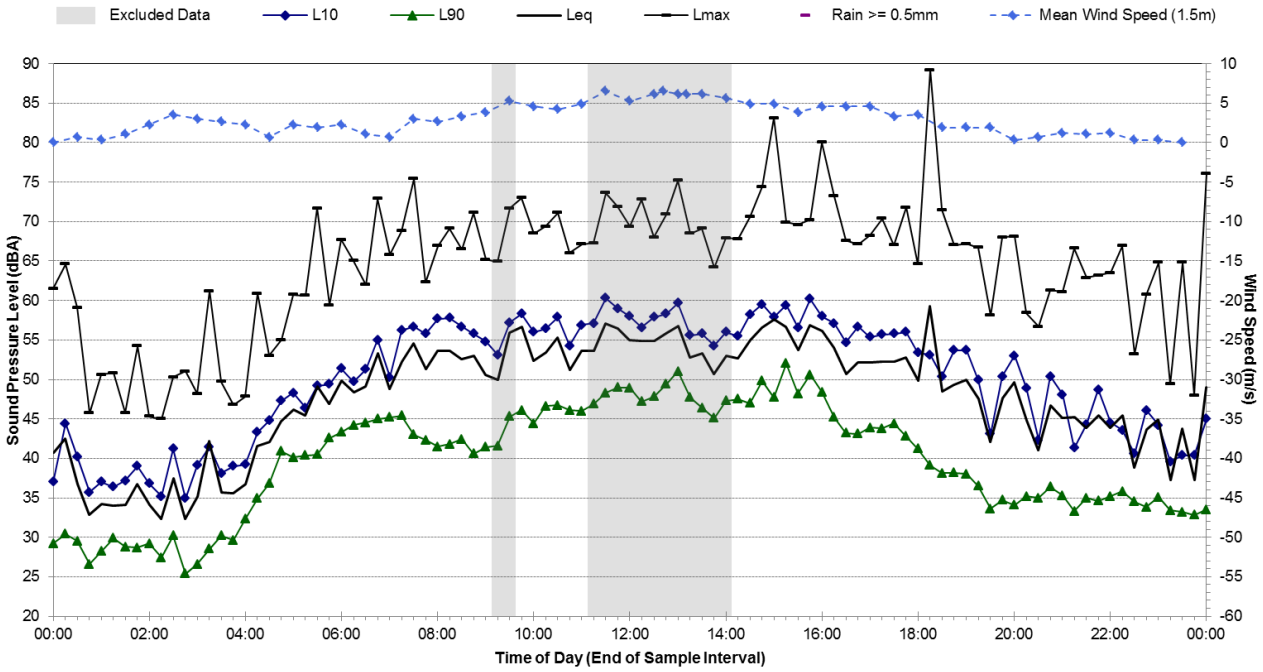
Statistical Ambient Noise Levels

Location One - Monday, 20 August 2018



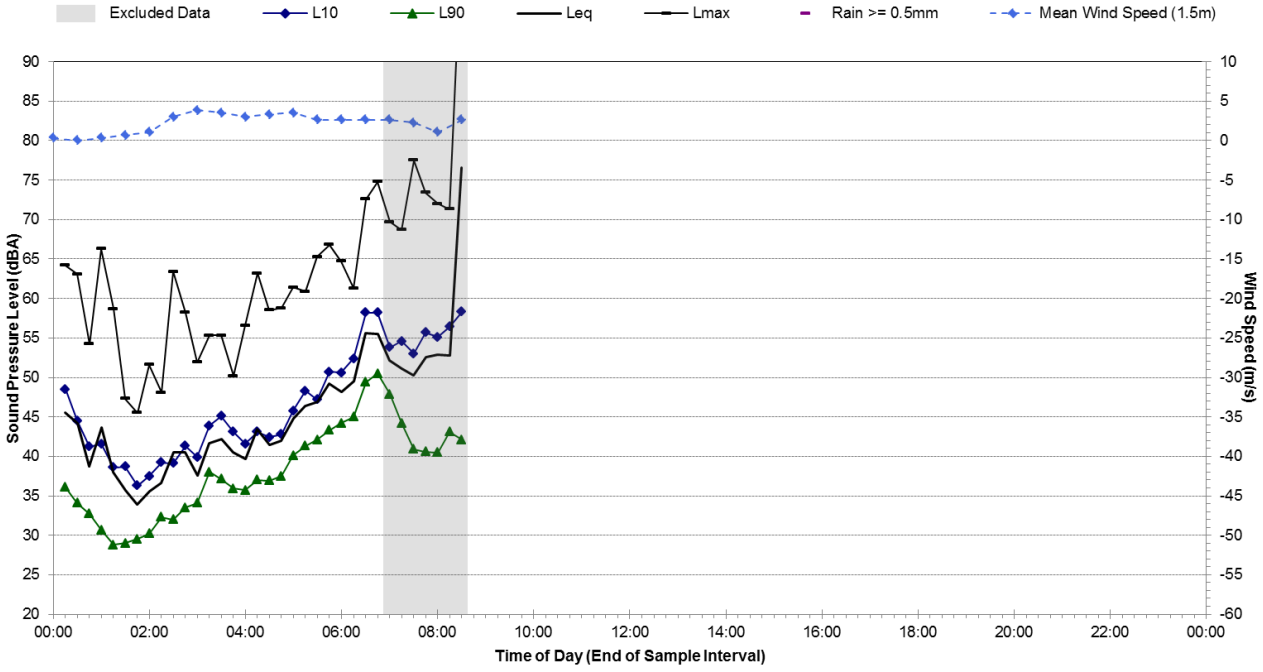
Statistical Ambient Noise Levels

Location One - Tuesday, 21 August 2018



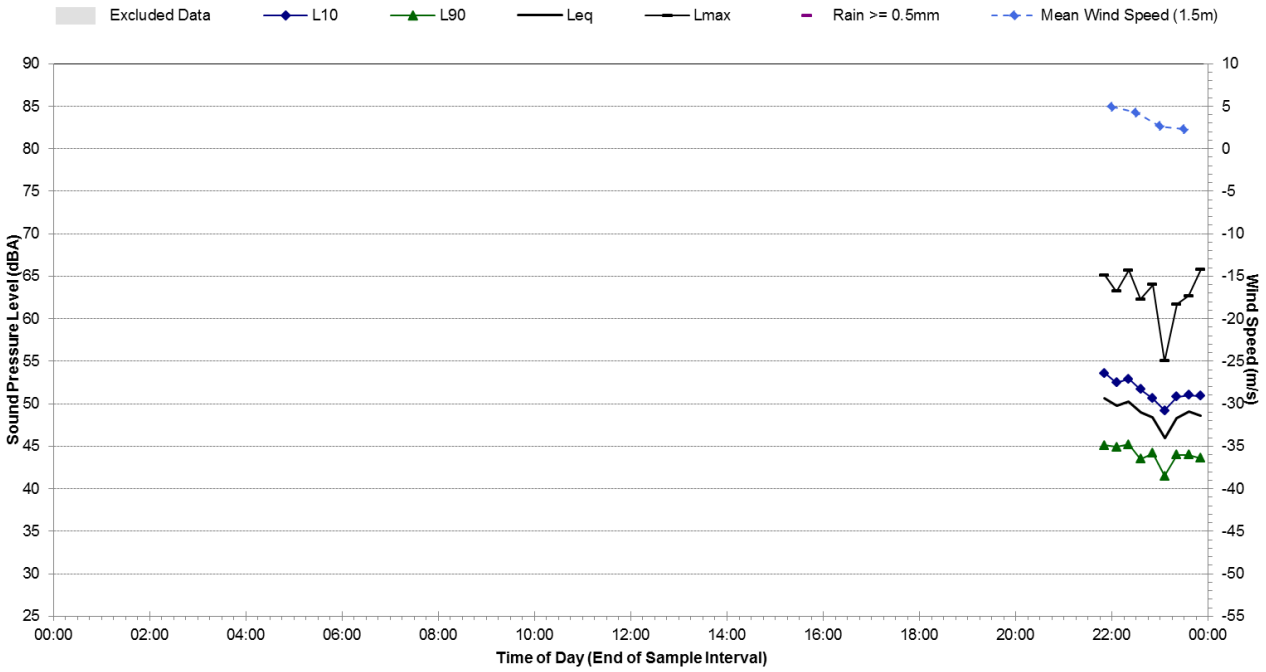
Statistical Ambient Noise Levels

Location One - Wednesday, 22 August 2018



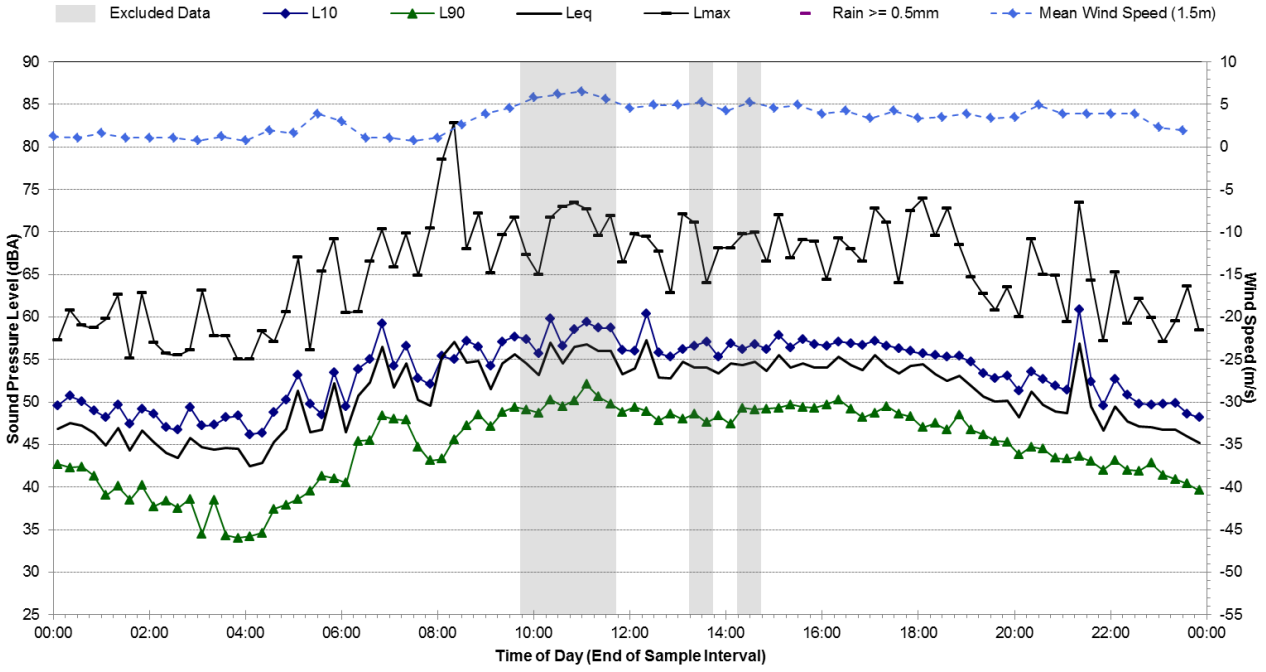
Statistical Ambient Noise Levels

Location Two - Saturday, 11 August 2018



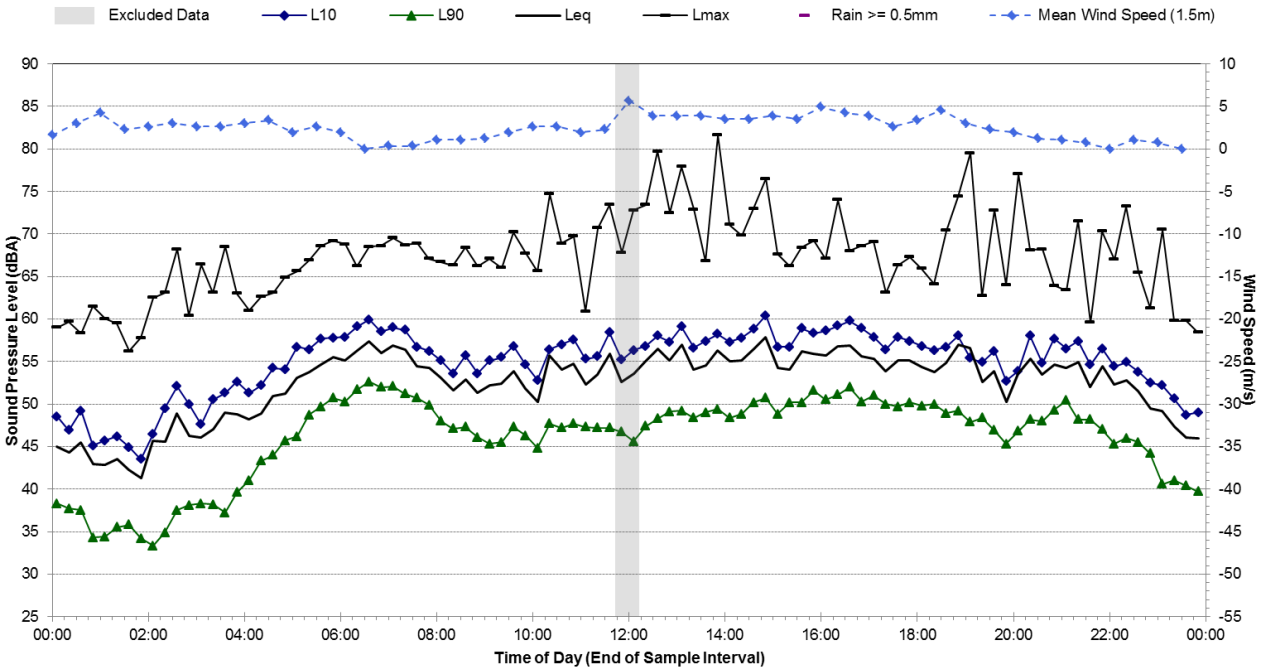
Statistical Ambient Noise Levels

Location Two - Sunday, 12 August 2018



Statistical Ambient Noise Levels

Location Two - Monday, 13 August 2018



Statistical Ambient Noise Levels

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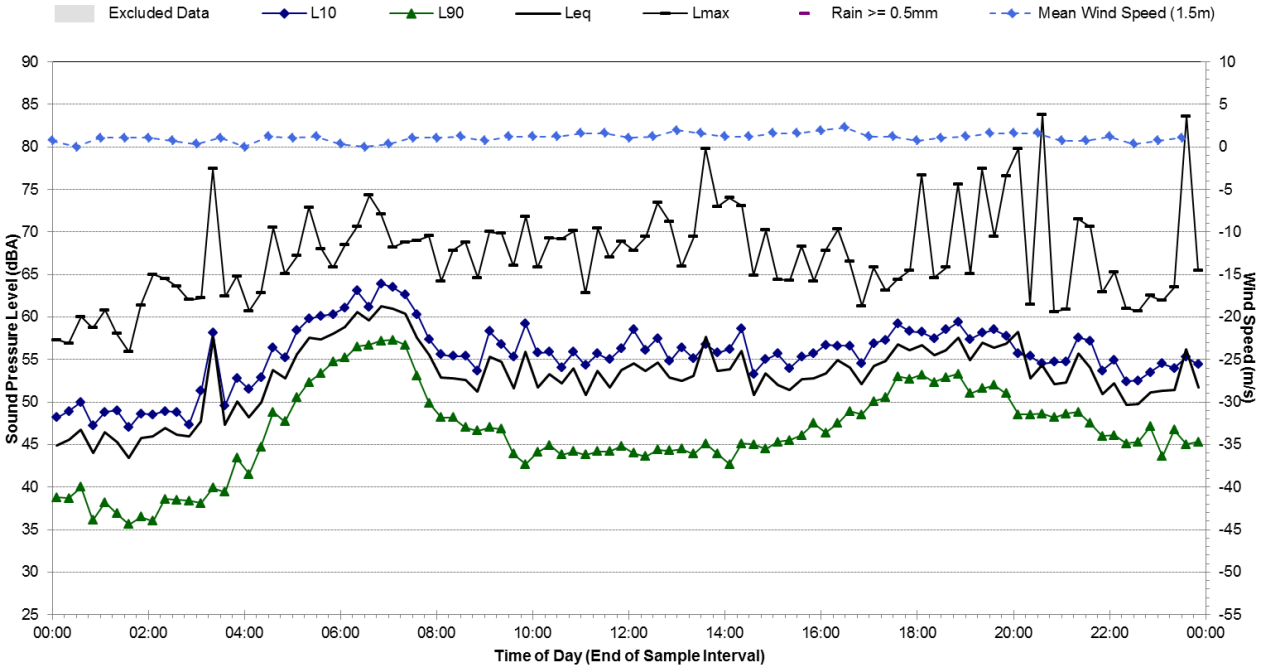
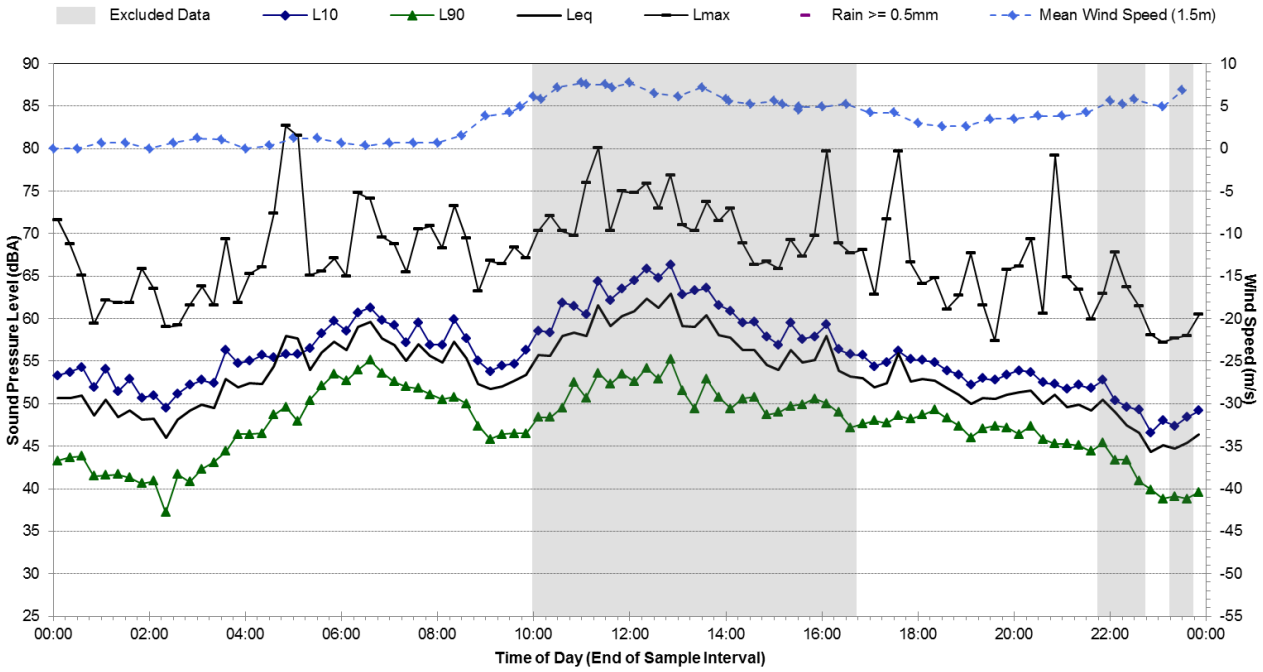


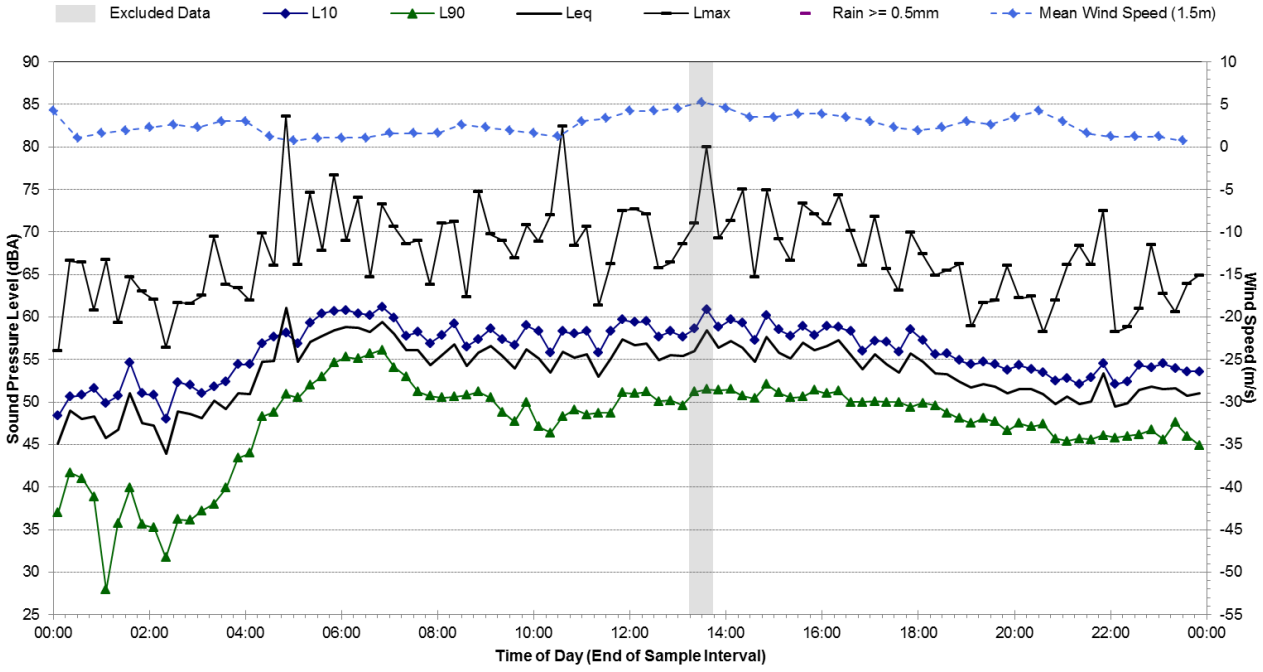
Statistical Ambient Noise Levels

Location Two - Wednesday, 15 August 2018



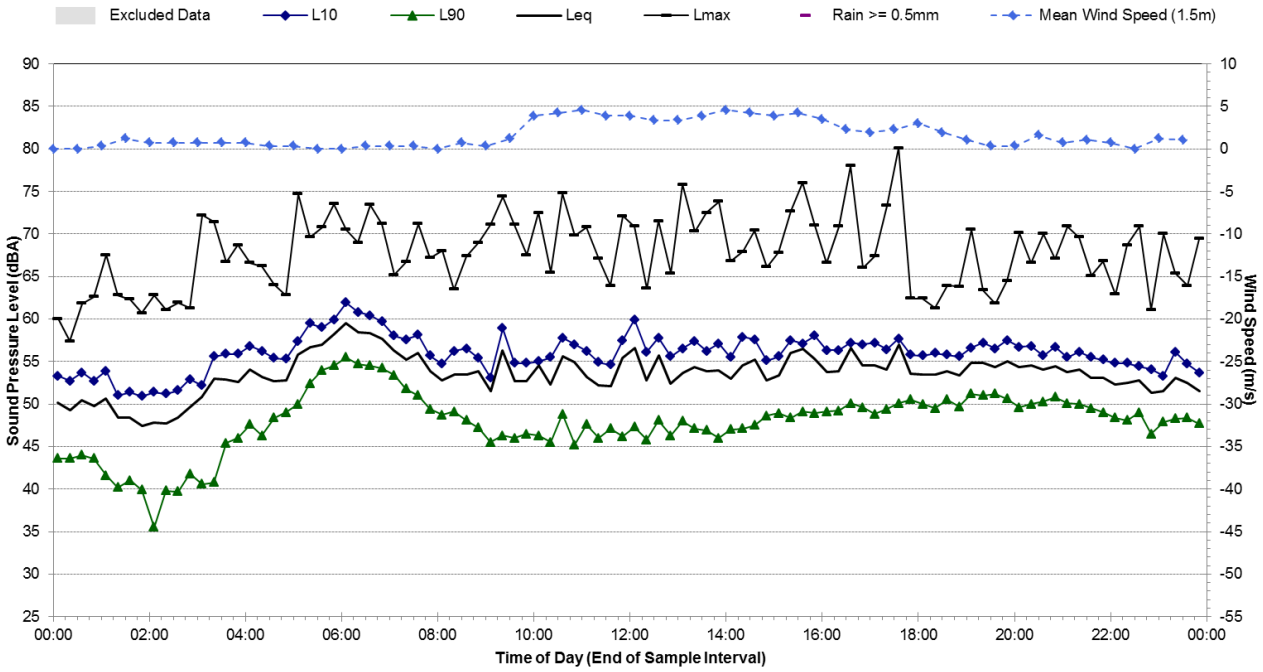
Statistical Ambient Noise Levels

Location Two - Thursday, 16 August 2018



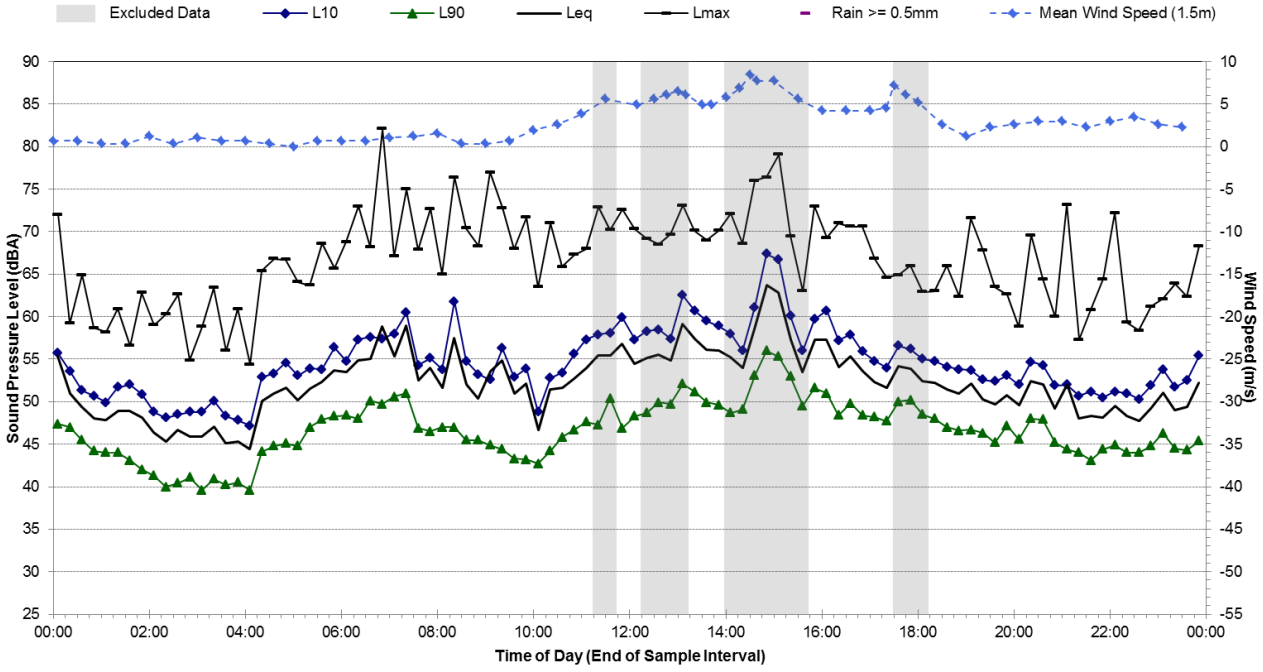
Statistical Ambient Noise Levels

Location Two - Friday, 17 August 2018



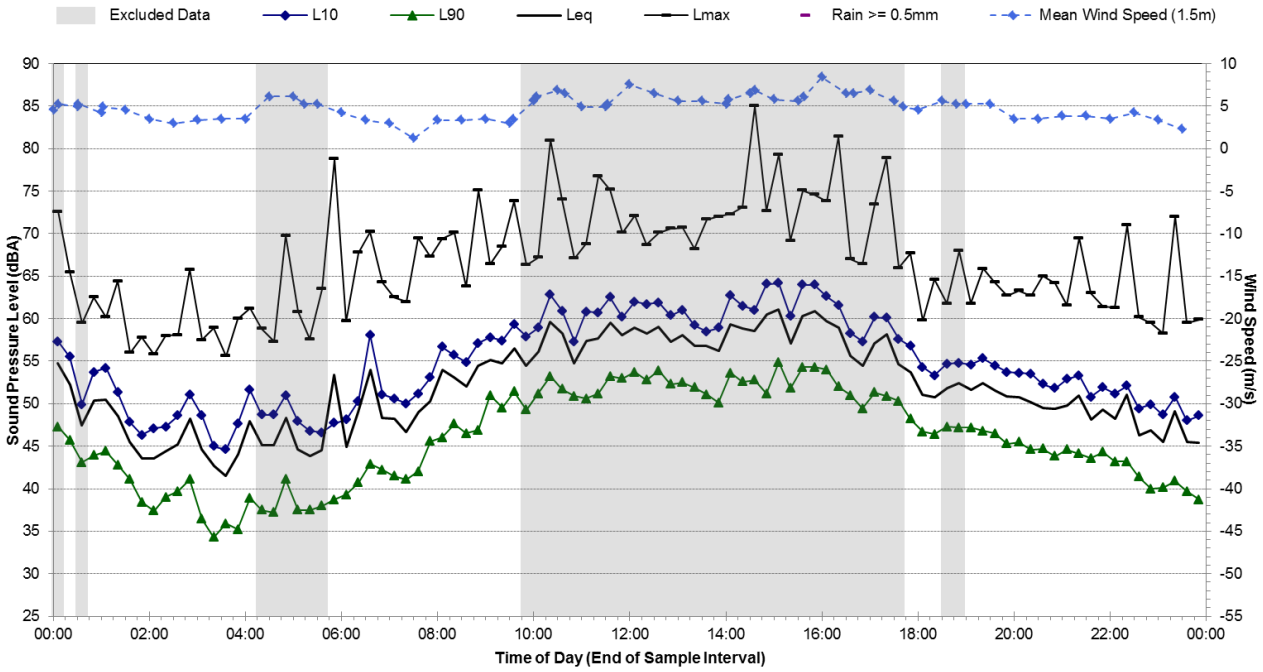
Statistical Ambient Noise Levels

Location Two - Saturday, 18 August 2018



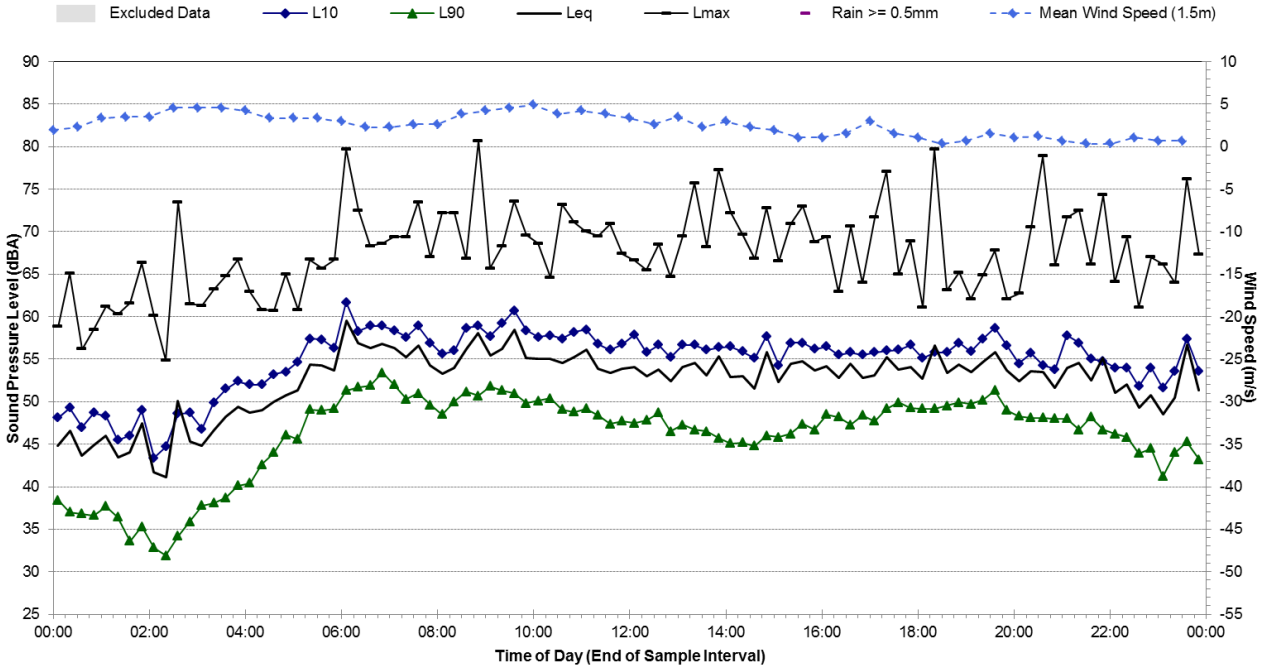
Statistical Ambient Noise Levels

Location Two - Sunday, 19 August 2018



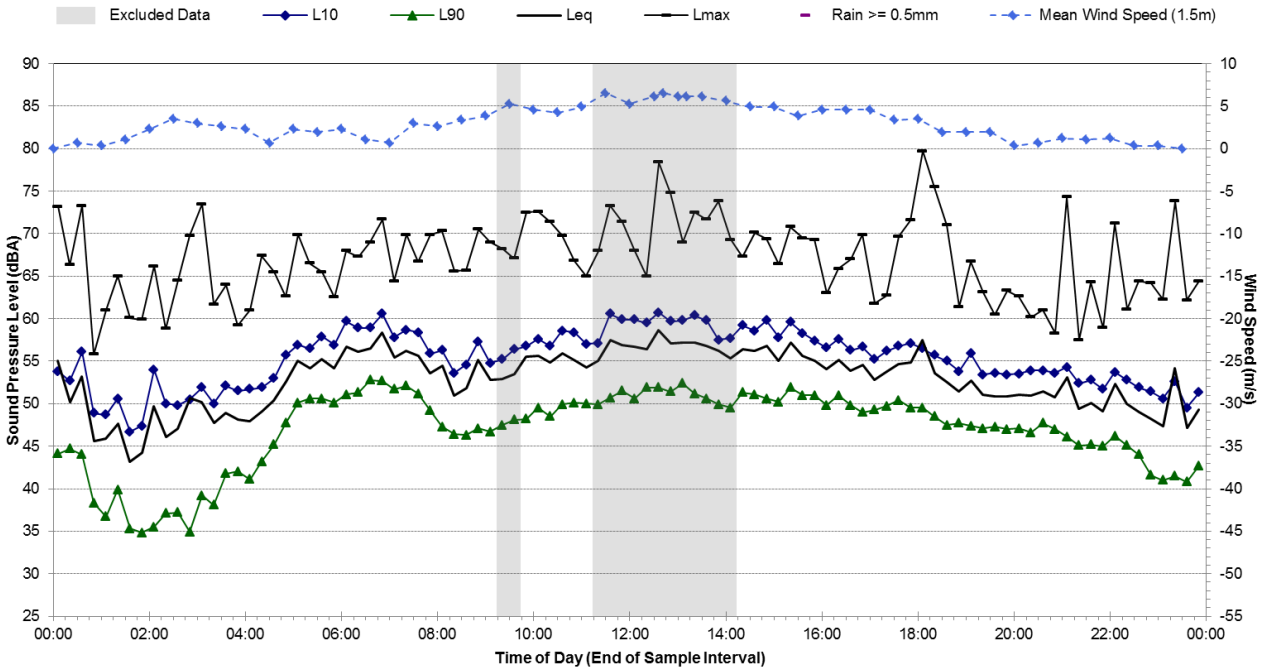
Statistical Ambient Noise Levels

Location Two - Monday, 20 August 2018



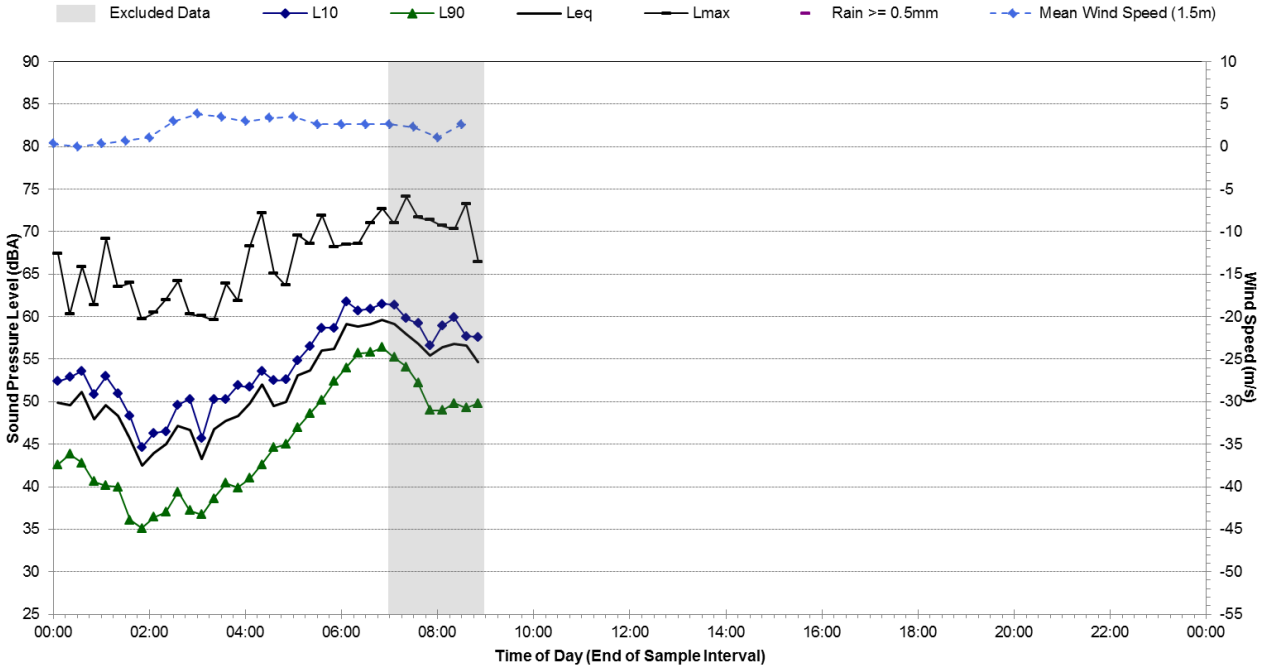
Statistical Ambient Noise Levels

Location Two - Tuesday, 21 August 2018



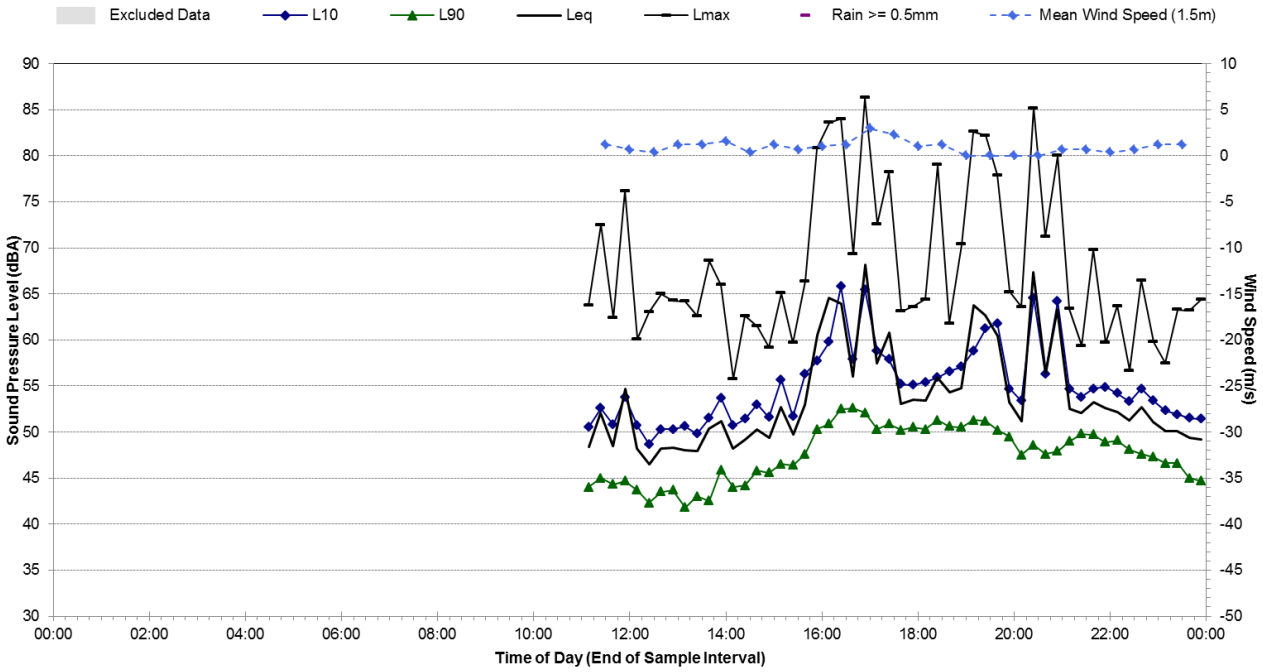
Statistical Ambient Noise Levels

Location Two - Wednesday, 22 August 2018



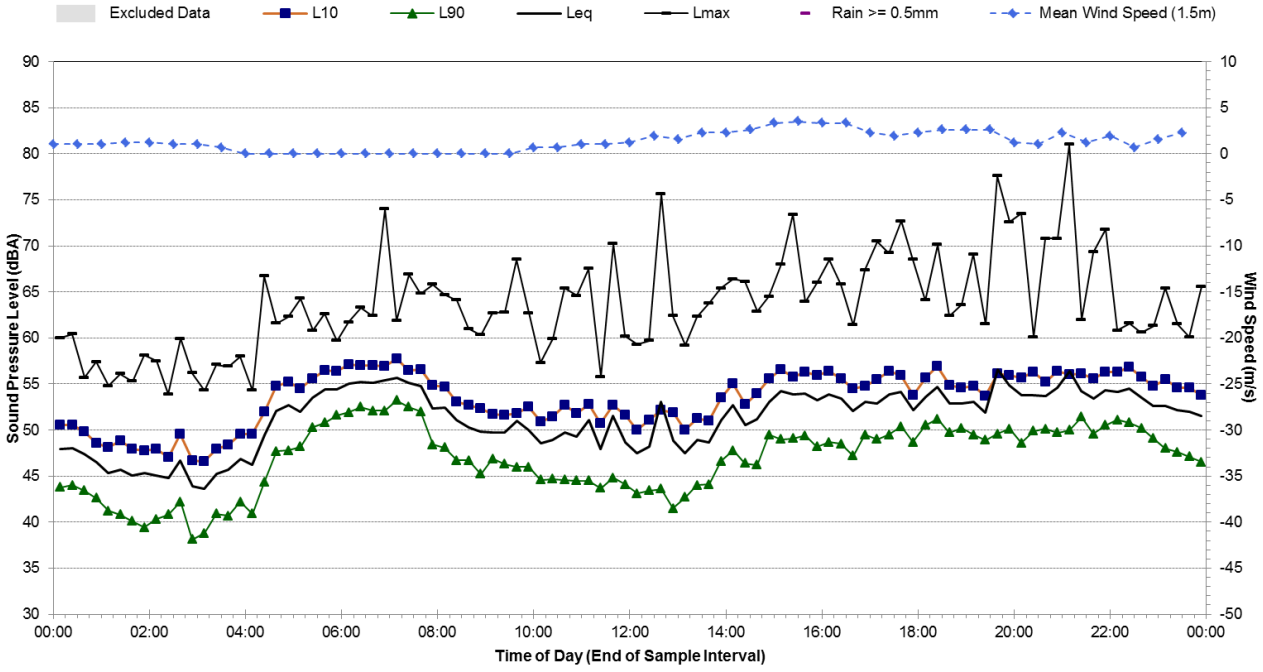
Statistical Ambient Noise Levels

Location Three - Thursday, 9 August 2018



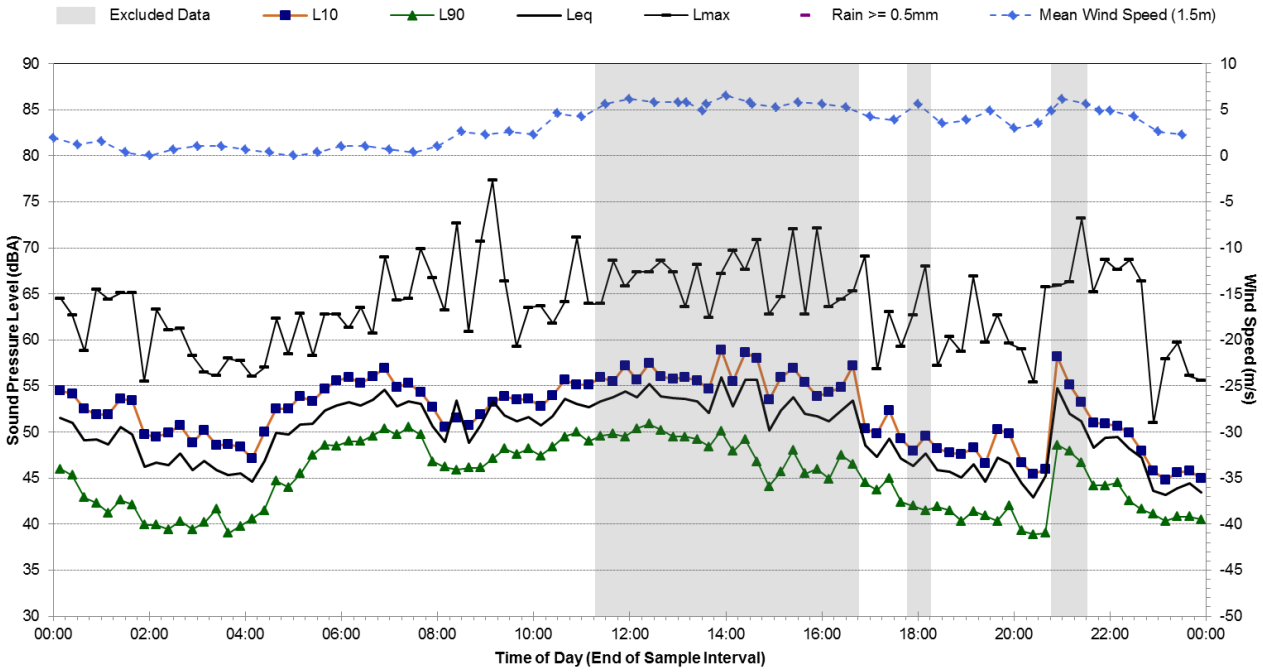
Statistical Ambient Noise Levels

Location Three - Friday, 10 August 2018



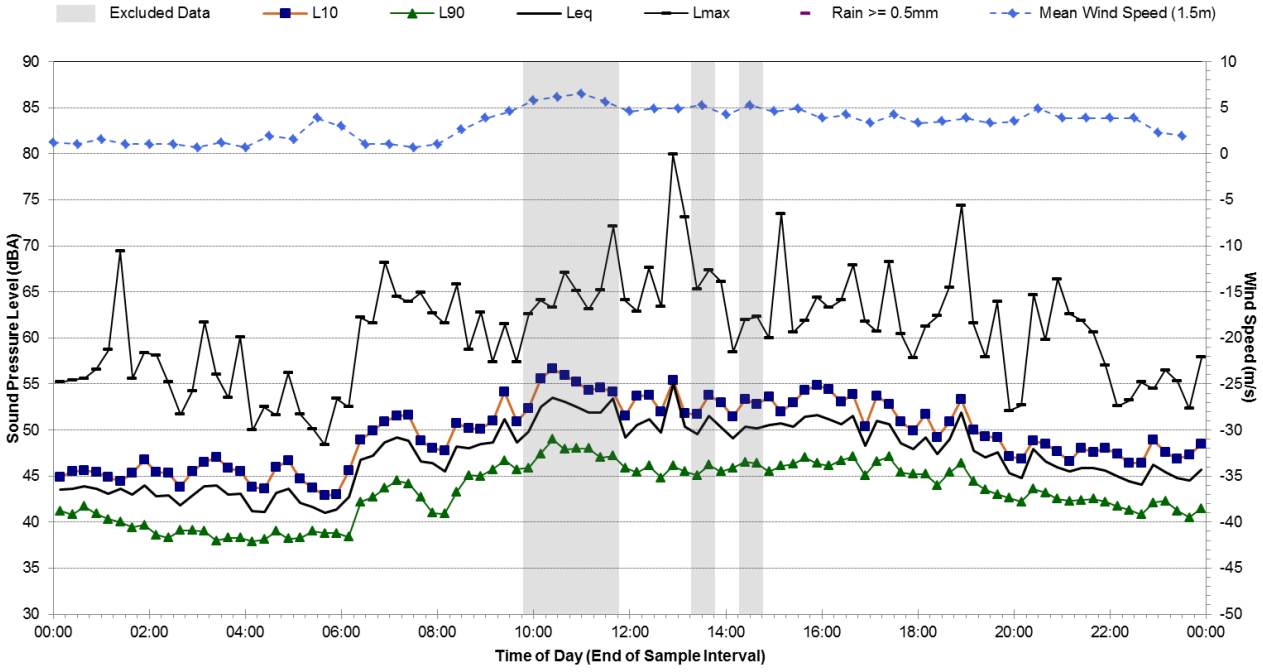
Statistical Ambient Noise Levels

Location Three - Saturday, 11 August 2018



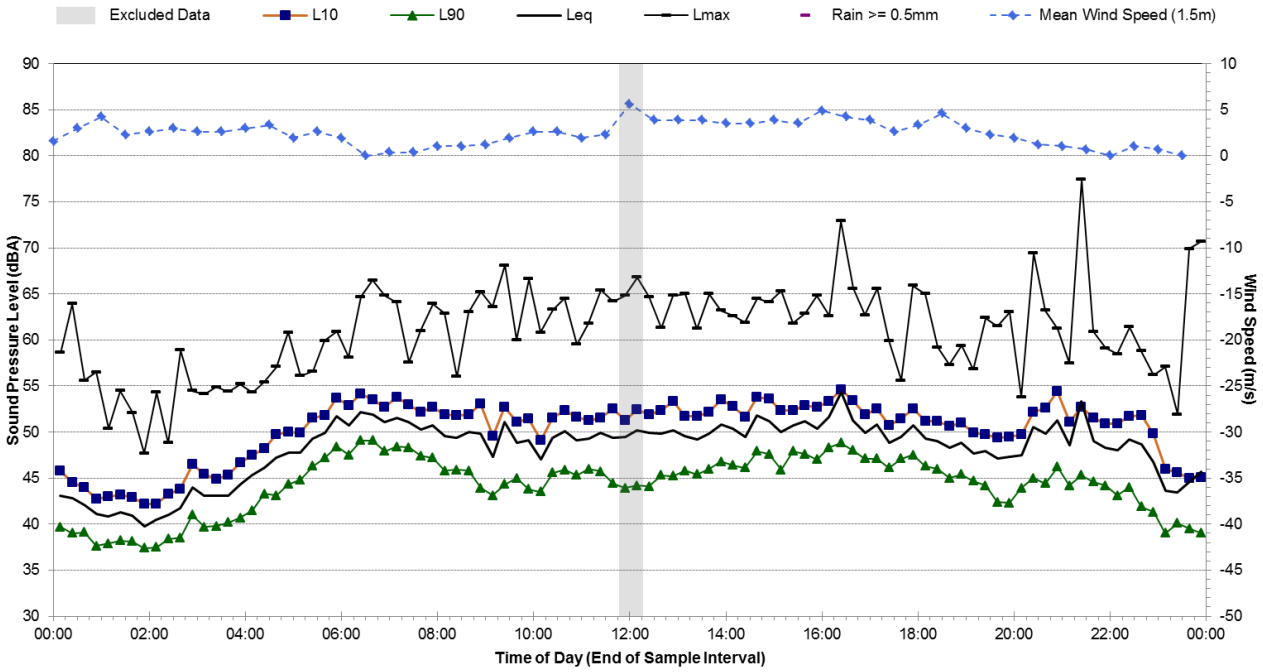
Statistical Ambient Noise Levels

Location Three - Sunday, 12 August 2018



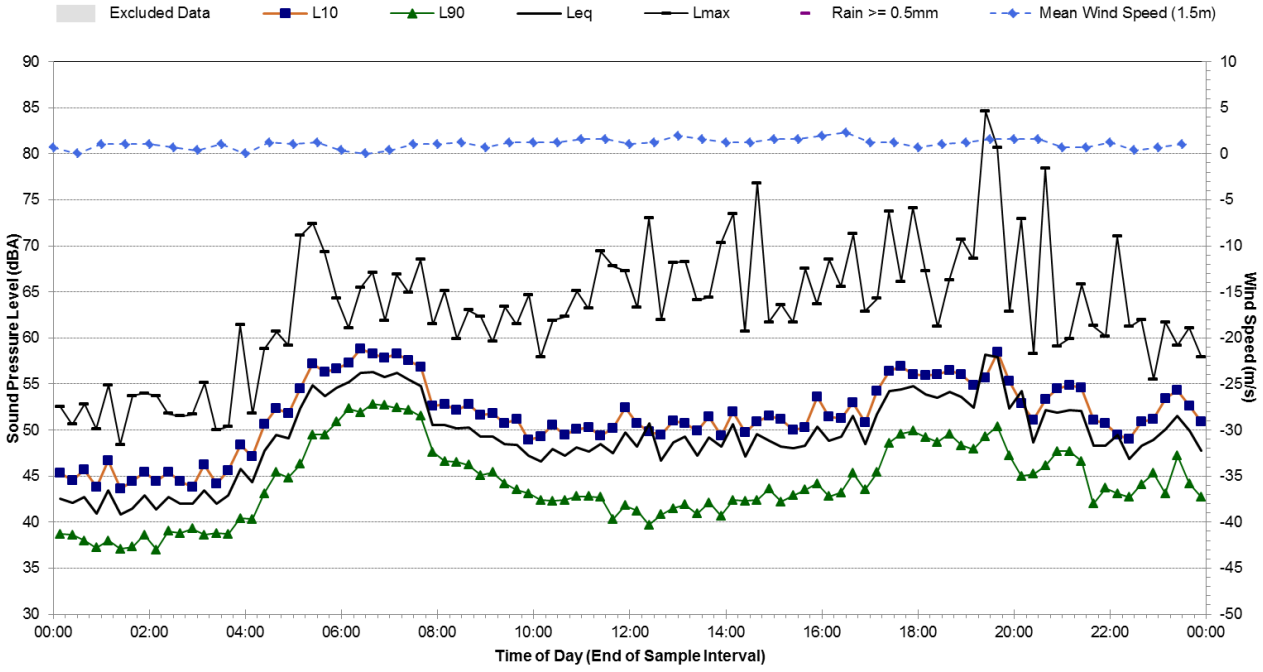
Statistical Ambient Noise Levels

Location Three - Monday, 13 August 2018



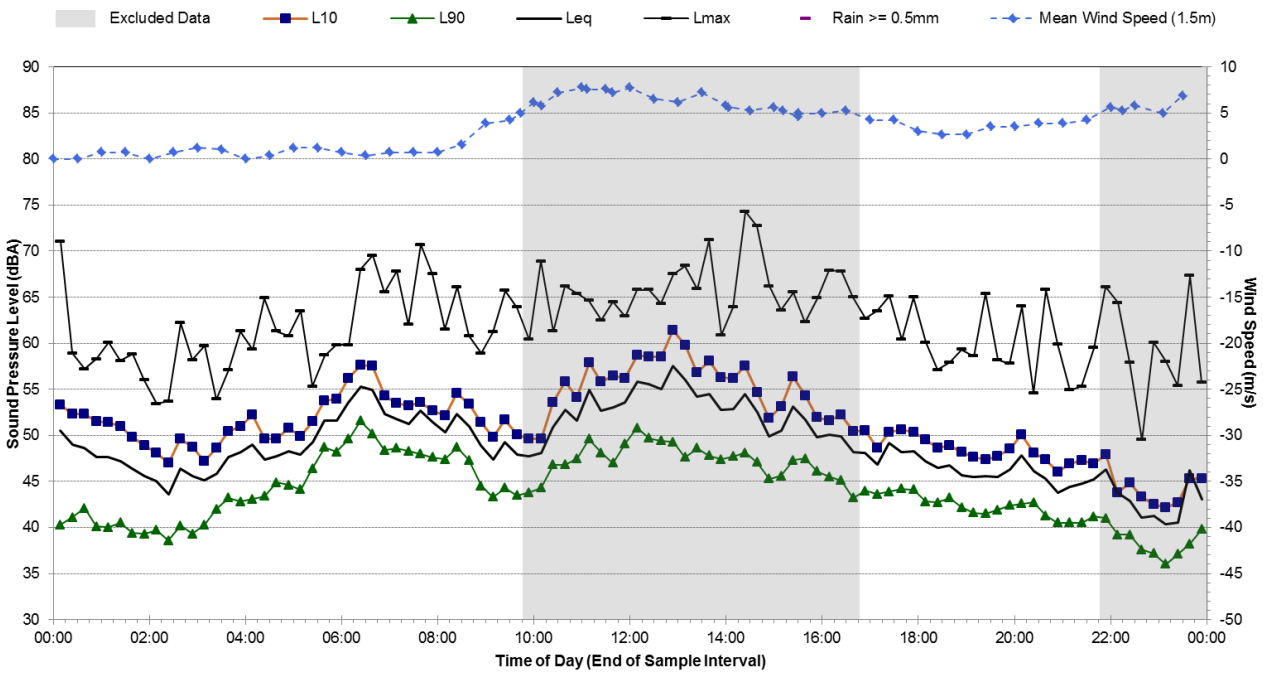
Statistical Ambient Noise Levels

Location Three - Tuesday, 14 August 2018



Statistical Ambient Noise Levels

Location Three - Wednesday, 15 August 2018



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