EnergyCo

Waratah Super Battery – Munmorah

Appendix G - Noise and Vibration Assessment

November 2022

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Abbreviations and acronyms

Term	Definition
AS	Australian Standards
BoM	Bureau of Meteorology
BS	British Standards
CEMP	Construction Environmental Management Plan
CNVG	Construction Noise and Vibration Guideline
CNVMP	Construction Noise and Vibration Management Plan
CNVS	Construction Noise and Vibration Strategy
DCNG	Draft Construction Noise Guideline
DEC	Department of Environment and Conservation NSW
DECC	Department of Environment and Climate Change NSW
DECCW	Department of Environment and Climate Change and Water NSW
DIN	German Institute for Standardisation (Deutsches Institut für Normung)
EIS	Environmental Impact Assessment
EPA	Environment Protection Agency NSW
HNA	Highly Noise Affected
ICNG	Interim Construction Noise Guideline
NCA	Noise Catchment Area
NML	Noise Management Level
NPfI	Noise Policy for Industry
NSW	New South Wales
NVIA	Noise and Vibration Impact Assessment
OOHW	Out of (standard) Hours Work
RBL	Rating Background Level
RNP	Road Noise Policy
SEARs	Secretary's Environmental Assessment Requirements

Glossary of terms

Term	Definition
A weighting	The human ear responds more to frequencies between 500 Hz and 8 kHz and is less sensitive to very low-pitch or high-pitch noises. The frequency weightings used in sound level measurements are often related to the response of the human ear to ensure that the meter better responds to what you actually hear.
Adverse weather	Weather conditions affecting background noise monitoring. Periods in which precipitation is present or wind speeds are greater than 5 m/s at ground level should be excluded.
Noise-enhancing weather conditions	Weather effects that enhance noise (i.e. wind and temperature inversions) that occur at a site for a significant period of time (i.e. light winds, up to and including 3 m/s, occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient air temperature	The air temperature of the environment surrounding the battery enclosures
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far. This is described using the Leq descriptor.
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L90 descriptor.
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context.
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
EIS	Environmental Impact Statement
Feasible and reasonable measures	Feasibility relates to engineering considerations and what is practical to build. reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors: – noise mitigation benefits (amount of noise reduction provided, number of people protected) – cost of mitigation (cost of mitigation versus benefit provided) – community views (aesthetic impacts and community wishes) – noise levels for affected land uses (existing and future levels, and changes in noise levels).
Hertz	The measure of frequency of sound wave oscillations per second. 1 oscillation per second equals 1 hertz.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
Maximum noise event	The loudest event or events within a given period of time. This is generally described using the L_{max} descriptor.
Meteorological conditions	Wind and temperature inversion conditions.
Minimum background level	Minimum background levels are threshold values for rating background levels used to avoid a situation where applying a very low background noise level would not improve the level of protection but may impose very strict requirements on a new development.
Most-affected location	Location(s) that experience (or will likely experience) the greatest noise impact from the construction works under consideration. In determining these locations, existing background noise levels, noise source location(s), distance and any shielding between the construction works (or proposed works) and the residences and other sensitive land uses need to be considered.

Term	Definition
Noise management level	The Noise Management Level (NML) as defined as the EPA's ICNG. To be measured and assessed at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the residential property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most affected point within 30 m of the residence.
Noise sensitive receiver	An area or place potentially affected by noise which includes: – a residential dwelling – an educational institution, library, childcare centre or kindergarten – a hospital, surgery or other medical institution – an active (e.g. sports field, golf course) or passive (e.g. national park) recreational area – commercial or industrial premises – a place of worship.
Non-compliance	Development is deemed to be in non-compliance with its noise consent/ licence conditions if the monitored noise levels exceed its statutory noise limit (exceptions may be given if the noise level exceeds by less than 2 dB).
Octave	A division of the frequency range into bands, the upper frequency limit.
One third-octave	Single octave bands divided into three parts.
Project noise trigger level	Target noise levels for a particular noise generating facility. They are based on the most stringent of the intrusive criteria or amenity criteria. Which of the two criteria is the most stringent is determined by measuring the level and nature of existing noise in the area surrounding the actual or propose noise generating facility.
Project site	The immediate location of the project, which is the area that has the potential to be directly disturbed by construction and operation.
Rating background level	The Rating Background Level (RBL) is defined by the Noise Policy for Industry (NPfI) as the overall, single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hour period used for the assessment background level). This is the level used for assessment purposes
Study area	Land in the vicinity of, and including, the proposal site. The 'study area' is the wider area surrounding the proposal site.
Temperature inversion	An atmospheric condition in which temperature increases with height above the ground.
Thermal load	Operating temperature of the battery, influenced by the ambient air temperature and the battery discharge load and duration.
Z-Weighting (or Unweighted)	Zero-weighting or Linear-weighting indicates no weighting filter has been applied and refers to a flat frequency response for sound level meters.

1. Introduction

1.1 Project overview

EnergyCo, which forms part of the NSW Treasury, propose to develop a lithium-ion battery energy storage system capable of storing up to 850 MW. The battery energy storage system would be supported by connecting transmission and related infrastructure, including a switchyard and overhead transmission line, to connect the proposed battery to the NEM. Additional ancillary infrastructure would also be required to support the project including access roads, site services, an administration building, maintenance building and storage yard, and signage and site security. The purpose of the proposed battery energy storage system is to reduce the chances of unscheduled power outages by reserving and then deploying power to support the electricity grid.

1.2 Scope of work

The purpose of this report is to assess the potential noise and vibration impacts from constructing and operating the project. The report:

– Addresses the SEARs and agency requirements listed in Table 1.1
– Describes the existing environment with respect to noise and vibration
– Assesses the impacts of constructing and operating the project on sensitive receivers
– Recommends measures to mitigate and manage the impacts identified.

Table 1.1 SEARs relevant to this assessment

Requirement	Section addressed
An assessment of the construction noise impacts of the development in accordance with the *Interim Construction Noise Guideline* (ICNG)	Section 5
Operational noise impacts in accordance with the *NSW Noise Policy for Industry* (2017)	Section 6
Cumulative noise impacts (considering other developments in the area)	Section 5.2
A draft noise management plan if the assessment shows construction noise is likely to exceed applicable criteria	Section 7.2

2. Approach and methodology

2.1 Relevant guidelines

The assessment was undertaken in accordance with the SEARs and with reference to the requirements of relevant legislation, policies and/or assessment guidelines, including:

- Interim Construction Noise Guideline (ICNG) (DECC, 2009)
- Noise Policy for Industry (NPfI) (EPA, 2017)
- Assessing Vibration: A Technical Guideline (DEC, 2006)
- *BS 7385-2:1993 Evaluation and measurement for vibration in buildings Part 2 – Guide to damage* (British Standards, 1993).
- NSW Road Noise Policy (RNP) (DECCW, 2011).

2.2 Study area

The study area has been defined as approximately 1.5 kilometres from the project site as noise impacts during construction or operation are not anticipated beyond this distance.

The nearest sensitive receivers are approximately 600 metres from the project site. Due to this large separation distance, vibration impacts during the operational phase are not anticipated. No further assessment of operational vibration impacts has been included in this assessment.

The project location, sensitive receivers and noise monitoring locations are shown on Figure 3.1.

2.3 Construction noise and vibration methodology

2.3.1 Construction noise prediction method

Acoustic modelling was undertaken using CadnaA 2021 noise modelling software to predict the effects of construction noise generated by the proposed works. General parameters used in the model are listed in Table 2.1.

Table 2.1 Noise modelling parameters

Variable	Parameter used
Calculation method	ISO 9613- 2:1996
Meteorology	Well-developed moderate ground based temperature inversion, such as commonly occurs on clear, calm nights or 'downwind' conditions which are favourable to sound propagation
Topography	Sourced from ELVIS GIS Australia – 5 metres elevation intervals
Receiver heights	1.5 metres above building ground level for ground floor and 4.5 metres above ground level for first floor
Ground absorption	1 for all areas (0 is non-porous ground and 1 is porous ground such as that found in a rural setting comprising of mainly grass and vegetation)

The exact details of the construction methodology, plant or equipment for the project, such as the intensity of works, sound power levels or operating duration are not yet known therefore this assessment is based on a variety of conservative assumptions. This information would be refined during detailed design and construction planning. The magnitude of the noise levels associated with construction activities would be dependent upon a number of factors, including:

- The intensity and location of construction activities
- The type of equipment used

– Existing local noise sources
– Intervening terrain or structures
– The prevailing weather conditions.

2.3.2 Construction vibration prediction method

The method for the construction vibration assessment included:

– Identifying safe working distances to comply with the human comfort and the cosmetic damage criteria. These buffer distances have been adopted from *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2019).
– Safe working distances for vibration intensive equipment are shown in Table 2.2. The vibratory equipment associated with the project include vibratory rollers and excavators.
– Buildings within the safe working distances have been identified for consideration of management measures.

Table 2.2 Vibration safe working distances

Equipment	Human comfort (OH&E Vibration guideline)	Cosmetic damage (BS 7385)
Piling rig – Bored <800 mm	N/A	2 m (nominal)
Piling rig–Hammer (12 tonnes down force)	50 m	15 m
Piling rig – Vibratory (sheet piles)	20 m	2 m to 20 m
Vibratory roller (>18 tonnes)	100 m	25 m
Vibratory roller (13-18 tonnes)	100 m	20 m
Vibratory roller (7-13 tonnes)	100 m	15 m
Vibratory roller (4-6 tonnes)	40 m	12 m
Vibratory roller (2-4 tonnes)	20 m	6 m
Vibratory roller (1-2 tonnes)	15 m	5 m
Small hydraulic hammer 300 kg (5-12t excavator)	7 m	2 m
Medium hydraulic hammer 900 kg (12-18t excavator)	23 m	7 m
Large hydraulic hammer 1600 kg (18-34t excavator)	73 m	22 m
Jackhammer (handheld)	Avoid contact with structure	1 m (nominal)

2.3.3 Construction hours

The majority of construction activities would be carried out during the following hours, consistent with the recommended standard hours of the Interim Construction Noise Guideline (Department of Environment and Climate Change 2009):

– 7am-6pm Monday to Friday.
– 8am-1pm Saturdays.
– No work on Sundays or Public Holidays.

Work that would be carried out outside of the above recommended standard construction hours may include:

– Work determined to comply with the relevant noise management level at the nearest sensitive receiver.
– The delivery of materials and heavy equipment – for instance power transformers outside approved hours, as required by the NSW Police or other authorities for safety reasons.

2.3.4 Construction equipment

The noise levels for the construction equipment have been sourced from AS2436 – Guide to Noise Control on Construction, Maintenance and Demolition Site (Australian Standards, 2010). The anticipated plant and equipment likely to be used for the project is shown in Table 2.3 with the corresponding sound power levels used in the noise model and the source of the noise level. The modelled construction scenarios and activity sound power levels are presented in Table 2.4.

Table 2.3 Construction equipment and sound power levels

Typical equipment	Sound power level, dBA
Backhoe	104
Concrete saw	117
Concrete truck and pump	108
Crane	105
Dump truck	117
Elevated work platform	105
Excavator	107
Front end loader	113
Generator	99
Grader	110
Hand tools	102
Light vehicles	106
Scraper	116
Truck	107
Vibratory roller	108
Water truck	107

Table 2.4 Construction noise scenarios – standard hours

Scenario ID	Activity description	Construction equipment	Activity sound power level, dBA
CS1: Site preparation	– Upgrading the construction access road from the existing internal access road to the project site. – Establishment of areas for laydown of materials and equipment. – Establishment of temporary site offices and crib facilities. – Clearing and grubbing – Earthworks and grading – Installation and relocation of utilities and services – Installation of asset protection zones – Installation of site security	– Front end loaders – Dump trucks – Water trucks – Excavators – Graders – Compactors and rollers – Concrete saws and grinders – Scrapers – Backhoe – Generators – Light vehicles	117

Scenario ID	Activity description	Construction equipment	Activity sound power level, dBA
CS2: Construction	– Construction/installation of the battery energy storage system – Construction/installation of connecting transmission and related infrastructure – Construction/installation of ancillary infrastructure	– Front end loaders – Trucks – Water trucks – Compactors and rollers – Concrete trucks and pumps – Elevated work platforms – Cranes – Concrete saws and grinders – Generators – Light vehicles – Hand tools	114
CS3: Commissioning	Commissioning would include final inspection and testing of all proposed facilities to ensure they operate as intended	– Elevated work platforms – Cranes – Hand tools – Trucks	109

2.3.5 Construction traffic noise

2.3.5.1 Traffic generation and access

The construction of the project is likely to involve a workforce of approximately 200 people. A maximum of 100 workers are expected on site during the peak construction period. Heavy vehicles would access the project site during construction via the former Munmorah Power Station. Light vehicles would access the project site during construction and operation via Central Coast Highway and an existing permanent access road off Station Road, Colongra.

Existing traffic volumes along Central Coast Highway are approximately 1500 vehicles during the peak hour, as such the construction traffic generation is not expected to contribute to the current road traffic noise level at residences along this road. Additionally, no receivers are located on Station Road and as such no impacts are predicted from traffic generation during construction.

2.4 Operational noise assessment

2.4.1 Methodology overview

The design of the BESS is still in the concept stage and the battery vendor has not been selected. Noise modelling has been based on typical equipment data. As further detail are confirmed, the operational noise model would be updated to ensure compliance with the noise limits.

To predict the noise levels at sensitive receivers surrounding the site, the following factors have been taken in account in the environmental noise modelling methodology:

– Terrain topography
– Absorption from ground coverage
– Atmospheric absorption
– Relevant shielding objects (e.g. buildings / noise barriers)
– The operating scenarios of the equipment for the relevant time period
– Noise enhancing meteorological conditions.

2.4.2 Noise modelling methodology

Acoustic modelling was undertaken using CadnaA 2021 noise modelling software to predict indicative environmental noise levels at the sensitive receivers surrounding the project site during the operation of the solar farm. CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation using industry standard models such as the ISO 9613-2 (ISO, 1996) or the CONCAWE (CONCAWE, 1981) prediction methods.

The ISO 9613-2 calculation method is considered appropriate as it takes into account a moderate temperature inversion and is considered representative of noise enhancing meteorological conditions which have the potential to be present at the site for more than 30% of the time during winter.

General parameters used in the model are listed in Table 2.5.

Table 2.5 Noise modelling parameters

Variable	Parameter used
Calculation method	ISO 9613-2
Topography	Sourced from ELVIS GIS Australia – 5 metres elevation intervals
Receiver heights	1.5 metres above building ground level for ground floor and 4.5 metres for first floor
Ground absorption	The area is surrounded by dense foliage, therefore a ground absorption of 1 has been adopted for the intervening terrain which represents grass and vegetation. For the site itself a ground absorption of 0 has been adopted which represents hard ground.
Temperature	20°C
Humidity	70%
Number of reflections	A maximum number of 1 reflections from surrounding structures
Temperature inversion	Moderate ground based temperature inversion

2.4.3 Hours of operation

The equipment has the potential to operate 24 hours per day, seven days per week, 365 days per year.

2.4.4 Sleep disturbance impacts

The potential for sleep disturbance is considered for short-duration, high level noise events. The equipment will operate in a steady state nature. Due to the nature of this project, significant maximum noise level events are not anticipated to occur during the night and as such, no further assessment of sleep disturbance has undertaken as no sleep disturbance impacts would be present.

2.4.5 Source noise levels

Operational noise source levels were developed based on available manufacturer data noting that the preferred battery technology supplier has not been confirmed. The modelled source noise levels are presented below in Table 2.6. These may require further refinement during the detailed design phase once the selected vendor technical data sheets for the selected equipment become available.

The sound power level of the battery fans is dependent on the thermal load the battery is under. The thermal load is dependent on both the ambient air temperature, the battery discharge rate and discharge duration. The batteries are designed to discharge over a 30 min period where cooling requirements would be at a maximum.

Table 2.6 Source noise levels used in the noise model, dBA

Equipment	Ambient air temperature, °C	Number of units	Octave-band noise level (Frequency, Hz), dBA									Overall noise level, dBA
			31.5	63	125	250	500	1k	2k	4k	8k	
No fans mode	<35	640	21	26	37	54	56	54	48	37	28	SWL 60 (each)
Battery fans	35		63	66	72	71	72	70	67	63	54	SWL 78 (each)
Battery fans	40		47	52	67	77	77	76	74	72	63	SWL 83 (each)
Battery fans	>40		47	52	71	77	82	82	80	79	70	SWL 87 (each)
Battery Transformer	NA	160	50	59	69	69	72	76	77	67	55	SWL 81
Tie in Transformer	NA	3	41	72	92	78	79	76	73	70	61	SWL 92

3. Existing environment

3.1 Project location

The project would be located on part of Lot 10/DP1201414 within the former Munmorah Power Station at Colongra on the Central Coast of NSW. Within the locality of the project site are the residential suburbs of Doyalson, San Remo, Buff Point, Budgewoi and Halekulani with the latter being approximately 600 metres distant (and the others further away).

3.2 Noise sensitive land uses

Noise and vibration sensitive receivers are defined based on the type of occupancy and the activities performed in the land use. Sensitive noise and vibration receivers could include:

– Residential dwellings
– Classrooms
– Hospitals
– Places of worship
– Passive and active recreational areas such as parks, sporting fields, golf courses. Note that these recreational areas are only considered sensitive when they are in use or occupied
– Commercial or industrial premises
– Hotels, motels, caretaker’s quarters, holiday accommodation and permanent resident caravan parks.

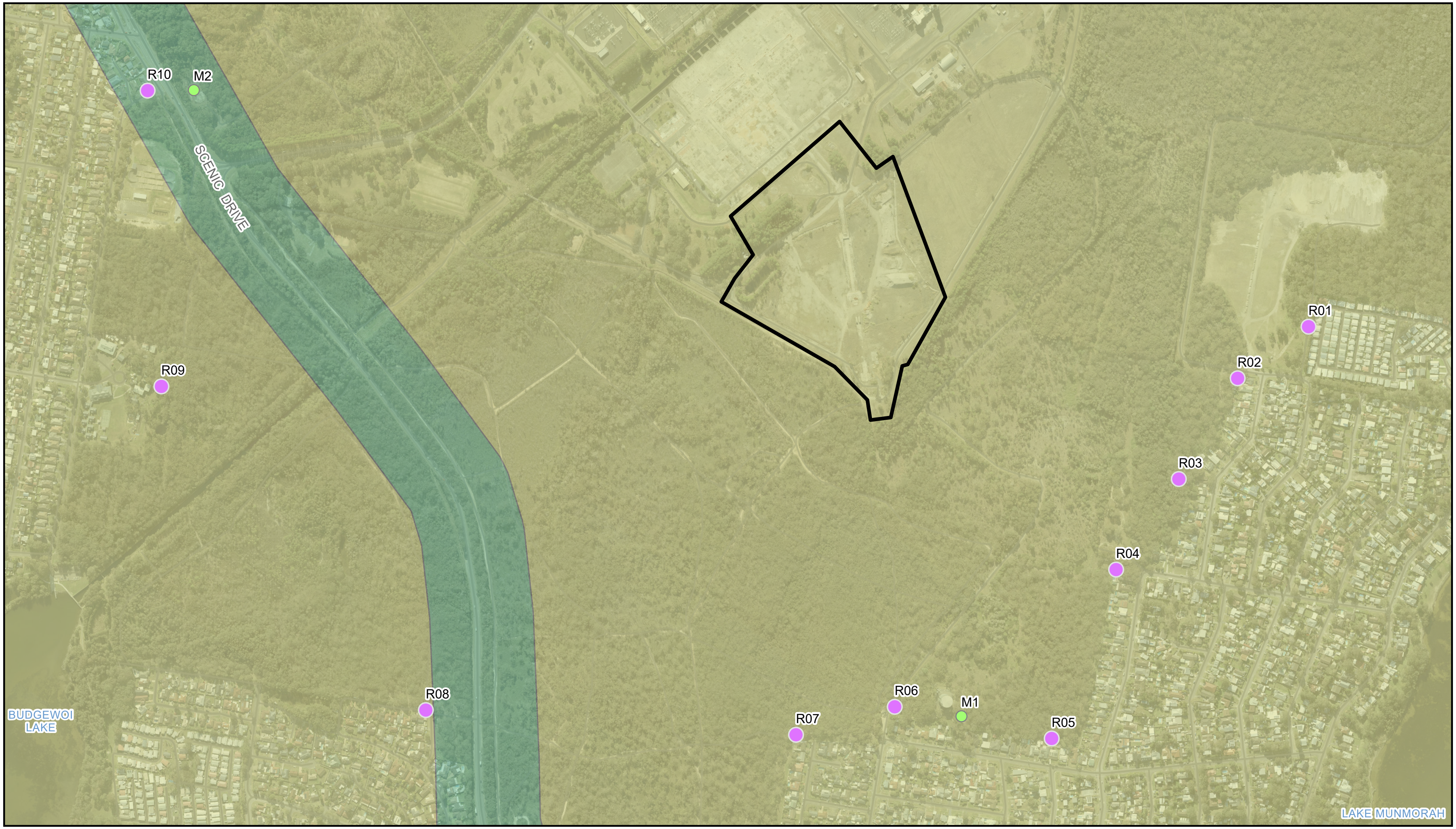
Locations representative of the worst affected residential receivers have been included in the model. The nearest sensitive receivers to the project site are residences approximately 600 metres to the south. The receiver locations are shown on Figure 3.1

3.3 Noise catchment areas

Noise catchment areas (NCAs) are used to classify areas of different noise environments. For this assessment the residential receivers have been categorised into two discrete noise catchment areas. The dominant noise sources surrounding the project site include the Central Coast Highway, Munmorah Power Station and other industrial premises in the area. Residential receivers have been classified into the two NCAs based upon their proximity to these noise sources as follows:

– NCA1: Residences located further than 100 m from Central Coast Highway
– NCA2: Residences located directly adjacent to the Central Coast Highway

These NCAs are shown on Figure 3.1



Legend
- Monitoring locations
- Receivers
- Project Site
- NCA1
- NCA2
- Roads

Paper Size ISO A4
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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Project site, sensitive receivers and noise monitoring locations

Project No. 12582669
Revision No. 0
Date 26/10/2022

FIGURE 3.1

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3.4 Noise environment

Noise monitoring was undertaken from Wednesday 17 August 2022 until Friday 26 August 2022 in 2 locations representative of residential areas to quantify and characterise the existing ambient noise environment across the study area. The long-term noise monitoring program was undertaken in accordance with *Noise Policy for Industry* (EPA, 2017) and the full noise monitoring methodology is outlined in Appendix B, along with the results of the attended noise monitoring survey at each location.

The noise monitoring locations are shown in Figure 3.1

The unattended noise monitoring results are presented in Table 3.1 for each monitoring location.

Ambient noise levels measured at location M1 may include some noise from Colongra Power Station, however since the Colongra Power Station is a peaking power plant, it is generally not operating. Due to the intermittent nature of the operation of the power station it would not influence the RBL which is the 90th percentile of the $L_{A90(15min)}$ levels for each period.

Table 3.1 Unattended noise monitoring results, dBA

Location	Rating Background Level[1] (RBL), $L_{A90(Period)}$			Ambient noise descriptors[1] $L_{Aeq(period)}$		
	Day	Evening	Night	Day	Evening	Night
M1	35	35	30	46	43	43
M2	48	42	30 (28)	55	53	50

Notes: The *Noise Policy for Industry (NPI)* defines day, evening and night-time periods as:

– Day: 7am to 6pm Monday to Saturday and 8am to 6pm Sunday
– Evening: 6pm to 10pm
– Night: 10pm to 7am Monday to Saturday and 10pm to 8am Sunday.

3.5 Local meteorology

Wind has the potential to increase noise levels at a receiver when it is light and stable and blows from the direction of the source of the noise. As the strength of the wind increases, the noise produced by the wind will mask noise from most industrial and transport sources.

Temperature inversions (i.e. where atmospheric temperature increases with altitude) typically occur during stable atmospheric conditions such as the night-time period in the winter months. Temperature inversion can also increase project noise levels at assessment locations. As such, wind effects and temperature inversions need to be considered when predicting the noise levels during the operation of the project.

3.5.1 Noise Policy for Industry requirements

The NPfI requires assessment of noise under standard and noise enhancing weather conditions. The NPfI defines these as follows:

– Standard meteorological conditions: defined by stability categories A through to D with wind speeds up to 0.5 m/s at 10 metres above ground level (AGL) for day, evening and night periods; and
– Noise-enhancing meteorological condition: defined by stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) for the day and evening periods; and stability categories A through to D with light winds (up to 3 m/s at 10 m AGL) and/or stability category F with winds up to 2 m/s at 10 m AGL.

The NPfI specifies the following two options to consider meteorological effects:

1. Adopt the noise-enhancing meteorological conditions for all assessment periods for noise impact assessment purposes without an assessment of how often these conditions occur – a conservative approach that considers source-to-receiver wind vectors for all receivers and F class temperature inversions with wind speeds up to 2 m/s at night; or

2. Determine the significance of noise-enhancing conditions. This involves assessing the significance of temperature inversions (F and G class stability categories) for the night-time period and the significance of light winds up to and including 3 m/s for all assessment periods during stability categories other than E, F or G. Significance is based on a threshold of occurrence of 30% determined in accordance with the provisions in this policy. Where noise-enhancing meteorological conditions occur for less than 30% of the time, standard meteorological conditions may be adopted for the assessment.

3.5.2 Wind effects

The NPfI recommends consideration of wind effects if they are “significant”. The NPfI defines “significant” as the presence of source-to-receiver wind speed (measured at 10 metres above ground level) of 3 m/s or less, occurring for 30% of the time in any assessment period and season.

This is further clarified by defining source-to-receiver wind direction as being the directional component of wind. The NPfI states that where wind is identified to be a significant feature of the area then assessment of noise impacts should consider the highest wind speed below 3 m/s, which is considered to prevail for at least 30% of the time.

A thorough review of the vector components of hourly wind data from 2017 to 2021 was undertaken for data from the Bureau of Meteorology’s Norah Head Automatic Weather Station (AWS) (SN: 061366). The observations are approximately 22 kilometres from the site and are considered representative for the site and surrounds. The analysis identified that wind directions were not found to be a feature of the area, as per the NPfI.

Figure 3.2 shows the wind roses (2017 to 2021) for wind speeds less than 3 m/s in each NPfI assessment period and for each season. Table 3.2 provides a summary of the prevailing wind conditions that are relevant to the assessment. The analysis indicates that noise-enhancing wind conditions are not identified to be a significant feature of the area during any season or period of the day, evening or night.

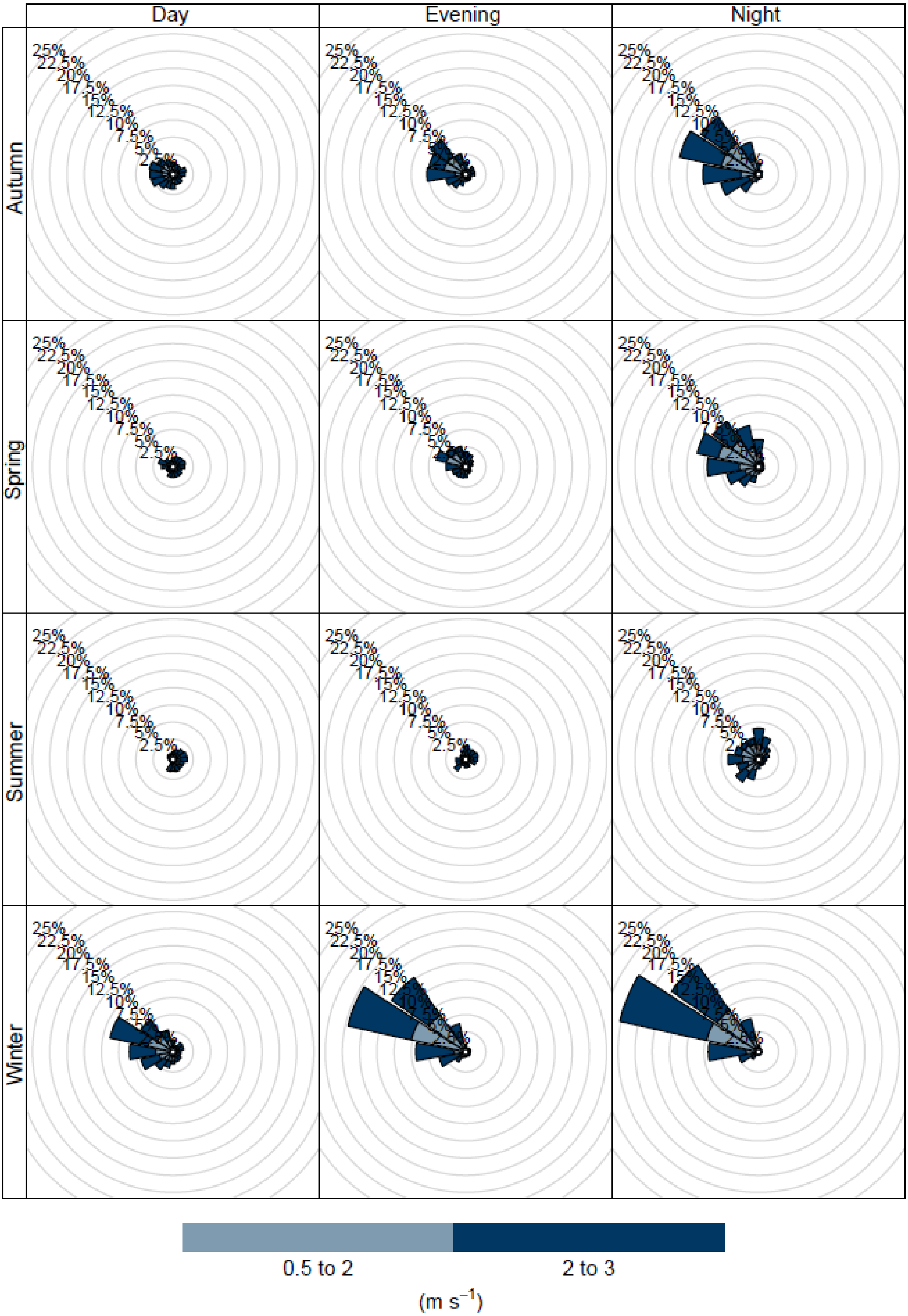

Figure 3.2 5 year wind rose (seasonal and relevant assessment periods) – Norah Head AWS

Table 3.2 Significant wind effects analysis – Norah Head AWS

Wind direction[1]	Summer			Autumn			Winter			Spring		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
N	4%	6%	14%	8%	11%	16%	11%	18%	20%	5%	10%	19%
NNE	5%	6%	13%	7%	7%	6%	7%	5%	5%	5%	8%	11%
NE	6%	7%	11%	6%	5%	2%	5%	2%	1%	6%	5%	6%
ENE	7%	6%	7%	6%	4%	0.7%	4%	1%	0.4%	6%	4%	3%
E	7%	5%	5%	6%	4%	0.8%	5%	1%	0.2%	6%	3%	2%
ESE	7%	5%	4%	6%	3%	0.7%	5%	1%	0.3%	6%	3%	2%
SE	7%	4%	4%	6%	3%	0.8%	5%	1%	0.2%	6%	3%	2%
SSE	7%	4%	5%	7%	3%	1%	6%	2%	0.3%	5%	4%	4%
S	6%	4%	8%	8%	5%	4%	8%	3%	1%	5%	5%	6%
SSW	5%	5%	11%	9%	7%	9%	11%	6%	4%	5%	6%	10%
SW	3%	5%	14%	11%	12%	17%	16%	13%	10%	5%	8%	17%
WSW	3%	5%	16%	13%	16%	28%	24%	29%	30%	5%	11%	25%
W	2%	5%	16%	13%	21%	37%	27%	41%	45%	5%	13%	31%
WNW	2%	4%	15%	13%	21%	38%	27%	44%	49%	5%	14%	34%
NW	3%	5%	17%	12%	20%	34%	24%	41%	47%	6%	14%	33%
NNW	3%	5%	16%	10%	15%	27%	19%	34%	40%	6%	13%	27%

Note: 1. The percentages shown are the frequency of counts by wind direction and include the arithmetic sum of the direction being reported and the four closest directions

3.5.3 Temperature inversions

Temperature inversions typically occur during the night-time period in the winter months and have the potential to also increase noise levels from the operations at the plastics recycling and reprocessing facility at the surrounding residents. As per the NPfI, temperature inversions are to be assessed when they are found to occur for 30% of the time (about two nights per week) or greater during the winter months. As the project has the potential to operate during the night period, the effect of temperature inversions on noise levels at night should be considered.

Noise enhancement due to temperature inversions occurs when the atmosphere is relatively stable which corresponds with atmospheric stability class category F and G. An analysis of the meteorological data for three winter months from 2017 to 2021 at the Norah Head AWS and cloud cover data at Maitland Airport AWS (SN: 061428) has been undertaken using the Turner method and considers to the following observation parameters:

- Hourly wind speed and direction at 10 metres
- Hourly cloud cover measurements
- Hourly cloud ceiling-height measurements
- Daily records of time of sunrise and sunset.

The percentage occurrence of the Pasquill stability categories are presented in Table 3.3.

Table 3.3 Percentage occurrence of Pasquill stability categories

Pasquill–Gifford stability category	Percentage occurrence (winter night period)	F and G combined (night period) – Step 2	Are temperature inversions a feature of the area?
A	0%	49%	Yes
B	0%		
C	0%		
D	23%		
E	28%		
F	38%		
G	11%		

The results indicate that ‘F’ class temperature inversions are a feature of the area as they occur for more than 30% of the time during the winter and therefore are relevant to the assessment.

3.5.4 Ambient air temperature

The ambient air temperature is used to determine the thermal load on the batteries and hence the cooling fan load required. The ambient air temperature at the Norah Head AWS for the years 2017 – 2021 was analysed and the diurnal patterns summer and winter temperatures are shown on Figure 3.3. The maximum temperatures approach 40°C during the day in summer as shown by the dashed red line, however, the average temperature for these months is around 25°C. During the night time summer period the maximum temperatures reach 35°C with the average temperature around 23°C.

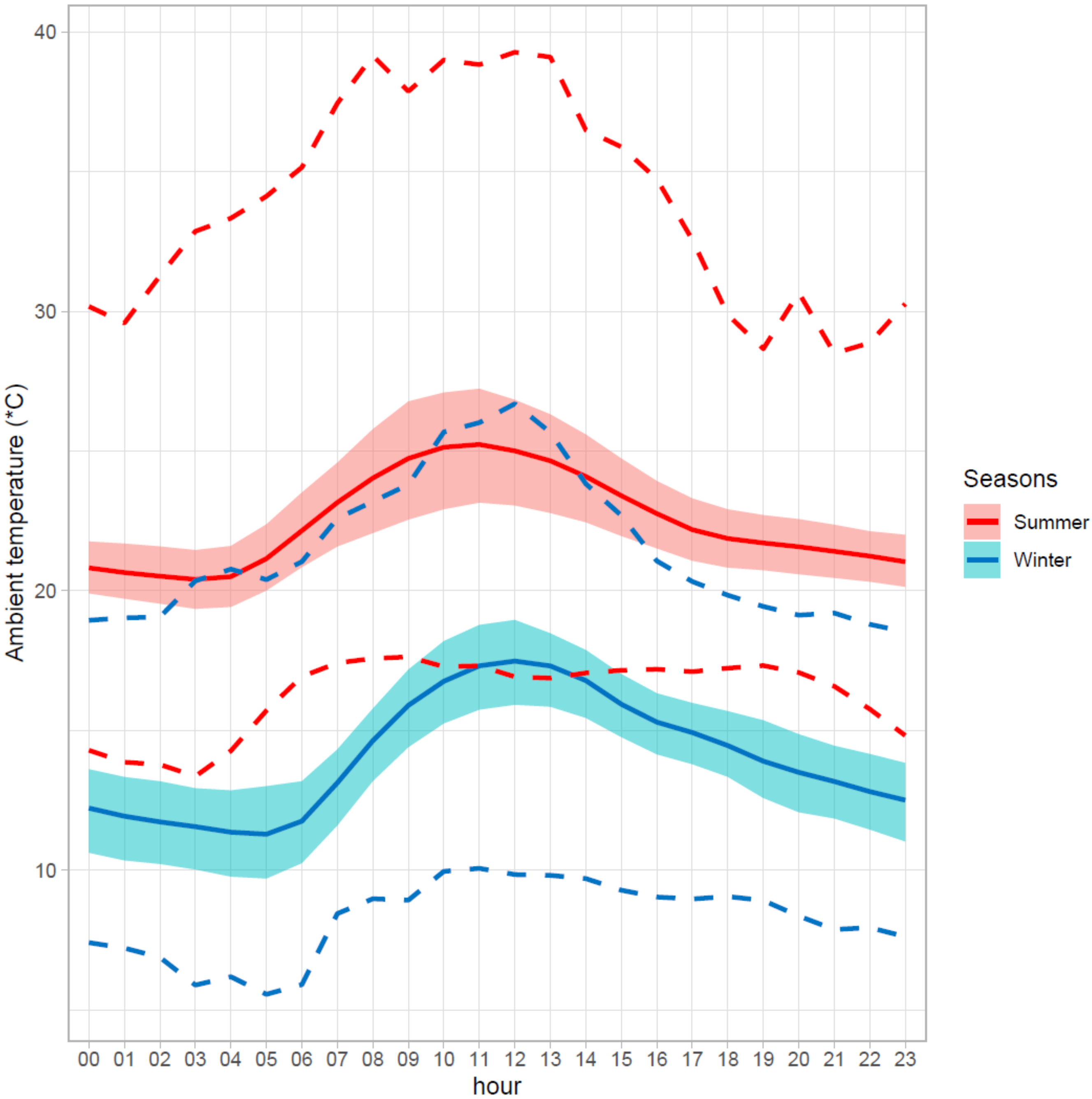

Figure 3.3 5-year diurnal ambient air temperature pattern for summer and winter

3.5.5 Atmospheric conditions

Temperature and humidity affects how sound is absorbed by the atmosphere. With a fixed temperature at 15ºC, a decrease in relative humidity from 80% to 20% can decrease the sound level at a listener standing 800 metres from the noise source by 3 dB (at 1000 Hz). Fixing the relative humidity at 80%, an increase in temperature from 15 ºC to 30 ºC can decrease the sound level 800 metres from the noise source by 3 dB (at 1000 Hz). An average temperature of 20 °C and average humidity of 70% has been adopted for the assessment and is representative of a conservative case, as temperatures are likely to be higher (which provides more atmospheric absorption) when noise emissions from the site associated with battery cooling are higher.

4. Assessment criteria

4.1 Construction noise

4.1.1 NSW Construction Noise Guidelines

The EPA has released the Draft Construction Noise Guideline (DCNG) in 2020 for public consultation purposes only and once public consultation is complete, the feedback will be used to provide a final guideline to replace the ICNG. The ICNG will remain applicable for projects as it is referred to in the SEARs.

However, the DCNG still provides useful guidance and includes the following changes:

- addition of a more stringent highly noise affected level during the night period
- emphasis on the need to engage with the community, to ensure that the community's views are considered when planning how to manage construction noise impacts
- improved guidance for managing noise from construction activities taking place outside the recommended standard hours of work
- alignment of the level of assessment required with risk of noise impact
- a simplified assessment path for routine activities undertaken by public authorities on public infrastructure through industry management procedures
- increased emphasis on the need for proponents to justify the selection of noise mitigation measures to improve transparency.

The intent of the key changes in the DCNG have been considered in this assessment however construction noise associated with the project has been assessed against the requirements of the ICNG.

4.1.2 Noise management levels

Table 2 in the ICNG provides recommended noise management levels for residences, which are detailed in Table 4.1. Noise management levels are also provided in the ICNG for other sensitive land uses in Table 4.2.

Table 4.1 Residential construction noise management levels, dBA (ICNG, 2009)

Time of day	Noise management level, $L_{Aeq(15\ min)}$	Application notes
Recommended standard hours	Noise affected: 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 $L_{Aeq(15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices 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 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 restricting 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, 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.

Time of day	Noise management level, $L_{Aeq(15\ min)}$	Application notes
Outside recommended standard hours	Noise affected: 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 measures have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Table 4.2 Noise at non-residential sensitive land uses, (ICNG, 2009)

Land use	Management level $L_{Aeq(15min)}$ (applies when properties are being used)
Educational institute	Internal noise level 45 dBA
Commercial premises	External noise level 70 dBA
Industrial premises	External noise level 75 dBA

Project specific construction noise management levels

The noise management levels at sensitive receivers in the study area are summarised in Table 4.3 and have been based on Table 4.1 and Table 4.2 using the minimum RBLs from the NPfI as outlined in Section 4.4.1.

Table 4.3 Project specific construction noise management levels

Sensitive receiver type	Construction Noise Management Levels				
	Standard construction hours		Outside standard construction hours[1]		
	Noise affected	Highly noise affected	Day	Evening	Night
Residential – NCA1	45	75	40	40	35
Residential – NCA2	58	75	53	47	35
Educational institute	External noise level 55 dBA (when in use)[2]				
Commercial premises	External noise level 70 dBA (when in use)				
Industrial premises	External noise level 75 dBA (when in use)				

Notes: 1. Noise management levels for outside of recommended standard construction hours are provided, however construction works are not proposed for non-standard hours.
2. Based on a 10 dB attenuation through an open window to achieve an internal level of 45 dBA.

4.1.3 Sleep disturbance

No construction works are proposed outside the recommended standard construction hours. As such, no sleep disturbance impacts are anticipated during the construction phase of the project.

4.2 Construction vibration

4.2.1 Human comfort

Vibration is assessed based on the criteria in *Assessing Vibration: A Technical Guideline* (DEC, 2006). *BS6472: Guide to Evaluation of Human Exposure to Vibration in Buildings* (1 Hz to 80 Hz) (British Standards, 2008) is recognised by the guideline as the preferred standard for assessing the 'human comfort criteria'. Intermittent vibration, such as construction work, is assessed using the vibration dose value.

Whilst the assessment of response to vibration in BS 6472-1:2008 is based on vibration dose value and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak particle velocity (PPV), since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage. Table 4.5 provides guidance on the effect of vibration levels for human comfort in peak particle velocity as reference against the vibration guide values shown in Table 4.4.

Table 4.4 Acceptable PPV Values for Human Comfort (BS 6472-2008)

Receiver	Period	Continuous and impulsive vibration guide goals	
		Preferred value	Maximum value
Residential	Day	0.28 (8.6)	0.56 (17.0)
Offices, schools, educational institutes and places of worship	When in use	0.56 (18.0)	1.1 (36.0)
Workshops	When in use	1.1 (18.0)	2.2 (36.0)

Note: Impulsive goals are shown in brackets. These are most relevant to activities that create up to 3 distinct vibration events in an assessment period (e.g. occasional dropping of heavy equipment, occasional loading and unloading).

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in *BS5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration* (British Standards, 2009), as shown below in Table 4.5.

Table 4.5 Guidance on effect of vibration levels for human comfort (BS 5228.2 – 2009)

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

4.2.2 Structural damage

The minimum working distances for structural (cosmetic) damage used for this assessment have been based on *BS 7385-2:1993 Evaluation and measurement for vibration in buildings Part 2 – Guide to damage* (British Standards, 1993) levels from ground borne vibration which enables the likelihood of building damage from ground vibration to be assessed. The use of BS7385-2 is the preferred standard in NSW to assess potential vibration impacts to unreinforced or light framed structures and is consistent with the Transport for NSW noise and vibration guidelines.

The vibration levels in this standard are adopted as building damage criteria and are presented in Table 4.6.

Table 4.6 Transient vibration guide values - minimal risk of cosmetic damage

Type of building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse[1]	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures industrial and heavy commercial building	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures residential or light commercial type buildings [2]	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

Notes: 1. Values referred to are at the base of the building.
2. At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

4.3 Construction traffic noise

The RNP provides traffic noise target levels for residential receivers in the vicinity of existing roads and are applied to road upgrades. For this assessment these levels are also applied to construction works to identify potential construction traffic impacts and the requirements for reasonable and feasible mitigation measures. The RNP road types are based on the following functional roles.

Table 4.7 Road Categories from RNP

Road category	Functional role	Existing roads used by proposal
Freeways or motorways/arterial roads	Support major regional and inter-regional traffic movement. Freeways and motorways usual feature strict access controls via grade separated interchanges.	Central Coast Highway
Sub-arterial roads	Provide connection between arterial roads and local roads. May support arterial roads during peak period. May have been designed as local streets but can serve major traffic generating developments or support non-local traffic.	NA
Local roads	Provide vehicular access to abutting property and surrounding streets. Provide a network of the movement of pedestrians and cyclists, and enable social interaction in a neighbourhood. Should connect ,where practicable, only to sub-arterial roads.	Station Road, Colongra

The application notes for the RNP state that "*for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds, the relevant day or night noise assessment criterion*."

If the road traffic noise increase from the construction work is within 2 dBA of existing noise levels, then the objectives of the RNP are met and no specific mitigation measures are required. Mitigation should be applied when road traffic noise levels increase by 2 dB and the controlling noise criterion in Table 4.8 are exceeded when assessed at the nearest façade of the residential dwelling.

Table 4.8 Road traffic noise criteria, dBA

Development type	Day 7 am to 10 pm	Night 10 pm to 7 am
Existing residence affected by **additional traffic** on arterial / sub-arterial / collector roads generated by land use developments	60 $L_{eq(15hr)}$	55 $L_{eq(9hr)}$
Existing residence affected by **additional traffic** on local roads generated by land use developments	55 $L_{eq(1hr)}$	50 $L_{eq(1hr)}$

4.4 Operational noise

4.4.1 Noise Policy for Industry

The SEARs incorporate and consolidate the assessment requirements of the Department of Planning, Industry and Environment (DPIE) for Development Consent Applications and the Environment Protection Authority (EPA) for environment Protection License (EPL) applications for their consideration during the planning approval phase of the project. The Development Consent and/or EPL will generally contain conditions stipulating environmental noise limits for noise from the site.

These limits are normally derived from operational noise levels applied at assessment locations and are based on EPA guidelines (i.e. NPfI) or noise levels that can be achieved at a specific site following the application of all reasonable and feasible noise mitigation. The objectives of project noise trigger levels (PNTL) for industry are to protect the community from excessive intrusive noise and preserve amenity for specific land uses.

In circumstances where noise the PNTLs cannot be achieved, residual noise levels are used to assess noise impacts and manage noise from the site in negotiation between the regulatory authority and community. The regulatory authority then sets statutory compliance levels that reflect the achievable and agreed noise limits from the development.

It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location. To ensure these objectives are met, the EPA provides two separate noise trigger levels: intrusiveness and amenity. The intrusiveness noise levels apply over 15 minutes in any period (day, evening or night) and aim to control the relative audibility of operational noise compared to the background level at residential receivers.

The amenity noise level limits the total level of extraneous noise for all receiver types and is assessed over the entire assessment period (day, evening or night). Both the intrusiveness and amenity noise levels are calculated and the lower of the two in each time period is set as the PNTL. For the purposes of assessment to standardise the approach the NPI recommends that the $L_{Aeq(15min)} = L_{Aeq(period)} + 3$ dBA unless an alternative approach can be justified.

4.4.2 Intrusiveness noise level

The intrusiveness noise level is determined by a 5 dB addition to the RBL with a minimum intrusiveness noise level of 35 dBA for the evening and night period and 40 dBA for the day period. The NPfI recommends that the intrusiveness noise level for the evening and night periods should not exceed the preceding period. The intrusiveness noise levels are only applicable to residential receivers.

4.4.3 Project amenity noise level

The recommended amenity noise level applies to all industrial noise in the area which when combined should remain below the recommended amenity noise level. The recommended amenity noise level represents the total industrial noise at a receiver location and a Project Amenity Noise Level is set at 5 dBA below the recommended amenity noise level.

Residential receiver areas are characterised into ‘urban’, ‘suburban’, ‘rural’ or other categories based on land uses and the existing level of noise from industry and road traffic. With consideration to the NPfI ‘noise amenity area’ classification, the residential receivers identified are classified as ‘Rural Residential’ as per the NPfI.

4.4.4 Summary of project noise trigger levels

Based on the NPfI, a summary of the project noise trigger levels (PNTLs) for residential land uses are presented in Table 4.9. All identified residential receivers have been classified as ‘rural residential’ to be conservative. Compliance with the residential PNTLs ensure compliance with the less-stringent non-residential PNTLs. The project noise trigger levels for non-residential receivers are presented in Table 4.10.

For a residence, the project noise trigger level and maximum noise levels are to be assessed at the reasonably most-affected point on or within the residential property boundary or, if that is more than 30 metres from the residence, at the reasonably most affected point within 30 metres of the residence, but not closer than 3 metres to a reflective surface and at a height of between 1.2–1.5 metres above ground level.

In assessing amenity noise levels at commercial or industrial premises, the noise level is to be assessed at the reasonably most-affected point on or within the property boundary.

Table 4.9 Project noise trigger levels for residential receivers

Receiver type	Assessment period	Intrusive noise level, $L_{Aeq(15min)}$ [1]	Project amenity noise level, $L_{Aeq(15min)}$	Project noise trigger level, $L_{Aeq(15min)}$ dBA
Rural residential receivers – NCA1	Day	**40**	48	40
	Evening	**40**	43	40
	Night	**35**	38	35
Rural residential receivers – NCA2	Day	53	**48**	48
	Evening	47	**43**	43
	Night	**35**	38	35

Notes: 1. Minimum assumed RBLs have been used to establish the intrusiveness noise level.
2. A +3 dB correction has been applied to convert LAeq(period) to LAeq(15 min).
3. Values in bold type show the minimum of the intrusiveness and amenity levels on which the project noise trigger level is based.

Table 4.10 Project noise trigger levels for non-residential receivers (external)

Type	Time of day	Project noise trigger level, $L_{Aeq(15min)}$ dBA
Educational institute	Noisiest 1-hour period when in use	43[1]
Commercial premises	When in use	63[1]
Industrial premises	When in use	68[1]

Note: 1. A + 3 dB correction has been applied to convert $L_{Aeq(period)}$ **to** $L_{Aeq(15\ min)}$

4.4.5 Modifying factor corrections

The NPfI requires that corrections for annoying characteristics are applied if the noise sources contain tonal, intermittent or low frequency characteristics, which have the potential to increase annoyance. The modifying factor adjustments are detailed in Table 4.11.

Table 4.11 NPfI modifying factor corrections

Factor	Assessment/ measurement	When to apply	Correction[1,2]
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: – 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz – 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive – 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz.	5 dBA[2]
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A weighted $L_{eq,T}$ levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more and: – where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dBA positive adjustment to measured/predicted A-weighted levels for the evening/night period	5 dBA[2]

Factor	Assessment/ measurement	When to apply	Correction[1,2]
		– where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dBA and cannot be mitigated, a 5 dBA positive adjustment to measured/predicted A-weighted noise levels applies for the evening/night period and a 2 dBA positive adjustment for the daytime period.	
Intermittent noise	Subjectively assessed	When the night-time noise level drops to that of the background noise level with a noticeable change in noise level of at least 5 dBA.	5 dBA
Duration	Single-event noise duration may range from 1.5 min to 2.5 h.	One event in any assessment period.	0 to 20 dBA

Notes: 1. Where two or more modifying factors are present the maximum correction is limited to 10 dBA.
2. Where a source emits a tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low frequency range.

4.4.6 Cumulative noise impacts

Cumulative noise impacts affecting receivers from all industrial noise sources are assessed against the amenity criteria of the NPfI. The combined impact of all industrial noise sources at a receiver location should be considered, where industrial facilities are either operating or have been approved for development. The cumulative noise criteria that apply for the residential receivers within the study area are the recommended amenity noise levels for ‘rural residential’ receivers being:

– Day period – $L_{Aeq(period)}$ 50 dBA
– Evening period - $L_{Aeq(period)}$ 45 dBA
– Night period - $L_{Aeq(period)}$ 40 dBA.

The objective of the NPfI amenity noise level is to limit continuing increases in noise levels from the application of the intrusiveness level so the total industrial noise level remains below the recommended amenity noise level for residential receivers. The NPfI provides a recommended amenity noise level to represent the objective for total industrial noise at a receiver location and a project amenity noise level for noise from a single industrial development at a receiver location.

To ensure that industrial noise levels (existing plus new) remain with the recommended amenity noise level for an area, the project amenity noise levels is set at the recommended amenity noise level minus 5 dBA.

The NPfI states that were the project amenity noise level can be met, no additional consideration of cumulative industrial noise is required.

4.4.7 Sleep disturbance impacts

To assess sleep disturbance the NPfI recommends the following screening criteria, assessed externally at the nearest residential location.

– $L_{Aeq(15min)}$ 40 dBA or the prevailing RBL + 5 dBA (whichever is greater); and/or
– L_{AFmax} 52 dBA or the prevailing RBL + 15 dBA (whichever is greater).

As the PNTLs for all NCAs during the night period are lower than the $L_{Aeq(15min)}$ 40 dBA sleep disturbance criteria, sleep disturbance should be assessed against the L_{AFmax} 52 dBA criteria.

The potential for sleep disturbance is considered for short-duration, high level noise events. In this case, significant maximum noise level events are not anticipated to occur during the night and as such, no further assessment of sleep disturbance has been deemed necessary.

5. Construction impact assessment

5.1 Construction noise

Construction noise levels have been predicted at representative sensitive receivers with consideration to the acoustic requirements of the ICNG. The predicted L_{Aeq} noise level along with the noise management levels (NML) for each receiver are presented in Table 5.1. The noise modelling assumes that the two loudest items of equipment in the scenario are operating at maximum capacity simultaneously at the closest distance between the construction works and the receiver. As such, the predicted noise levels are often highly conservative and actual noise levels are likely to be lower than the levels presented below for the majority of the time.

The noise modelling results show that there are some exceedances of the noise management levels exceeded during CS1. Construction noise contours for site preparations works (CS1) are presented in Appendix C.

Table 5.1 Summary of predicted noise levels during construction

Receiver	NCA	NML	CS1	CS2	CS3
R01	NCA1	45	45	42	37
R02	NCA1	45	47	44	39
R03	NCA1	45	44	41	36
R04	NCA1	45	42	39	34
R05	NCA1	45	39	36	31
R06	NCA1	45	47	44	39
R07	NCA1	45	46	43	38
R08	NCA2	58	36	33	28
R09	NCA1	45	35	32	27
R10	NCA2	58	41	38	33

5.2 Cumulative noise impacts

There is potential for cumulative construction noise impacts should construction of the project occur concurrently with other major projects within the same area.

A search of the DPE Major Projects database was undertaken on 5 September 2022 to identify SSD and SSI projects within the vicinity of the project that may be relevant for the EIS cumulative impact assessment. These projects are outlined in Table 5.2.

Table 5.2 Relevant existing/future projects for cumulative impact assessment

Project	Assessment stage	Relevance
St Philip's Christian College Charmhaven (SSD-14082938)	Prepare EIS	The St Philip's Christian College project is about 5.6 kilometres southwest of the project site and proposes the construction of a new school for 1,500 students. There is potential for the two projects to be constructed concurrently.
Chain Valley Colliery Consolidation Project (SSD-17017460)	Prepare EIS	The Chain Valley Colliery Consolidation project is about 5.6 kilometres north of the project site and proposes to consolidate the Chain Valley Colliery and Mannering Colliery consents, align extraction and production rates and extend the approved mining area. There is potential for the two projects to be constructed concurrently

Construction Noise and Vibration Management Plans (CNVMP) would be prepared for this project to minimise the potential for impacts to nearby sensitive receivers and should consider cumulative impacts. Furthermore, consultation and coordination would be undertaken with other proponents or applications of other State Significant development and infrastructure works near the project once information on timing is available. Reasonable steps would be taken to co-ordinate works to minimise cumulative impacts of noise and vibration and maximise respite for affected sensitive receivers.

5.3 Construction vibration

Safe working distances for vibration intensive equipment has been sourced from the TfNSW CNVS and are shown in Table 2.2. The most vibration intensive activities associated with the construction works are anticipated to be excavation works during site preparation.

Excavation works have the potential to exceed the cosmetic damage criteria should these works occur within 22 metres of a sensitive receiver building. No buildings have been identified within 22 metres of excavation works and as such, no adverse cosmetic damage vibration impacts are anticipated as a result of the project.

Excavation activities have the potential to exceed the human comfort vibration criteria should these works occur within 73 metres of residences, while vibratory rolling works have the potential to exceed human comfort levels within 100 metres. No sensitive land uses are within 73 metres of the proposed construction work.

6. Operational impact assessment

Four scenarios based on a maximum battery discharge for 30 minutes and varying ambient air temperatures have been modelled for the operation of the project, as follows:

– Scenario 1: Ambient air temperature of less than 35 °C
– Scenario 2: Ambient air temperature of 35 °C
– Scenario 3: Ambient air temperature of 40 °C
– Scenario 4: Ambient air temperature greater than 40 °C.

The source levels for the battery fans in each of these scenarios are outlined in Table 2.6.

Predicted noise levels at the representative worst-case receivers are presented in Table 6.1 below and modifying factor adjustments are discussed in Section 6.1.

The noise modelling indicates compliance is predicted at all sensitive receiver locations for all modelled operations during the day and evening periods.

Compliance should also be achieved during the night time period. There is the possibility that an exceedance could occur during the night-time period under extreme ambient conditions if night time temperatures were to exceed 35 °C. The 5-year temperature history indicates that this scenario has never occurred at night and the maximum night time temperature has reached 35 °C. As such no significant impacts are expected to occur.

There are some other factors which could also be considered which make this assessment conservative:

– Atmospheric absorption of higher ambient temperature is higher, which would result in lower received noise levels. Atmospheric absorption has been conservatively modelled at 20 °C.
– The maximum discharge rates would be limited to 30 min, which would be considered a short duration event and in accordance with the NPfI, during the day and evening a positive 5 dBA correction to the criteria could be applied. For conservatism this positive correction has not been adopted.
– Temperature inversions typically occur in the winter months when ambient temperatures are cooler. A noise enhancing temperature inversion is less likely to occur in the summer month during high ambient temperatures and even less likely to coincide with maximum discharge of the battery. Nevertheless for conservatism a noise enhancing temperature inversion has been considered in the predictions.
– For the majority of the time the ambient temperatures would be significantly lower than the scenario modelling assumptions S2, S3 and S4.

Table 6.1 Operational noise modelling results, dBA

Receiver	S1 (ambient <35°C)	S2 (ambient 35°C)	S3 (ambient 40°C)	S4 (ambient >40°C)
R01	29	33	35	38
R02	31	34	36	39
R03	29	34	36	39
R04	30	34	36	39
R05	26	31	33	36
R06	29	33	35	39
R07	28	32	35	38
R08	24	29	31	34
R09	21	27	29	32
R10	24	27	29	32

L_{Aeq} noise contours at 1.5 metres above ground are presented in Appendix E for the operation during each scenario.

6.1 Corrections for annoying noise characteristics

An assessment of the predicted noise levels has been undertaken to determine if corrections should be applied in accordance with Fact Sheet C of the NPfI for tonal noise, low frequency noise, intermittent noise and duration. Details of these corrections are provided in Table 4.11.

6.1.1 Tonal noise

Unweighted third octave band noise levels predicted at the receiver locations have been analysed to determine if tonality is a feature of the project. These levels are presented in Table 6.2 for the nearest receiver (R02) for all modelled scenarios and shows no tonal noise. Third octave band results for all modelled receivers are provided in Appendix D.

Table 6.2 One-third octave band levels for all scenarios at R02, dBZ

Frequency (Hz)	Adjacent exceedance level, dB	S1 (ambient <35°C)	S2 (ambient 35°C)	S3 (ambient 40°C)	S4 (ambient <40°C)
25	15	38	57	41	38
31.5		41	58	44	41
40		37	49	38	37
50		36	45	37	36
63		33	42	34	33
80		37	42	38	37
100		46	46	46	46
125		28	36	33	37
160	8	23	38	32	35
200		27	33	33	33
250		21	29	39	33
315		23	28	27	36
400		19	24	24	27
500	5	21	25	30	31
630		20	24	29	36
800		19	22	26	31
1000		20	21	23	26
1250		18	21	24	29
1600		18	19	21	25
2000		17	18	20	25
2500		12	13	16	21
3150		4	7	13	17
4000		0	0	7	15
5000		0	0	0	6
6300		0	0	0	0
8000		0	0	0	0
10000		0	0	0	0

6.1.2 Low-frequency noise

Unweighted one-third octave band noise levels in the range 25 – 160 Hz predicted at the receiver locations along with the overall A-weighted and C-weighted levels have been analysed to determine if low-frequency noise is a feature of the project. During scenario 1 and scenario 2 the difference in the overall A-weighted and C-weighted levels exceeds the 15 dB limit at all receivers, however, the low-frequency noise thresholds are not exceeded at any receiver.

While the NPfI requires analysis of low frequency noise down to 10 Hz, noise levels have only been modelled as low as 25 Hz due to limitations with the prediction algorithm. Source data was available for third octaves in the range 16-160 Hz and these levels have been used to estimate the noise levels at the nearest receiver based on propagation and attenuation at 25 Hz. Predicted levels at the nearest receiver (R02) are shown on Figure 6.1, as a solid bar, along the estimated levels, hatched pattern, sound power levels and low-frequency noise threshold. Both the estimated levels at the receiver location and the sound power levels are well below the threshold and there is significant head room. Based on this analysis the possibility of any low frequency noise is low.

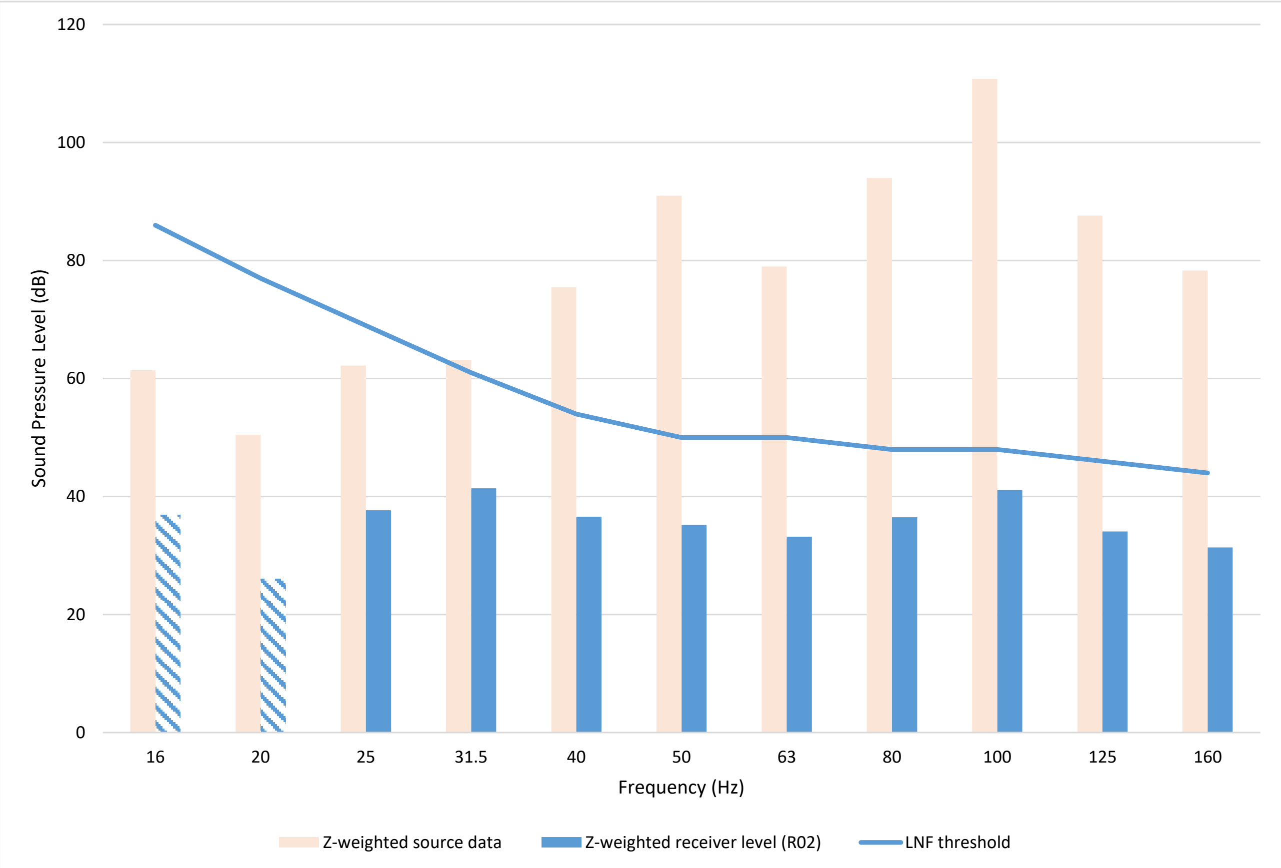

Figure 6.1 Low-frequency noise prediction at receiver R02

6.1.3 Intermittent noise

The NPfI defines intermittent noise as *noise where the level suddenly drops/increases several times during the assessment period, with a noticeable change in source noise level of at least 5 dB(A)* and should be assessed only in the night period. The nature of the operations of the project, with batteries providing maximum discharge for 30 minutes at a time, requires assessment of intermittent noise during the night.

Table 6.3 outlines noise levels for the two operating scenarios during the night period (switching between scenario 1 and 2) at all modelled receivers. The assessment requires subjective assessment at the receiver to gauge the change in noise level so the levels consider the influence of the RBL The difference in noise level is up to 3 dB and therefore the intermittency correction has not been applied.

Table 6.3 Difference in noise levels during the night period, dBA

Receiver	Night scenario 1 (including RBL)	Night scenario 2 (including RBL)	Change in noise level
R01	32	34	2
R02	33	35	2
R03	32	35	3
R04	32	35	3
R05	31	33	2
R06	32	34	2
R07	31	34	3
R08	29	31	2
R09	29	30	1
R10	29	30	1

6.1.4 Short Duration

A positive correction may be applied to the criteria levels during the daytime and evening for duration of +5 dBA. Since the operation of the BESS is for emergency backup, the period where the batteries would operate at their maximum capacity is likely to be one continuous 30-minute period in an assessment period. This correction has not been applied for this assessment, however, could be considered when assessing the impacts and would provide a further level of conservatism to the results presented in Section 6.

7. Mitigation recommendations

7.1 Effectiveness of mitigation measures

Measures for reducing noise impacts from construction activities follow three main control strategies:

– First preference and most desirable – Reducing the noise at the source

– Second preference – Reducing the noise in transmission (between source and receiver)

– Third preference and least desirable – Reducing the noise at the receiver.

The following sections present the justification for the mitigation measures recommended in in the following sections along with a discussion of the reasonableness or feasibility of the noise control type.

Mitigation at the source is deemed the most reasonable and feasible mitigation strategy, due to the large construction area this strategy will benefit the greatest number of receivers when compared with other methods. A majority of the plant required for construction is mobile and as such silencers or mufflers should be considered to reduce noise levels at the source. This would provide a reduction at the source, and subsequently at the receiver of 5-10 dB.

7.1.1 Mitigation at the source

The relative effectiveness of various forms of noise control at the source are presented in Table 7.1.

Table 7.1 Effectiveness of various forms of noise control at the source

Control by	Nominal noise reduction, dBA	Mobile plant[1]		Stationary plant[2]	
		Discussion of effectiveness	Reasonable or feasible test	Discussion of effectiveness	Reasonable or feasible test
Distance (first preference)	Approximately 6 for each doubling of distance	Very effective when implemented.	Considered reasonable and feasible.	Very effective when implemented.	Considered reasonable and feasible.
Silencing / mufflers (second preference)	Normally 5 to 10 (maximum 20)	Very effective when implemented – expected reduction of up to 10 dB for mobile plant and trucks. Silenced jackhammers can reduce noise levels by up to 10 dB.	Considered reasonable and feasible, where possible.	Compressors, pumps and generators can be selected include silencers, if appropriate.	Considered reasonable and feasible, where possible.
Screening (third preference, if required)	Normally 5 to 10 (maximum of 15)	Not generally possible and not effective for mobile plant within large construction areas during early construction works. Screening can be utilised once buildings have been erected.	Not considered feasible for mobile plant until buildings have been erected.	If screening is possible for stationary plant, screening can be very effective.	Considered reasonable if distance alone cannot provide sufficient attenuation.
Enclosure (fourth preference, if required)	Normally 15 to 25 (maximum 50)	Not generally possible and not effective for mobile plant.	Not considered feasible for mobile plant.	If possible and appropriate, enclosing stationary plant such as generators, pumps, compressors, transformers etc. can be very effective. Effectiveness of the enclosure will depend on the material and design of the enclosure.	Considered reasonable if distance alone cannot provide sufficient attenuation.

Notes: 1. Mobile plant refers to equipment such as excavators, dump trucks, bulldozers, loaders, water carts etc.

2. Stationary plant equipment such as refers to generators, compressors, pumps, A/C units etc.

7.1.2 Controls in transmission

The relative effectiveness of various forms of noise control in transmission are presented in Table 7.2.

Table 7.2 Effectiveness of various forms of noise control at transmission

Control by	Nominal noise reduction, dBA	Mobile plant		Stationary plant	
		Discussion of effectiveness	Reasonable or feasible test	Discussion of effectiveness	Reasonable or feasible test
Shield stationary noise sources such as pumps, compressors, fans etc.	Depends on the location of source and the receiver (normally 5 to 15)	Not applicable	Not applicable	Effective when it breaks the line of sight between the source and receiver. Not effective if it doesn't.	Considered reasonable and feasible, where possible.
Temporary noise barriers	Depends on the location of source and the receiver (normally 5 to 15)	Not generally possible and not effective for mobile plant within large construction areas.	Not feasible	Effective when it breaks the line of sight between the source and receiver. Not effective if it doesn't. Using distance, screening, enclosures, silencers are probably more appropriate and effective mitigation measures.	Feasible but not reasonable as other mitigation measures are more appropriate for main site works. Temporary noise barriers can be used if generators or transformers are required at the temporary workers accommodation facility.

7.1.3 Controls at the receiver

The relative effectiveness of various forms of noise control in transmission are presented in Table 7.3.

Table 7.3 Effectiveness of various forms of noise control at the receiver

Control by	Nominal noise reduction, dBA	All construction equipment	
		Discussion of effectiveness	Reasonable or feasible test
Temporary accommodation	Generally eliminates the noise impacts	Where all reasonable and feasible mitigation measures have been applied and there are significant residual impacts at residential receivers, temporary accommodation can be offered to affected residences.	Based on the low-impact residual noise levels at sensitive receivers (subsequent to the incorporation of controls at the source and in transmission), temporary accommodation is not considered reasonable.
Architectural treatment to a sensitive receiver	Depends on the type of treatment (normally 10 to 20)	Where all reasonable and feasible mitigation measures at source and transmission have been applied, and temporary accommodation has been offered and there are significant residual impacts at residential receivers, architectural treatments at the affected residences can be considered.	Based on the low-impact residual noise levels at sensitive receivers (subsequent to the incorporation of controls at the source and in transmission), architectural treatment at the receiver is not considered reasonable.

7.2 Construction mitigation measures

7.2.1 Standard mitigation measures

It is anticipated that construction activities would exceed the construction noise management levels at three representative locations during the worst case construction scenario for the project. Standard mitigation measures recommended in the ICNG would be implemented to reduce the potential for noise and vibration impacts during construction. These mitigation measures are presented in Table 7.4 below.

A draft Construction Noise and Vibration Management Plan (CNVMP) has been provided in Table 7.4.

Table 7.4 Draft CNVMP

Control type	Environmental Safeguard	Responsibility	Timing
Community consultation			
Notification of works	Notification of receivers in the study area will be undertaken a minimum of 7 calendar days prior to the start of works and should include information such as total building time, what works are expected to be noisy, their duration and what is being done to minimise noise. If there are works outside standard hours, inform affected residents and other sensitive land use occupants within 14 days of commencement. Provide information to neighbours before and during construction through media such as letterbox drops, meetings or individual contact. All receivers potentially vibration affected will be notified for each of the relevant construction scenarios.	Contractor	Pre-construction
Community relations	– Ensure site managers periodically check the site and nearby residences and other sensitive land uses for noise problems so that solutions can be quickly applied. – Maintain good communication between the community and project staff. – Consider a regular newsletter with site news, significant project events and timing of different activities. – Facilitate contact with people to ensure that everyone can see that the site manager understands potential issues, that a planned approach is in place and that there is an ongoing commitment to minimise noise.	Contractor	Pre-construction / Construction
Complaints handling.	Provide a readily accessible contact point, e.g. through a 24 hour toll-free information and complaints line. Document and maintain a complaints register detailing the following: – date and time – complainants details – person receiving complaint and person referred to – description of complaint. Provide quick response to complaints, with complaint handling staff having both a good knowledge of the works and ready to access information.	Contractor	Pre-construction / Construction

Control type	Environmental Safeguard	Responsibility	Timing
Management measures			
Site inductions	All employees, contractors and subcontractors will receive an environmental induction. The induction must at least include: – all 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	Contractor	Construction
Schedule activities to minimise noise impacts	All activities on site will be confined between the hours: daytime hours of 7:00 am to 6:00 pm from Monday to Friday and 8:00 am to 1:00 pm on Saturday, with the exception of the following activities: – the delivery of oversized plant of structures – emergency work to avoid the loss of life or damage to property, or to prevent environmental harm.	Contractor	Pre-construction / Construction
Update Construction Environmental Management Plans	The Construction Environmental Management Plan CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.	Contractor	Pre-construction / Construction
Out of hours works	An out of hours works procedure will be developed as part of the CEMP for the project if these works are required. This should include a detailed construction noise and vibration assessment for the potential construction activities proposed to occur out of hours. An out of hours works application form for any works outside of the approved working hours for the project will be re required. A description of the works, justification and management measures would also be included as part of the application. It is expected that strong justification and negotiation with the community would be required if these works are to be undertaken during any out of hours periods.	Contractor	Pre-construction / Construction
Source mitigation measures			
Plant noise levels	The noise levels of plant and equipment should have an operating sound power lower or similar to the levels presented in Table 2.3.	Contractor	Pre-construction / Construction
Maintain equipment	– Regularly inspect and maintain equipment to ensure it is in good working order. Also check the condition of mufflers. – Equipment must not be operated until it is maintained or repaired, where maintenance or repair would address the annoying character of noise identified.	Contractor	Construction

7.3 Operational mitigation measures

The design of the BESS should be consistent with the assumptions listed in Section 2.4. The noise levels of plant and equipment should have an operating sound power lower or similar to the levels presented in Table 2.6.

An operational Noise Management Plan (NMP) should be developed to minimise the risk of adverse noise impacts during the operation of the facility. The operational NMP should have consideration to:

– The relevant conditions (to be confirmed)
– *The Noise Policy for Industry* (EPA, 2017)
– *Approved methods for the measurement and analysis of environmental noise in NSW* (EPA, 2021).

The NMP is to be refined throughout the design process. Table 7.5 provides recommendations for inclusions in the operational NMP to minimise the risk of adverse noise impacts at sensitive receivers during the operation of the project.

Table 7.5 Operational Noise Management Plan (NMP) inclusions

Control type	Measure	Responsibility	Timing
Design considerations			
Equipment design	Battery supplier selection and layout design would ensure project noise trigger levels outlined in Section 4.4 would net be exceeded at any sensitive locations.	Design team / Contractor	Detailed design / Pre-construction
Complaints handling protocol			
Complaints handling	In situations where noise emission levels are perceived by residents to be a problem, the following procedure should be undertaken when receiving, handling, responding to and reporting community complaints: – A site manager should investigate to determine the possible source of the noise. – Should a problem noise source be identified, the method of operation is to be altered or controlled – If required, noise monitoring at the complainant's property should be undertaken if a noise source if the complainant is not satisfied with the corrective action. – Any corrective action is to be recorded and reported to the site manager, who is to keep a record of all significant actions. – The site manager should be informed of any complaint and details must be recorded in a complaints register. – The site manager should notify potentially affected receivers if observations indicate that the noise criteria is being exceeded due to the activities carried out on site. The affected receiver should be notified of exceedances and the source of the impact in writing within 48 hours of detection and verification.	Operators / Staff	During operation
Noise monitoring program			
Noise complaint records	In the event of a noise complaint received from the community and during the initial stage of the development's operation, compliance noise monitoring is to be conducted. Noise will be monitored at the most critical time of day near the complainant and near the identified source of the impact	Operators / Staff	During operation
Noise monitoring qualifications	All attended noise monitoring is to be carried out by a suitably qualified noise specialist. Records of routine equipment calibration and testing are to be maintained by the qualified noise specialist undertaking the monitoring	Operators / Staff	During operation
Frequency of noise monitoring	It is recommended that noise monitoring is carried out once at the commencement of operations.	Operators / Staff	During operation

Control type	Measure	Responsibility	Timing
Identification of potential noise issues and control measures	Where a non-compliance is measured and recorded by the monitoring, an investigation should be launched to identify the causes and control measures required. A non-compliance should be reported to site management as soon as possible after verification. The investigation should occur as soon as practically possible after a non-compliance is measured. A noise specialist may be engaged to carry out the investigation. The investigation as a minimum should detail the following: – date and time of exceedance – the location where the exceedance was identified – the meteorological conditions during the identification of the exceedance – the identified cause of the exceedance from the project – identification of other non-project related noise sources – recommendations for corrective action.	Operators / Staff	During operation

8. Conclusion

This report was prepared by GHD for the purpose of documenting the results of the assessment of the potential noise and vibration impacts during the construction, operation and decommissioning of the project.

The noise and vibration impact assessment has described the existing noise environment and assessed the potential noise and vibration impacts associated with the construction and operational phases of the project with respect to the following guidelines:

– Interim Construction Noise Guideline (ICNG)
– Assessing Vibration: A Technical Guideline
– Noise Policy for Industry (NPfI).

An assessment of potential noise impacts during the construction phase has been undertaken against the ICNG during standards hours. Construction noise levels during site preparation are predicted to result in noise levels above the NML at some sensitive receivers within the study area. These exceedances are not greater than 5 dBA above the NML and are therefore able to be managed with reasonable and feasible mitigation measures outlined in Section 7.2. No sensitive receivers have been identified within the safe working distances for vibratory intensive work. As such, no adverse (structural damage or human comfort) vibration impacts are anticipated during construction.

Noise modelling was undertaken based on available data using CadnaA computer software to predict operational noise levels at sensitive receivers and assessed against the NPfI project noise trigger levels during the day, evening and night periods. The assessment has based on worst-case operating conditions likely to occur during these assessment periods and is considered a conservative assessment. The noise modelling indicates compliance is predicted at all sensitive receiver locations for all modelled operations during the day and evening periods and compliance should also be achieved during the night time period.

9. References

Australian Standards. (2010). *AS2234 Guide to noise and vibration control on construction, demolition and maintenance sites.*

British Standards. (1993). *Evaluation and measurement for vibration in buildings Part 2 – Guide to damage .*

British Standards. (2008). *BS6472 Guide to Evaluation of Human Exposure to Vibration in Buildings.*

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CONCAWE. (1981). *The propagation of noise from petroleum and petrochamical complexes to neighbouring communities.*

DEC. (2006). *Assessing Vibration: A Technical Guideline.*

DECC. (2009). *Interim Construction Noise Guideline.*

DECCW. (2011). *Road Noise Policy.*

EPA. (2017). *Noise Policy for Industry.*

EPA. (2021). *Approved methods for the measurement and analysis of environmental noise in NSW .*

ISO. (1996). *Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation.*

ISO. (2005). *Mechanical vibration - Ground-borne noise and vibration arising from rail systems.*

TfNSW. (2019). *Construction Noise and Vibration Strategy.*

Appendix A

Acoustical concepts and terminology

Acoustic concepts and terminology

Definition of 'noise'

Sound may be defined as any pressure variation that the human ear can detect. The terms "sound" and "noise" are more or less interchangeable however, "noise" is generally often referred to as unwanted sound.

Factors that contribute the environmental noise

Noise from an activity such as construction noise or noise during the operation of a facility at a given receiver location can be affected by a number of different factors, including:

- How loud the source activity is and the type of source:
  - Point (e.g. a pump or motor)
  - Line (e.g. a road or railway line)
  - Area (e.g. the external façades of an industrial building)
- The distance from the source to receiver
- The type of ground between the sound and receiver locations (e.g. hard surfaces or porous ground)
- The ground topography between the source and the receiver, e.g. is it flat or hilly? Blocking the line of sight will generally reduce the noise level for the receiver
- Obstacles that may block the line of sight between the source and the receiver (e.g. buildings or noise walls
- Atmospheric absorption (dependent on humidity and temperature)
- Meteorological conditions that may increase or reduce environmental sound propagation (e.g. wind direction or temperature inversions)

Noise measurements

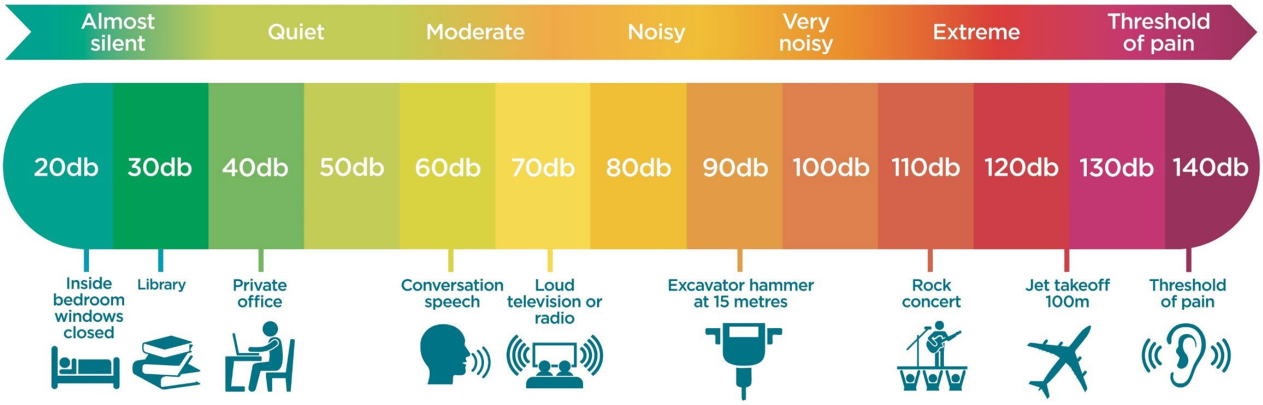
Noise is generally measured using a specially designed 'sound level meter' (SLM) and must meet internationally recognized performance standards. To avoid expressing sound or noise in terms of Pa, which could involve some unmanageable numbers, the logarithmic decibel or dB scale is used. The scale uses the hearing threshold of 20 µPa or 20 x 10^{-6} Pa as the reference level and is defined as 0 dB.

Typical noise levels

The figure below presents typical noise sources for each various sound pressure levels and a corresponding subjective noise level description.

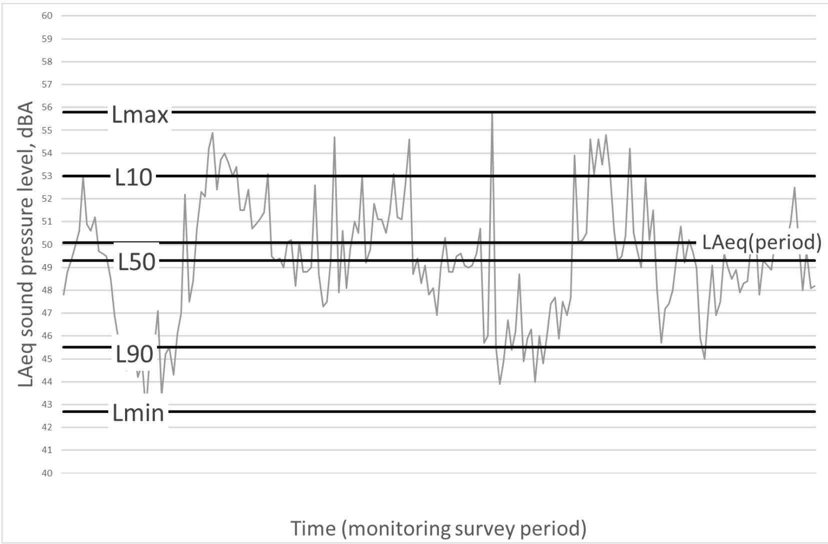
Noise level comparisons

People's perception of noise is strongly influenced by their environment.
A noise level that is perceived as loud in one situation may apear quiet in another.



Typical noise descriptors

Noise is represented by the descriptor L_{AN}, representing a statistical sound measurement recorded on the 'A' weighted scale. A typical noise monitoring chart is shown in the graph below along with the noise descriptors.



Where:

- L_{Amax}: The maximum sound level recorded during the measurement period.
- L_{Amin}: The minimum sound level recorded during the measurement period.
- $L_{A10(period)}$: The A-weighted sound pressure level that is exceeded for 10% of the measurement period.
- $L_{Aeq(period)}$: Equivalent sound pressure leve, the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
- $L_{A90(period)}$: The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise e.g. $L_{A90(15min)}$.

Changes in noise levels

The table below presents a qualitative description of average human responses to changes in noise levels.

Difference	Human response
Difference of 2 dBA	Generally imperceptible by the human ear
Difference of 5 dBA	Considered significant
Difference of 10 dBA	Perceived as a doubling (or halving) of the noise source
Addition of two identical noise levels	Increase levels by 3 dBA
Addition of second noise level of similar character	If the secondary noise level is a minimum 8 dBA below the primary noise level, the noise level will not significantly increase
Doubling of distance between source and receiver	Results in a 3 dBA decrease for a line source and 6 dBA for a point source
A doubling of traffic volume	Results in a 3 dBA increase in noise

Audibility of noise

The table below presents quantitative guidance and qualitative descriptions regarding the audibility of noise.

Audibility	Description
Inaudible	Noise source cannot be heard. The noise level is generally less than the background noise level, potentially by more than 10 dBA or greater
Barely audible	Characteristics of the noise is difficult to define or masked by extraneous noise. The noise level is generally 5-7 dBA below the background noise or ambient noise level, depending on the nature of the noise e.g. constant or intermittent
Just audible	Characteristics of the noise can be defined but extraneous noise sources are also contributing to the received noise. The noise level is typically below the background and ambient noise level.
Audible	Characteristics of the noise can be easily defined. The noise level may be at the level of the background noise and above.
Dominant	The noise source is significantly ‘louder’ than all other noise sources. The noise level will likely be significantly greater than the background noise level.

Types of noise sources

The table below offers a qualitative description of various noise types and provides the noise descriptor that is typically used to measure the type of noise.

Duration of the noise	Description
Continuous noise	Continuous noise is produced by equipment or activities that operates without interruption in the same mode, for e.g. blowers, pumps and processing equipment. Measuring for just a few minutes with hand-held equipment is sufficient to determine the noise level. If tones or low frequencies are heard, the frequency spectrum can be measured for documentation and further analysis. Continuous noise sources are generally captured by the L_{90} noise descriptor.
Intermittent noise	Intermittent noise is a noise level that increases and decreases rapidly. This might be caused by a train passing by, factory equipment that operates in cycles, or aircraft flying above. Intermittent noise is measured in a similar way to continuous noise, with a sound level meter. The duration of each occurrence and the time between each event is important to note. To gain a more reliable estimate of the noise level, multiple occurrences of the noise source is measured to gain a reliable estimate. Intermittent noise sources are generally captured by the L_{eq} noise descriptor.

Duration of the noise	Description
Impulsive noise	The noise from impacts or explosions, for e.g. from a pile driver, punch press or gunshot, is called impulsive noise. It is brief and abrupt, and its startling effect causes greater annoyance than would be expected from a simple measurement of sound pressure level. To quantify the impulsiveness of noise, the difference between a quickly responding and a slowly responding parameter can be used. Impulsive noise sources are generally captured by the L_{max} or L_{peak} noise descriptor.
Frequency content	Description
Low frequency	Noise containing major components in the low-frequency range (10 hertz [Hz] to 160 Hz) of the frequency spectrum
Tonal noise	Tonal noise contains one or more prominent tones (i.e. distinct frequency components), and is normally regarded as more offensive than 'broad band' noise
Defining characteristic	Description
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
Subject noise	The noise in question removed from any extraneous noise in the area
Offensive noise	The definition of offensive noise in the POEO Act is noise: (a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances: (i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or (ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or (b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.

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)

Vibration

Definition of '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.

Vibration descriptors

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/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organisations.

Types of vibration

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). A description of each vibration type including examples are presented in the table below.

Vibration type	Description	Examples
Continuous vibration	Vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration values	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)
Impulsive vibration	A vibration source (continuous or intermittent) which has a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). This type of vibration is assessed on the basis of weighted rms acceleration values	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Interrupted periods of continuous (for e.g. a drill) or repeated periods of impulsive vibration (for e.g. a pile driver), or continuous vibration that varies significantly in magnitude. This type of vibration is assessed on the basis of vibration dose values	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria

How humans perceive 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.

Typical vibration levels

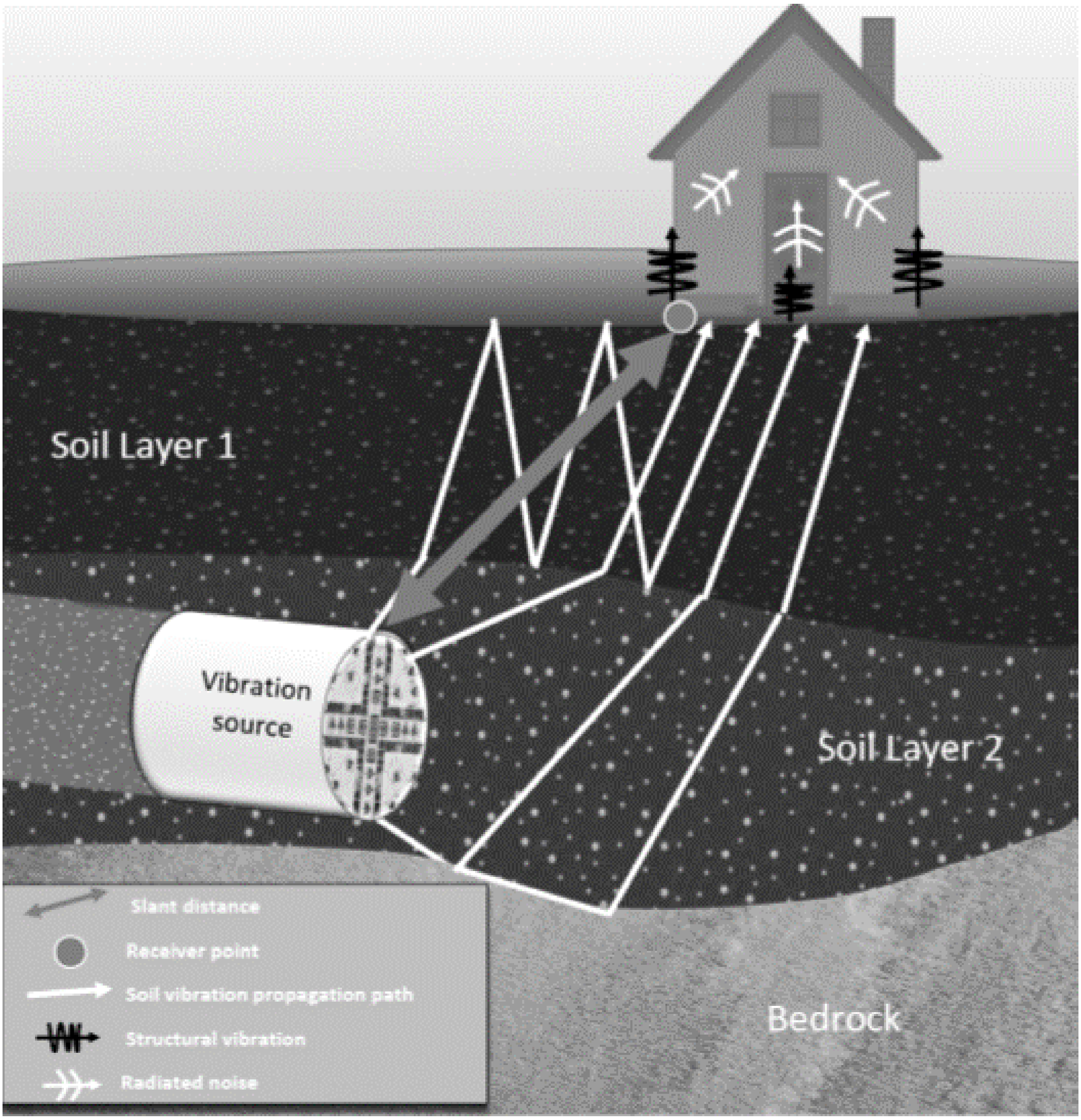
Typical ground vibration from civil construction activities occurs in the frequency range of approximately 8 Hz to 100 Hz. Within this frequency range, building contents such as blinds and pictures would commence visible movement at 0.5 mm/s. At vibration levels higher than 0.9 mm/s, rattling of windows, crockery or loose objects would be audible and annoying.

Velocity level (mm/s)	Typical source	Response
0.01	Typical background vibration level	Scanning electron microscopes to 50000 x amplification
0.03		500x amplification bench microscopes
0.1	Average passenger train vibration	Approximate threshold for human perception of vibration
0.3	Average freight train vibration Max passenger train vibration	Approx. residential annoyance for train passbys
1	Large rock breaker	Vibration level that will generally result in complaints
3	Blasting/ Impact pile driving	Threshold for minor cosmetic damage

Ground-borne noise and vibration

Noise that propagates through a structure as vibration and is radiated by vibrating wall, ceiling and floor surfaces is termed “ground-borne noise”, “regenerated noise”, or sometimes “structure borne noise”. Ground-borne 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 noise include tunnelling construction works or underground railway operations.

The figure below presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities that occur below the ground level (for e.g. a tunnel boring machine).



Acronyms and abbreviations

Term	Definition
AWS	Automatic Weather Station
BOM	Bureau of Meteorology
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dBA	Decibel expressed with the frequency weighting filter used to measure ‘A-weighted’ sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at low and high frequencies.
dBZ or dBL	The unit used to measure ‘Z-weighted’ sound pressure levels with no weighting applied, linear.
CEMP	Construction Environmental Management Plan
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EPA	Environmental Protection Authority
ICNG	*Interim Construction Noise Guideline* (DECC, 2009).
NPfI	*Noise Policy for Industry* (EPA, 2017).
$L_{Aeq(period)}$	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
$L_{A10(period)}$	The noise level exceeded for 10 per cent of the time and is approximately the average of the maximum noise levels.
$L_{A90(period)}$	The sound pressure level that is exceeded for 90% of the measurement period.
L_{Amax}	The absolute maximum noise level in a noise sample
NSW	New South Wales
OOHW	Out-of-hours Works
PPV	Peak particle velocity is the maximum vector sum of three orthogonal time-synchronized velocity components regardless of whether these component maxima occurred simultaneously.
RBL	Rating Background Level . The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
rms	Root Mean Square Amplitude (rms) is the square root of the average of the squared values of the waveform. In the case of the sine wave, the RMS value is 0.707 times the peak value, but this is only true in the case of the sine wave.
RNP	*Road Noise Policy* (DECCW, 2011).
SEARs	Secretary’s Environmental Assessment Requirements
SPL	Sound Pressure Level
SWL	Sound Power Level
SWRO	Seawater Reverse Osmosis
Rw	Weighted Sound Reduction Index which provides a single-number quantity which characterises the airborne sound insulation of a material or building element over a range of frequencies
TBM	Tunnel Boring Machine
VDV	Vibration dose value - As defined in BS6472 – 2008, VDV is given by the fourth root of the integral of the fourth power of the frequency weighted acceleration.
WFP	Water Filtration Plant

Common Terms

Term	Definition
A weighting	The human ear responds more to frequencies between 500 Hz and 8 kHz and is less sensitive to very low-pitch or high-pitch noises. The frequency weightings used in sound level measurements are often related to the response of the human ear to ensure that the meter better responds to what you actually hear
Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far. This is described using the Leq descriptor
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L90 descriptor
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context.
Determining authority	Defined by Section 110 of the *Environmental Planning and Assessment Act 1979* as 'a Minister or public authority and, in relation to any activity, means the Minister or public authority by or on whose behalf the activity is or is to be carried out or any Minister or public authority whose approval is required in order to enable the activity to be carried out.'
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous
EIS	Environmental Impact Assessment
Feasible and reasonable measures	Feasibility relates to engineering considerations and what is practical to build. reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors: - Noise mitigation benefits (amount of noise reduction provided, number of people protected); Cost of mitigation (cost of mitigation versus benefit provided); Community views (aesthetic impacts and community wishes); Noise levels for affected land uses (existing and future levels, and changes in noise levels)
Ground-borne noise	Noise heard within a building that is generated by vibration transmitted through the ground into the structure from construction works, sometimes referred to as 'regenerated noise' or 'structure-borne noise'. Ground-borne noise can be more noticeable than airborne noise for underground works such as tunnelling. The ground-borne noise levels are only applicable when ground-borne noise levels are higher than airborne noise levels.
Ground-borne vibration	Vibration transmitted from a source to a receptor via the ground
Hertz	The measure of frequency of sound wave oscillations per second. 1 oscillation per second equals 1 hertz.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
Maximum noise event	The loudest event or events within a given period of time. This is generally described using the L_{max} descriptor
Meteorological conditions	Wind and temperature inversion conditions
Most-affected location	Location(s) that experience (or will likely experience) the greatest noise impact from the construction works under consideration. In determining these locations, existing background noise levels, noise source location(s), distance and any shielding between the construction works (or proposed works) and the residences and other sensitive land uses need to be considered.

Term	Definition
Noise management level	The Noise Management Level (NML) as defined as the EPA's ICNG. To be measured and assessed at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the residential property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most affected point within 30 m of the residence.
Noise sensitive receiver	An area or place potentially affected by noise which includes: a residential dwelling an educational institution, library, childcare centre or kindergarten a hospital, surgery or other medical institution an active (e.g. sports field, golf course) or passive (e.g. national park) recreational area commercial or industrial premises a place of worship.
Non-compliance	Development is deemed to be in non-compliance with its noise consent/ licence conditions if the monitored noise levels exceed its statutory noise limit (exceptions may be given if the noise level exceeds by less than 2 dB)
Octave	A division of the frequency range into bands, the upper frequency limit
Project noise trigger level	Target noise levels for a particular noise generating facility. They are based on the most stringent of the intrusive criteria or amenity criteria. Which of the two criteria is the most stringent is determined by measuring the level and nature of existing noise in the area surrounding the actual or propose noise generating facility.
Proposal	The construction and operation of the SWRO site, the modifications to the Illawarra WFP site and associated infrastructure including the power route, the delivery pipeline, the se and the intake and outlet tunnels.
proposal site	The immediate location of the proposal, which is the area that has the potential to be directly disturbed by construction and operation.
Resonance	Resonance describes the phenomenon of increased amplitude that occurs when the frequency of a periodically applied force is equal or close to a natural frequency of the system on which it acts.
Study area	Land in the vicinity of, and including, the proposal site. The 'study area' is the wider area surrounding the proposal site.
Temperature inversion	An atmospheric condition in which temperature increases with height above the ground.
Third-octave	Single octave bands divided into three parts.

Appendix B

Noise monitoring methodology

Long-term noise monitoring was undertaken between 17 August 2022 and 26 August 2022 at 2 locations representative of residences.

Attended noise monitoring was also undertaken at each noise logger location to characterise the existing noise environment and describe the contribution of the various roads noise sources in the area. L_{A1}, L_{Aeq}, L_{A10} and L_{A90} noise levels were measured during the 15-minute monitoring period.

The methodology for the noise monitoring program included the following:

– Noise monitoring was undertaken using 2 Svan 977 Type 1 environmental noise loggers. All noise loggers were programmed to accumulate L_{A90}, L_{A10} and L_{Aeq} noise descriptors continuously over the entire monitoring period. Details and results of the noise monitoring equipment are provided in the tables below.

– A calibration check was performed on the noise monitoring equipment using a sound level calibrator. At completion of the measurements, the meter's calibration was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dBA.

– All monitoring activities were undertaken with consideration of the specifications outlined in Australian Standard AS1055 (1997) *Description and Measurement of Environmental Noise.*

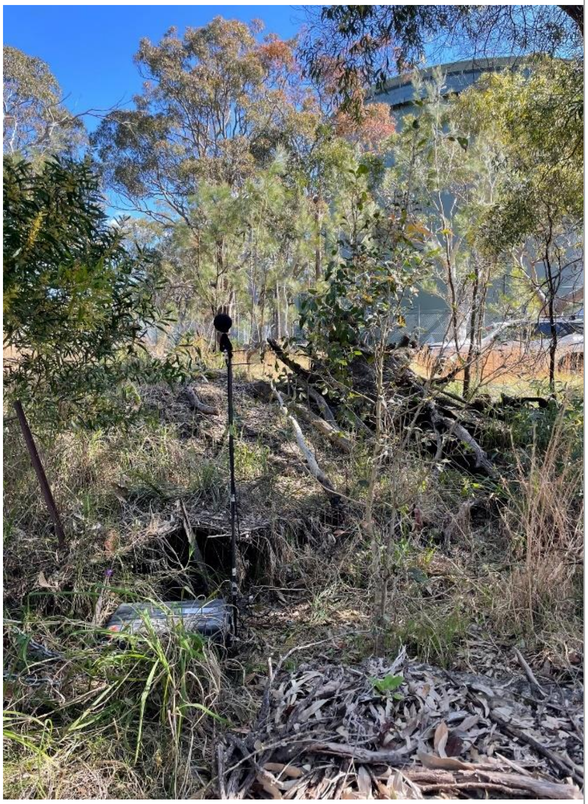
– Meteorological data (wind speed, wind direction, rainfall, temperature and humidity) was sourced from the Bureau of Meteorology's Norah Head weather station (station number 061366).

– The data collected by the noise loggers was downloaded and analysed to determine invalid data due to adverse weather conditions. Invalid data generally refers to periods of time where average wind speeds were greater than 5 m/s, or when rainfall occurred.

– Attended noise measurements were undertaken using a Svan 979 Type 1 environmental sound level meter (SLM) (Serial no. 27100). A calibration check was performed on the SLM using a sound level calibrator. At completion of the measurements, the meter's calibration was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The noise logger was found to be within the acceptable tolerance of ± 1 dBA.

The monitoring details and results are presented in the tables below.

Table 9.1 Logger M1

Equipment details	Equipment settings	Location description	Logger photo
Svan 977 Type 1 SN: 45744 1.5 m above ground Free field IEC 61672-3:2013 Compliant Manufactured prior 2019	A-weighted Fast time response 15 minute intervals Pre and post calibration variation: 0.4 dBA Svantek SV30A Class 1 Sound level calibrator SN: 39467 AS 60942:2003 Compliant Manufactured prior 2017	– Ulana Avenue water tower – Noise sources: Children playing, birds, road noise – Munmorah Power Station audible occationally	

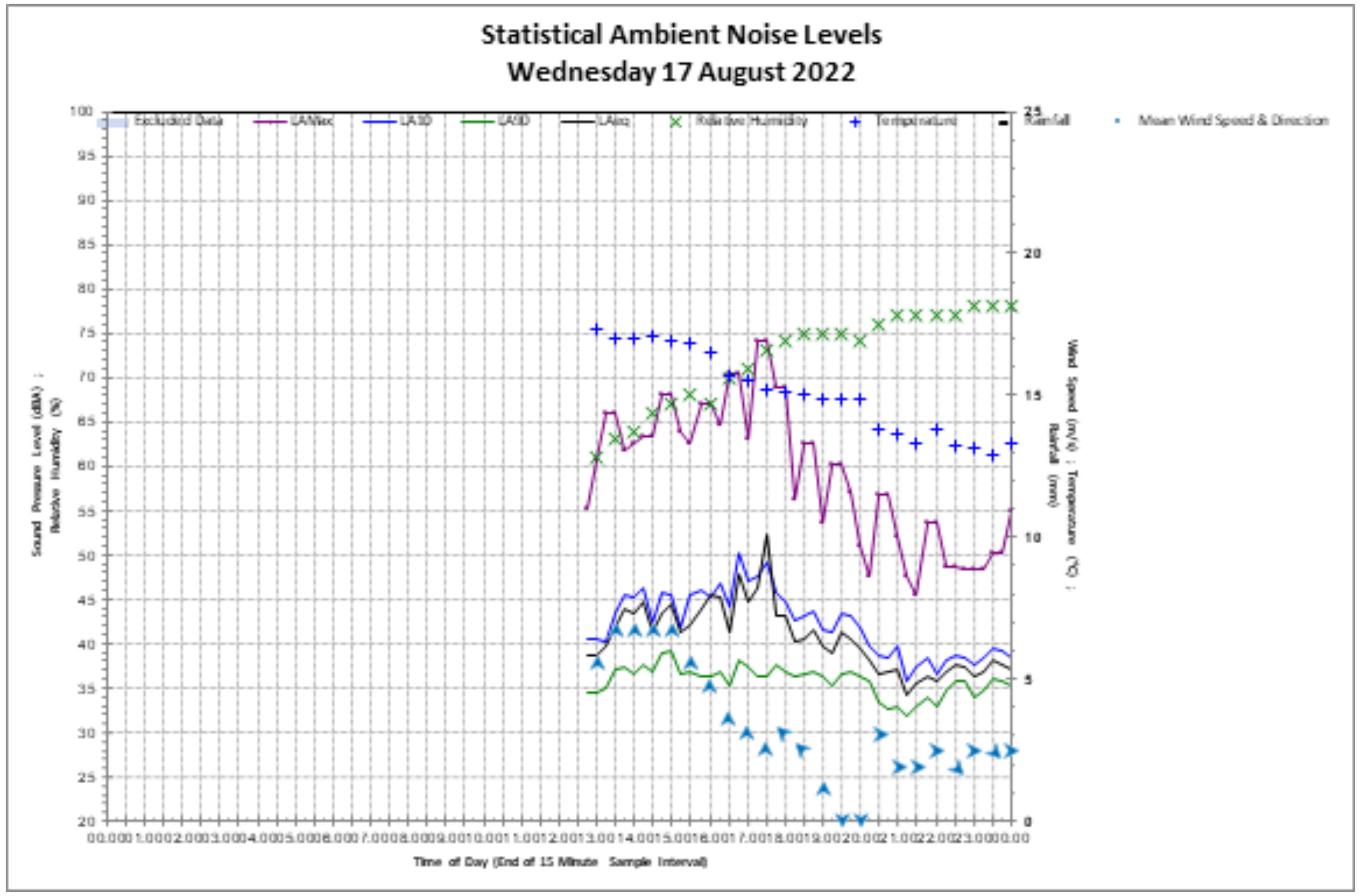
Ambient and background noise monitoring results

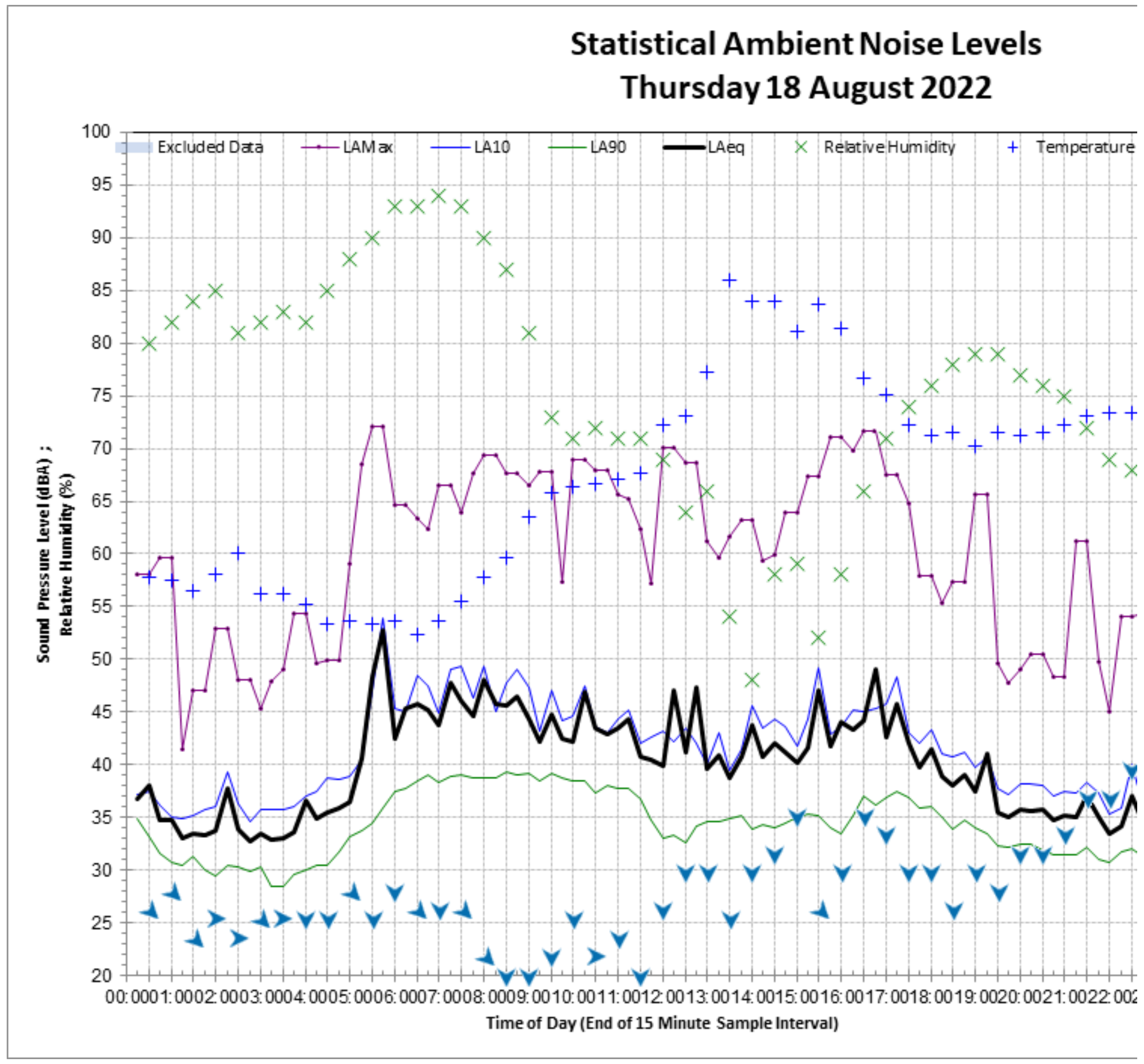
Period	Noise level		
	RBL	L_{Aeq}	L_{10}
Daytime	35	46	45
Evening	35	43	42
Night	30	43	38

Attended noise measurements

Date	Time	Noise level			
		L_{A90}	L_{Aeq}	L_{A10}	L_{A1}
26/08/22	1:10pm	38	42	43	47

Logger location


Statistical Ambient Noise Levels
Wednesday 17 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Rainfall (mm) ; Temperature (°C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Thursday 18 August 2022
Excluded Data
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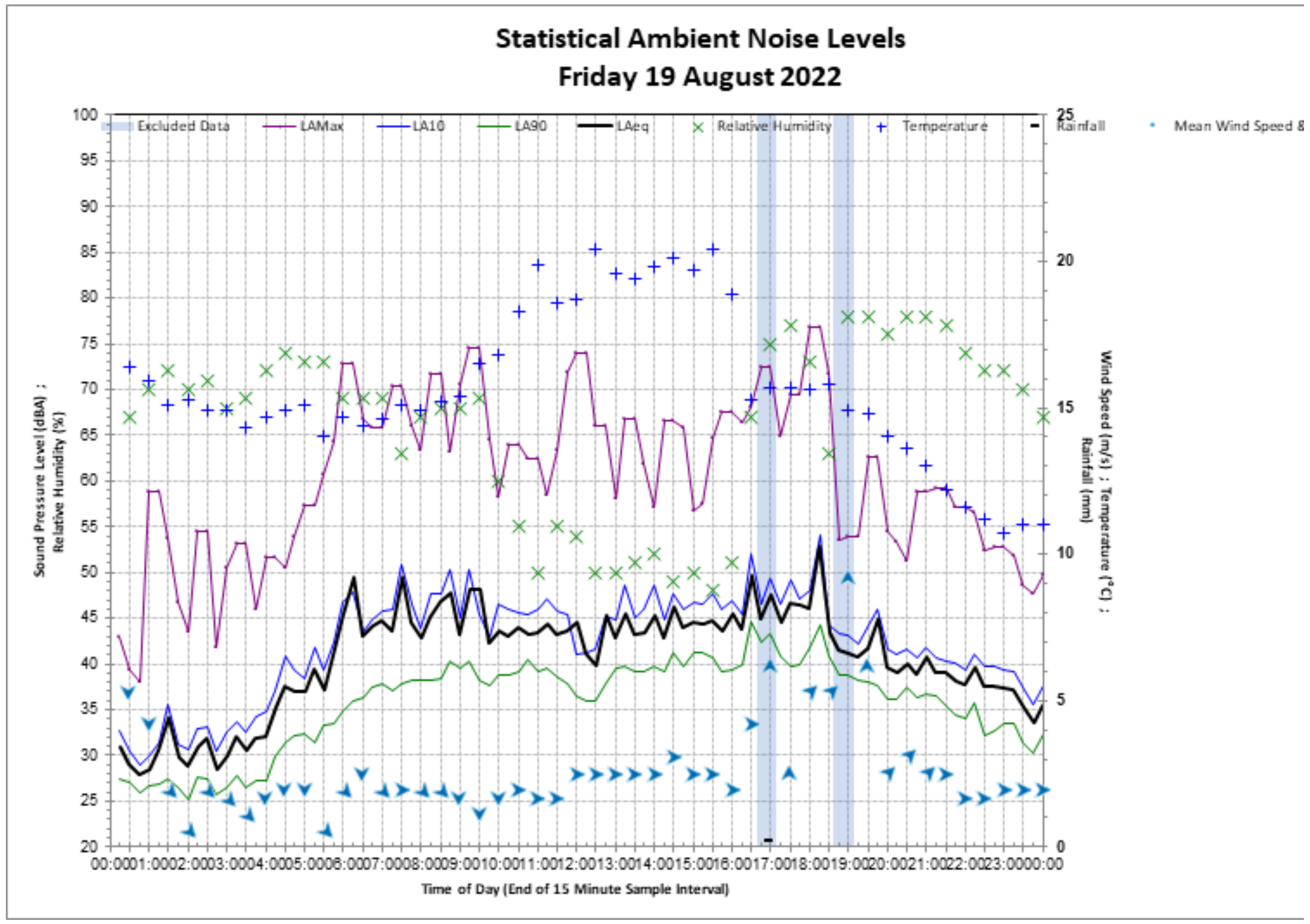
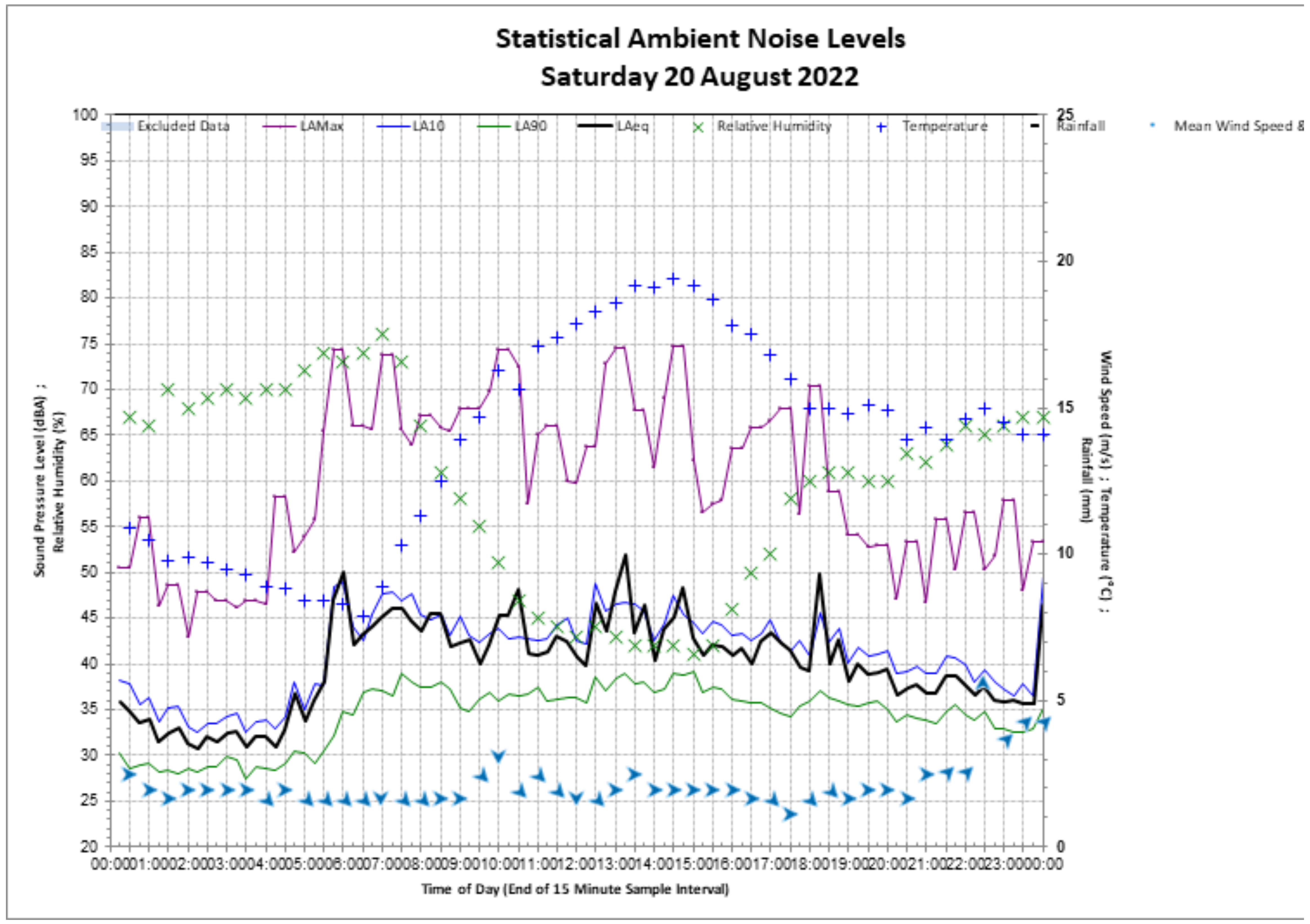
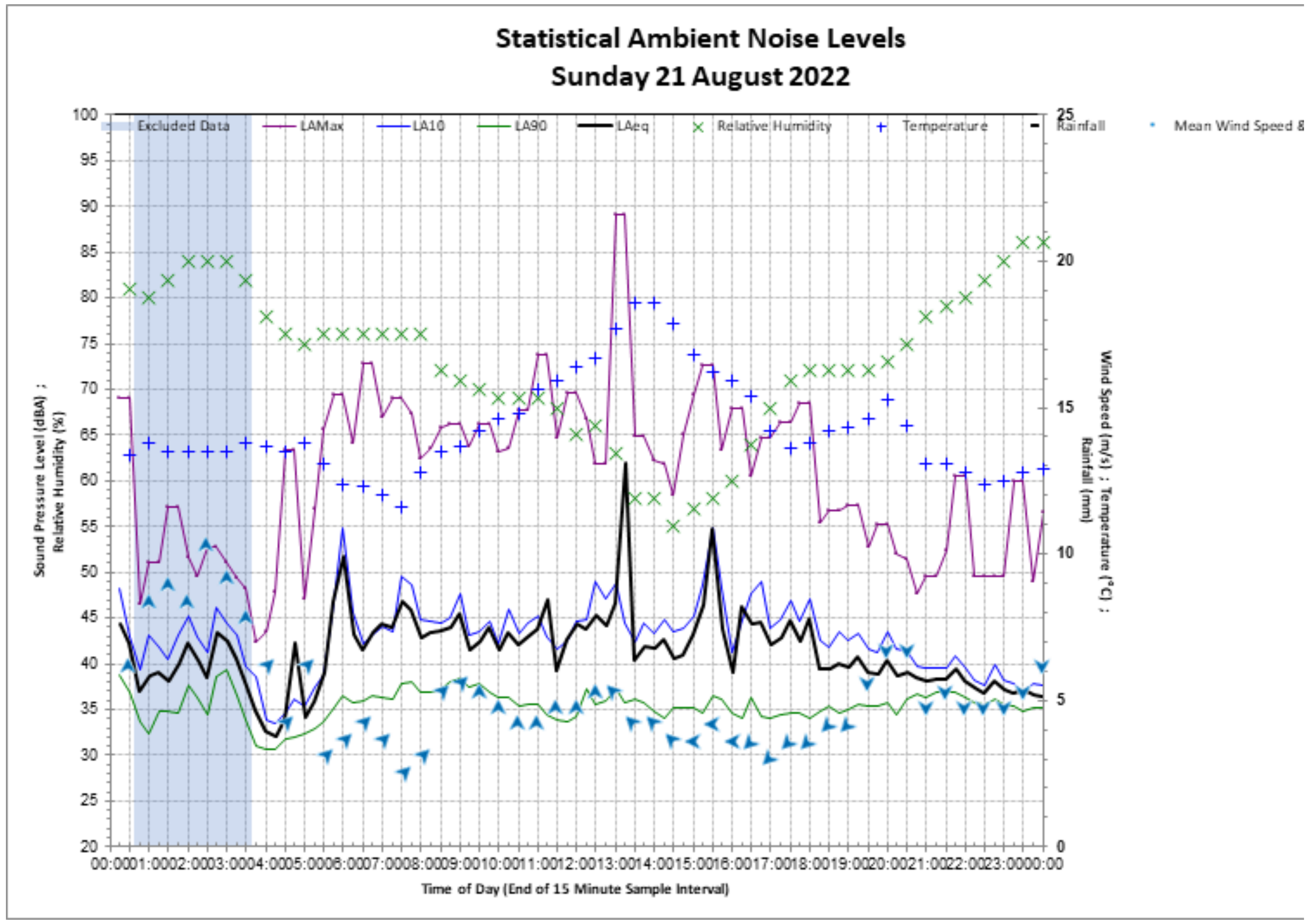
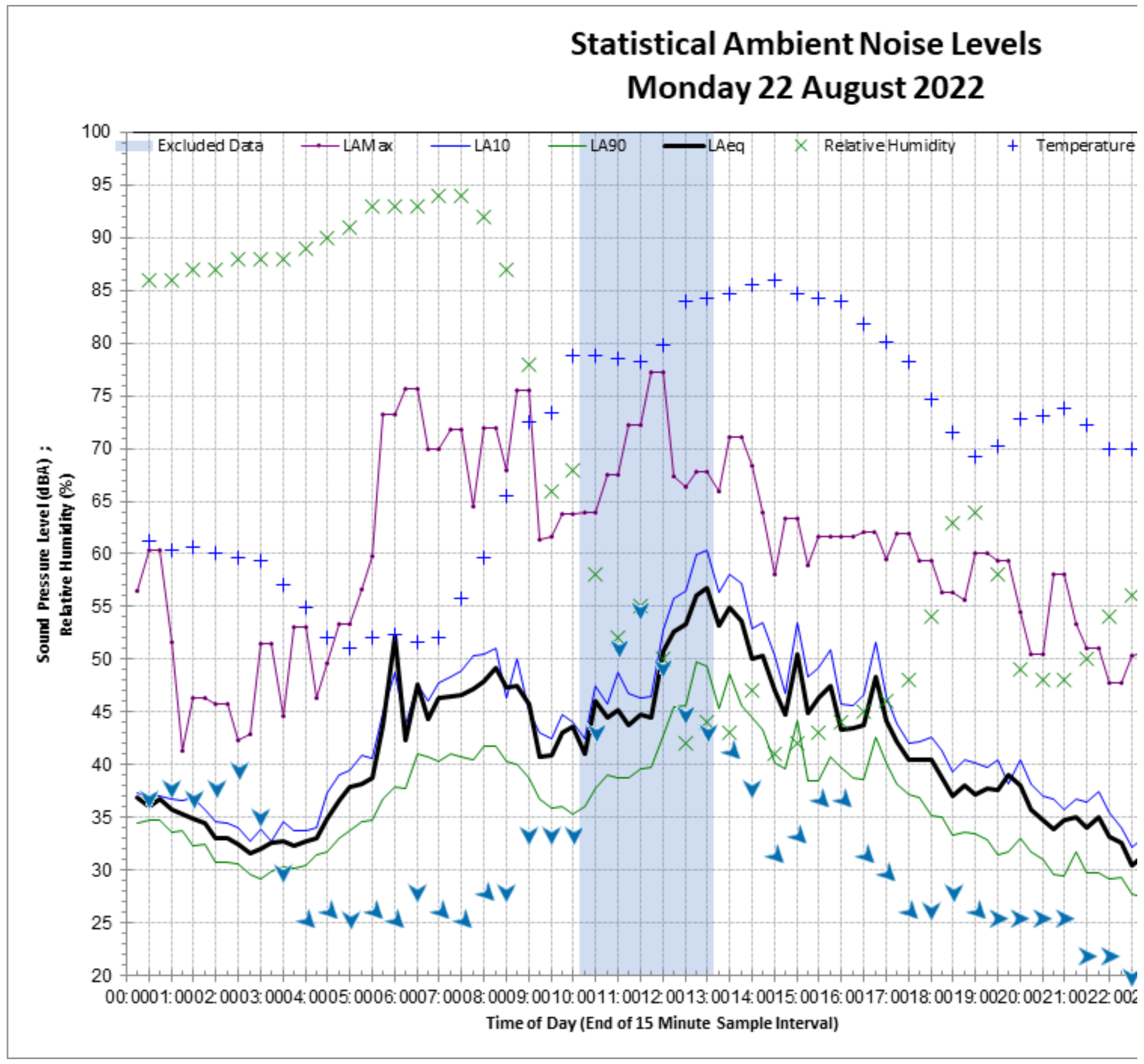
LA10
LA90
LAeq
Relative Humidity
Temperature
Sound Pressure Level (dBA) ; Relative Humidity (%)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Friday 19 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed &
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Rainfall (mm) ; Temperature (°C)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Saturday 20 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed &
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Rainfall (mm) ; Temperature (°C)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Sunday 21 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Monday 22 August 2022
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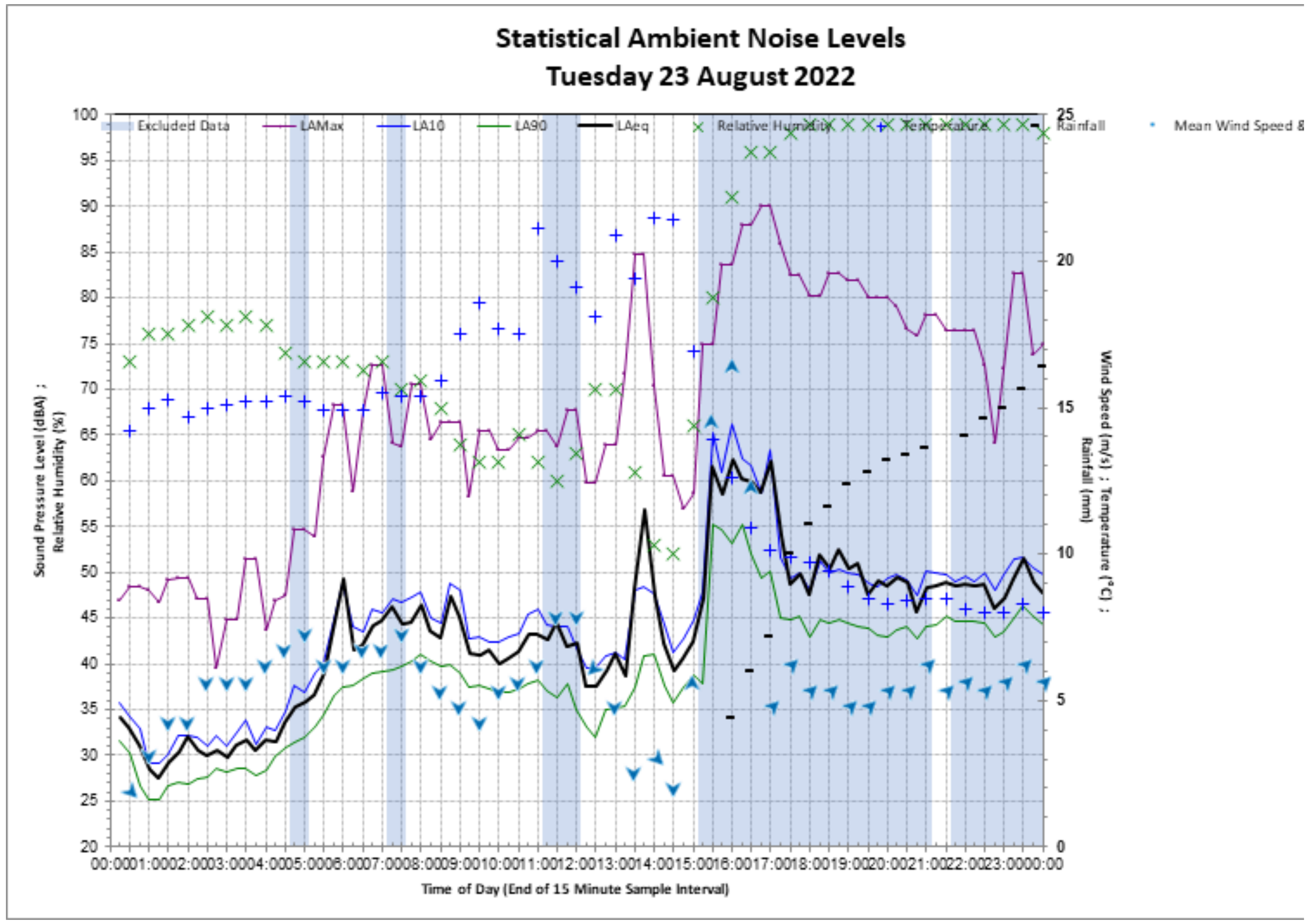
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Sound Pressure Level (dBA) ; Relative Humidity (%)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Tuesday 23 August 2022
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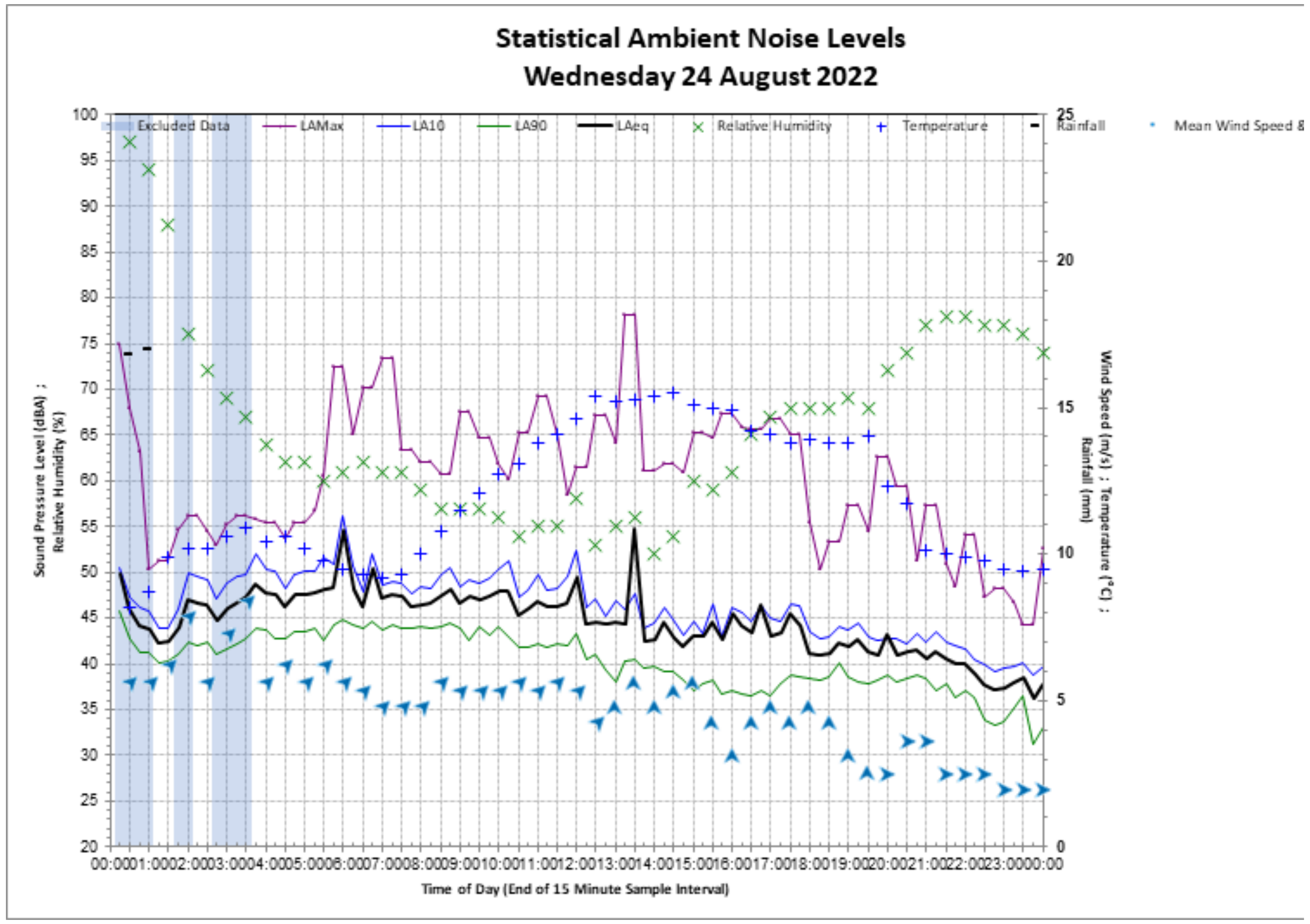
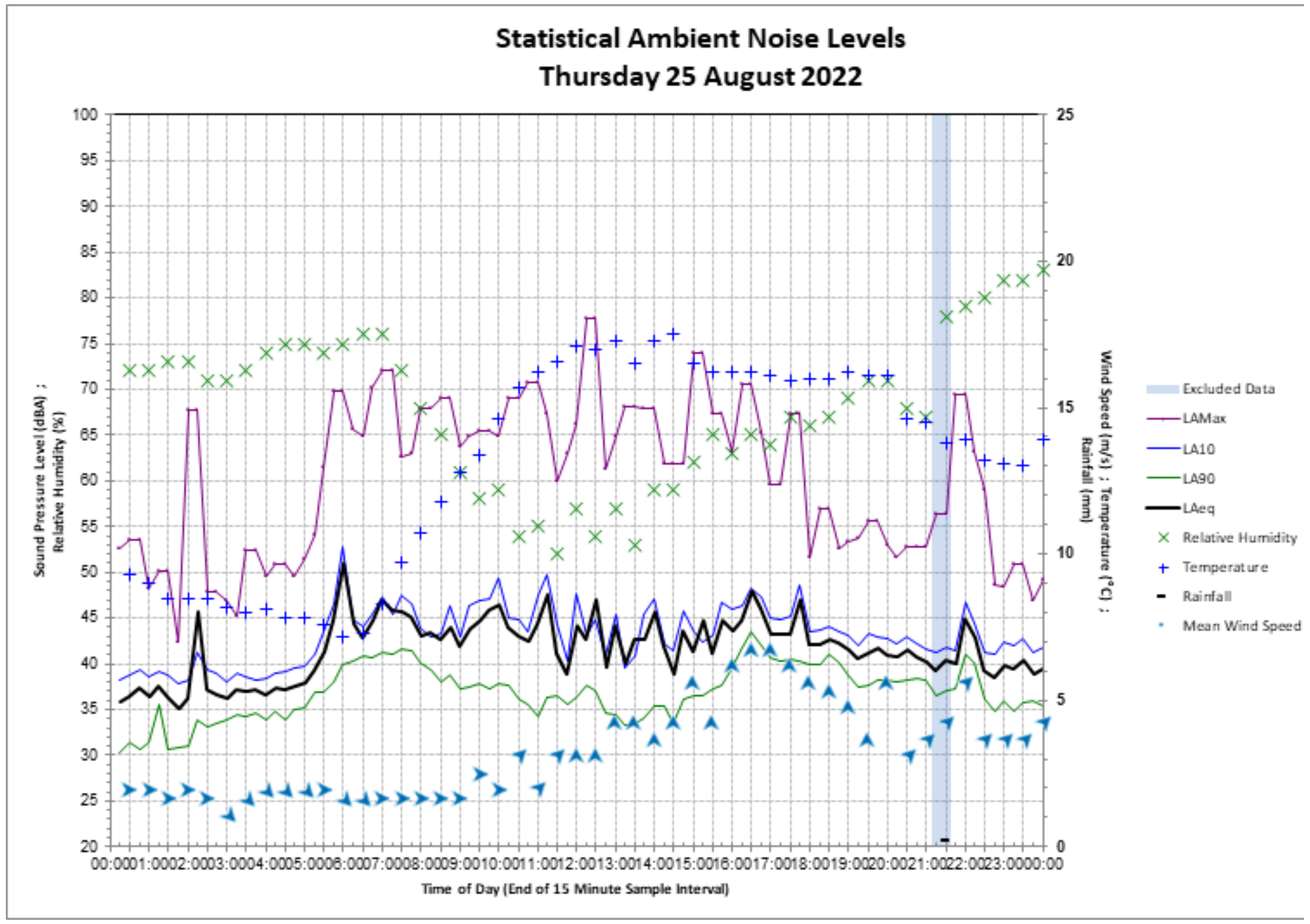
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)



Statistical Ambient Noise Levels
Wednesday 24 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Thursday 25 August 2022
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed

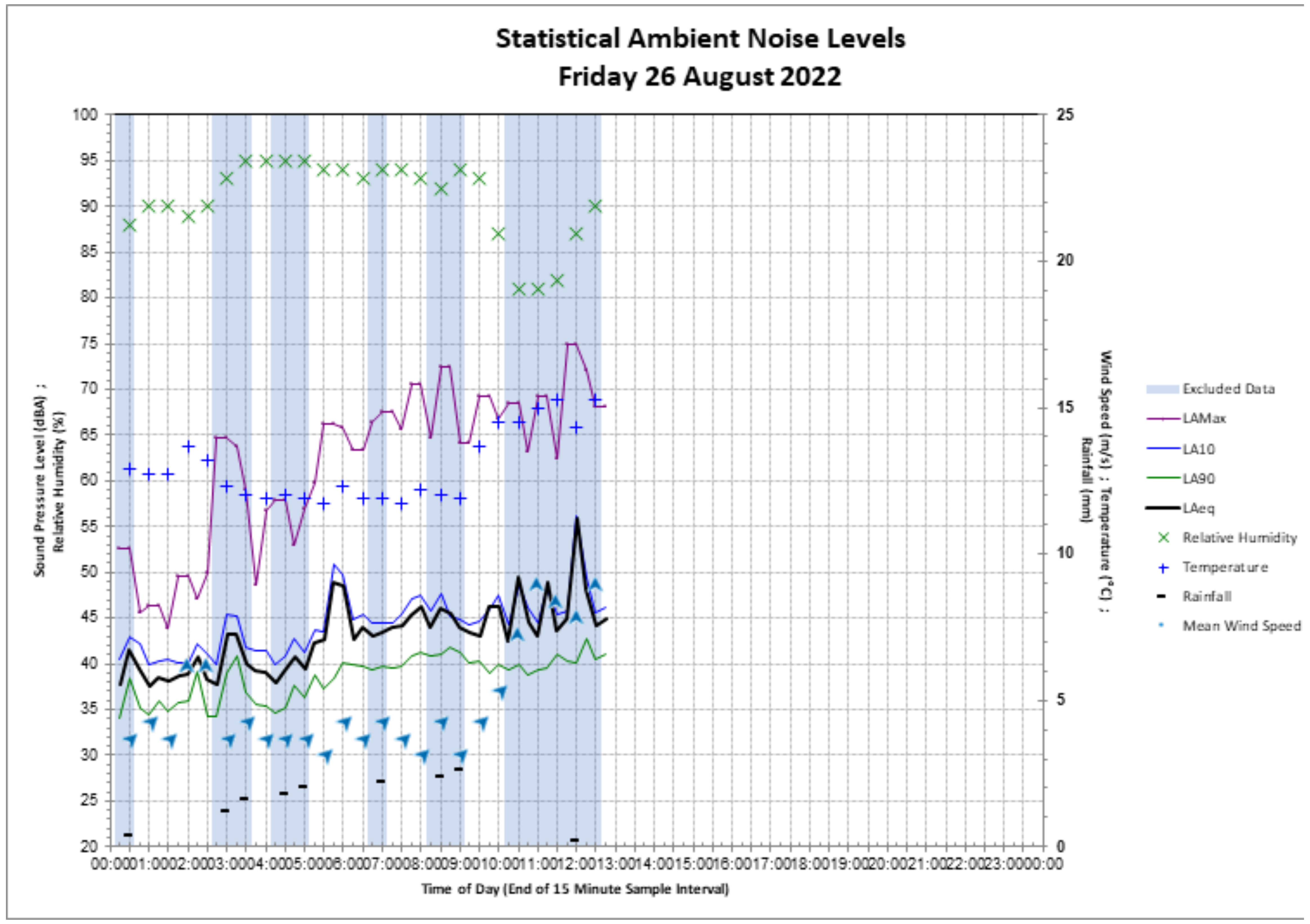

Statistical Ambient Noise Levels
Friday 26 August 2022
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed

Table 9.2 Logger M2

Equipment details	Equipment settings	Location description	Logger photo
Svan 977 Type 1 SN: 36873 1.5 m above ground Free field IEC 61672-3:2013 Compliant Manufactured prior 2019	A-weighted Fast time response 15 minute intervals Pre and post calibration variation: -0.6 dBA Svantek SV30A Class 1 Sound level calibrator SN: 39467 AS 60942:2003 Compliant Manufactured prior 2017	– Central Coast Highway is the dominant noise source – Other noise sources: birds, car horn noise	

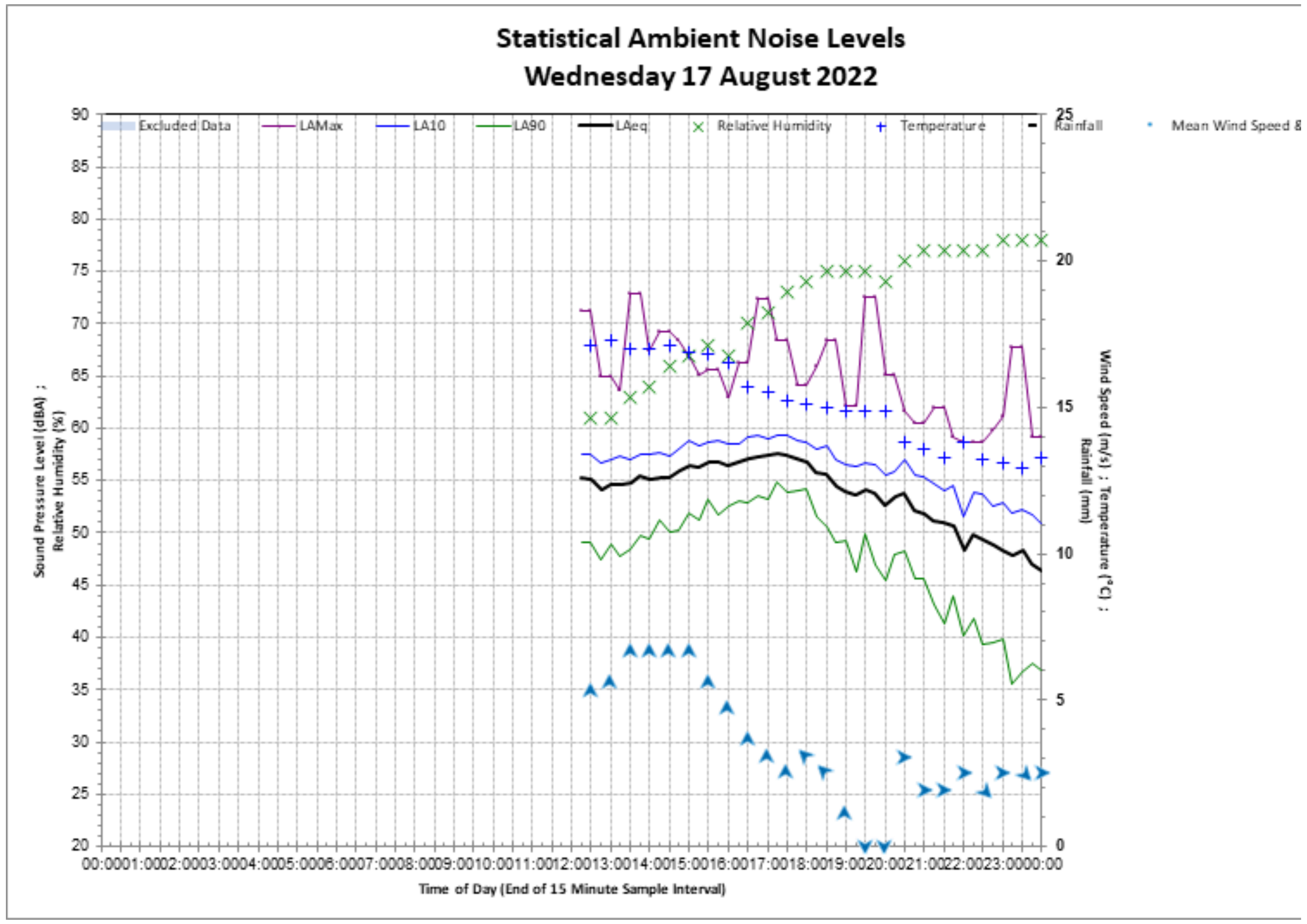
Ambient and background noise monitoring results

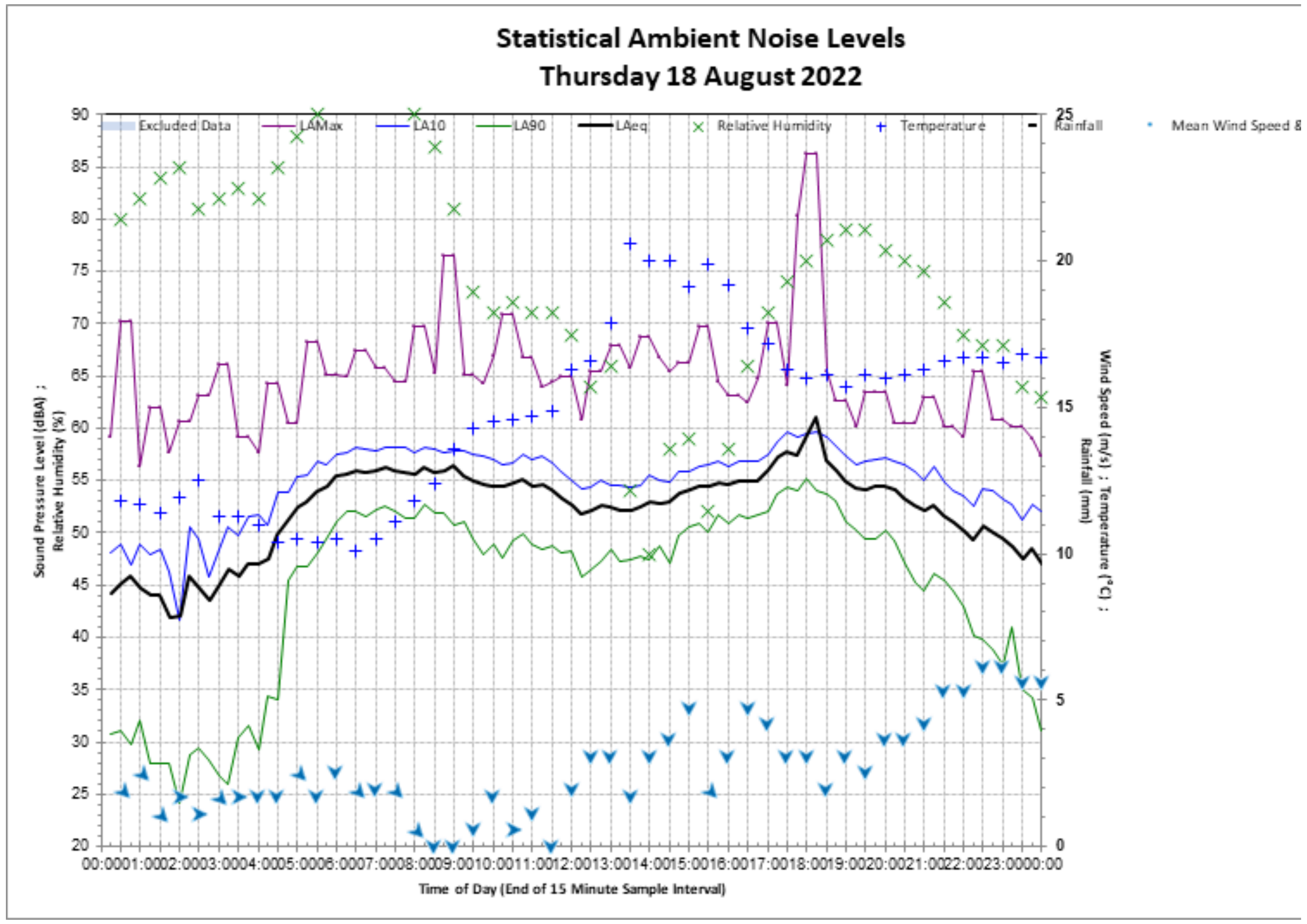
Period	Noise level		
	RBL	L_{Aeq}	L_{10}
Daytime	48	55	57
Evening	42	53	56
Night	28	50	52

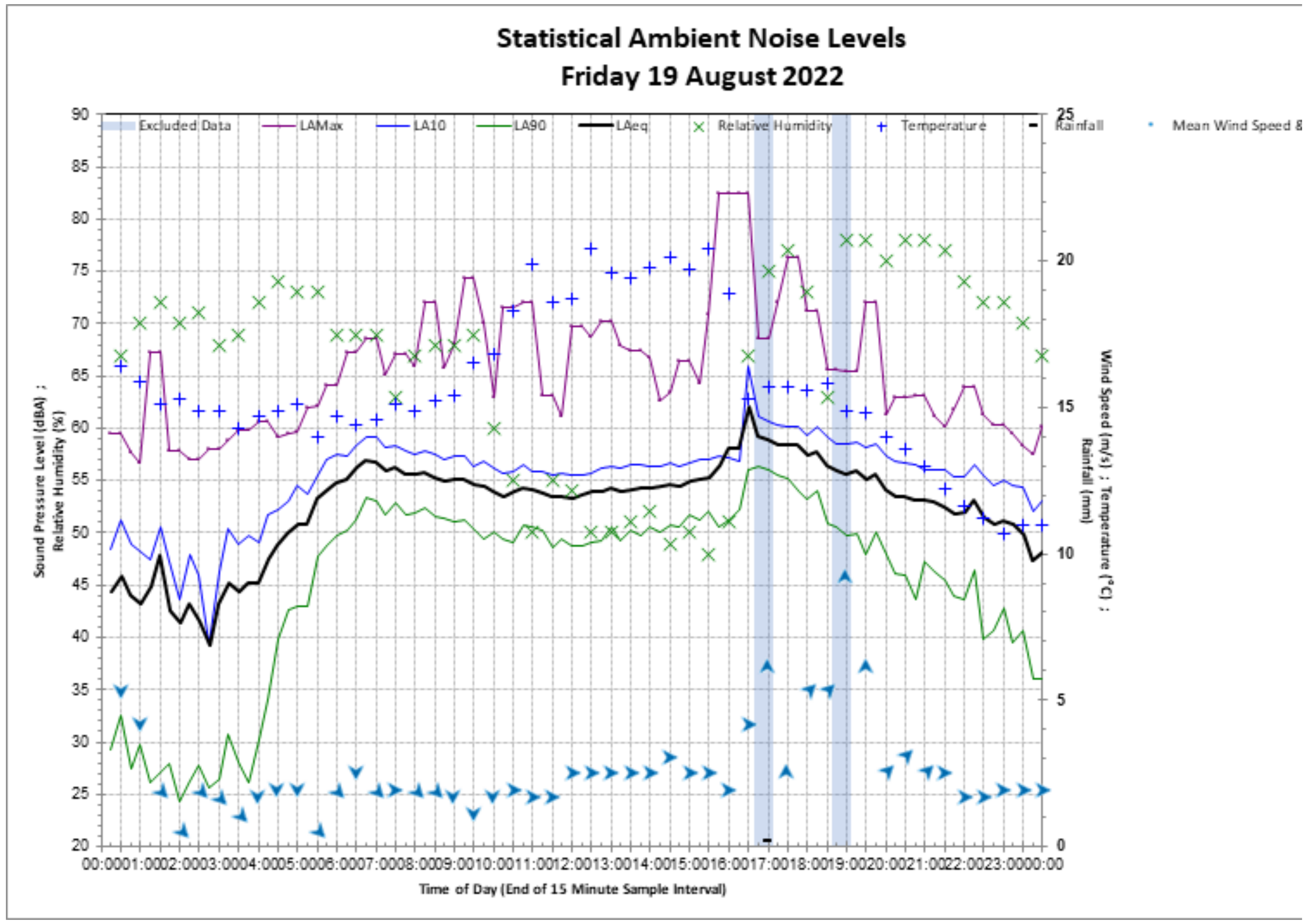
Attended noise measurements

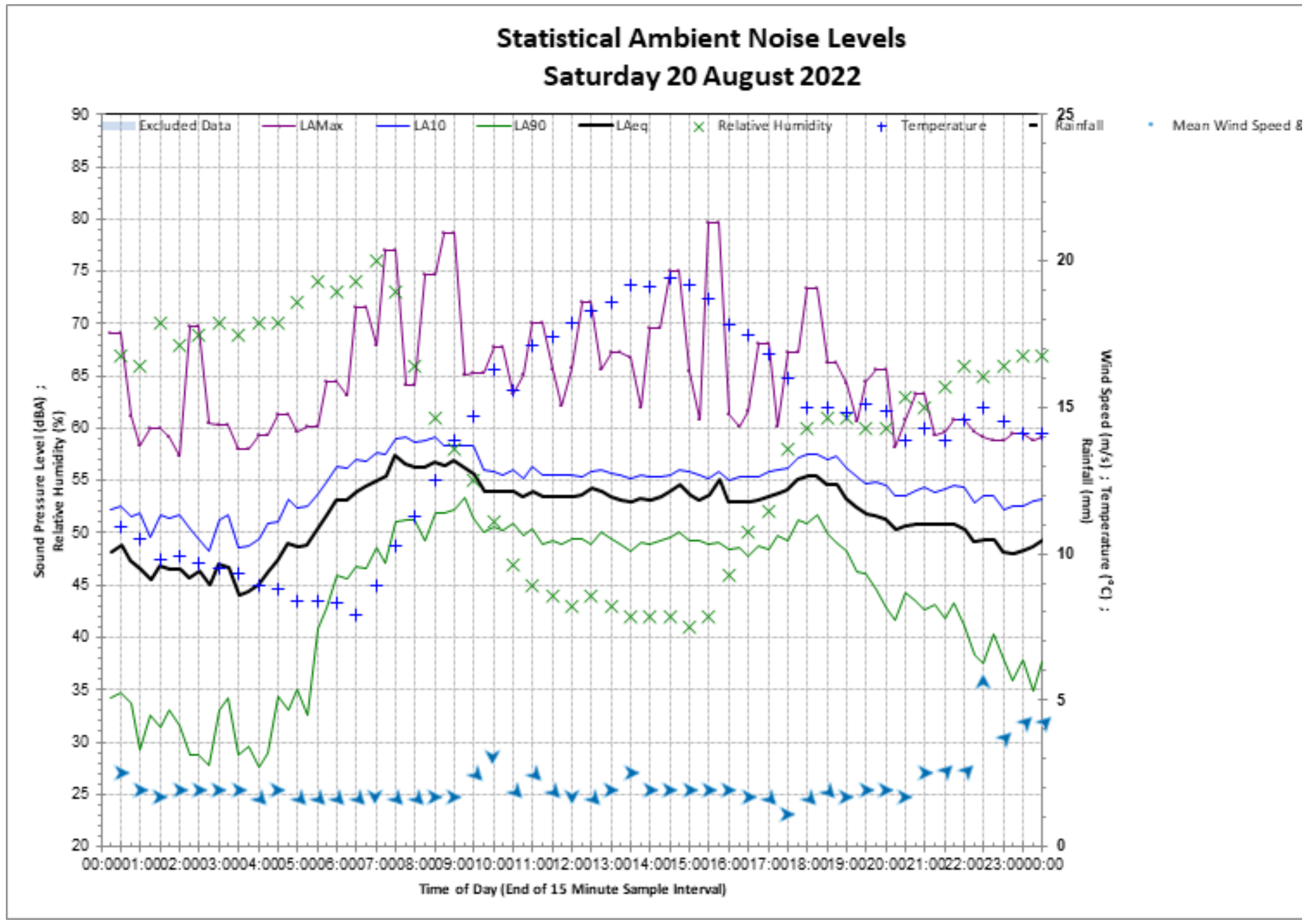
Date	Time	Noise level			
		L_{A90}	L_{Aeq}	L_{A10}	L_{A1}
26/08/22	12:22 pm	51	56	58	61

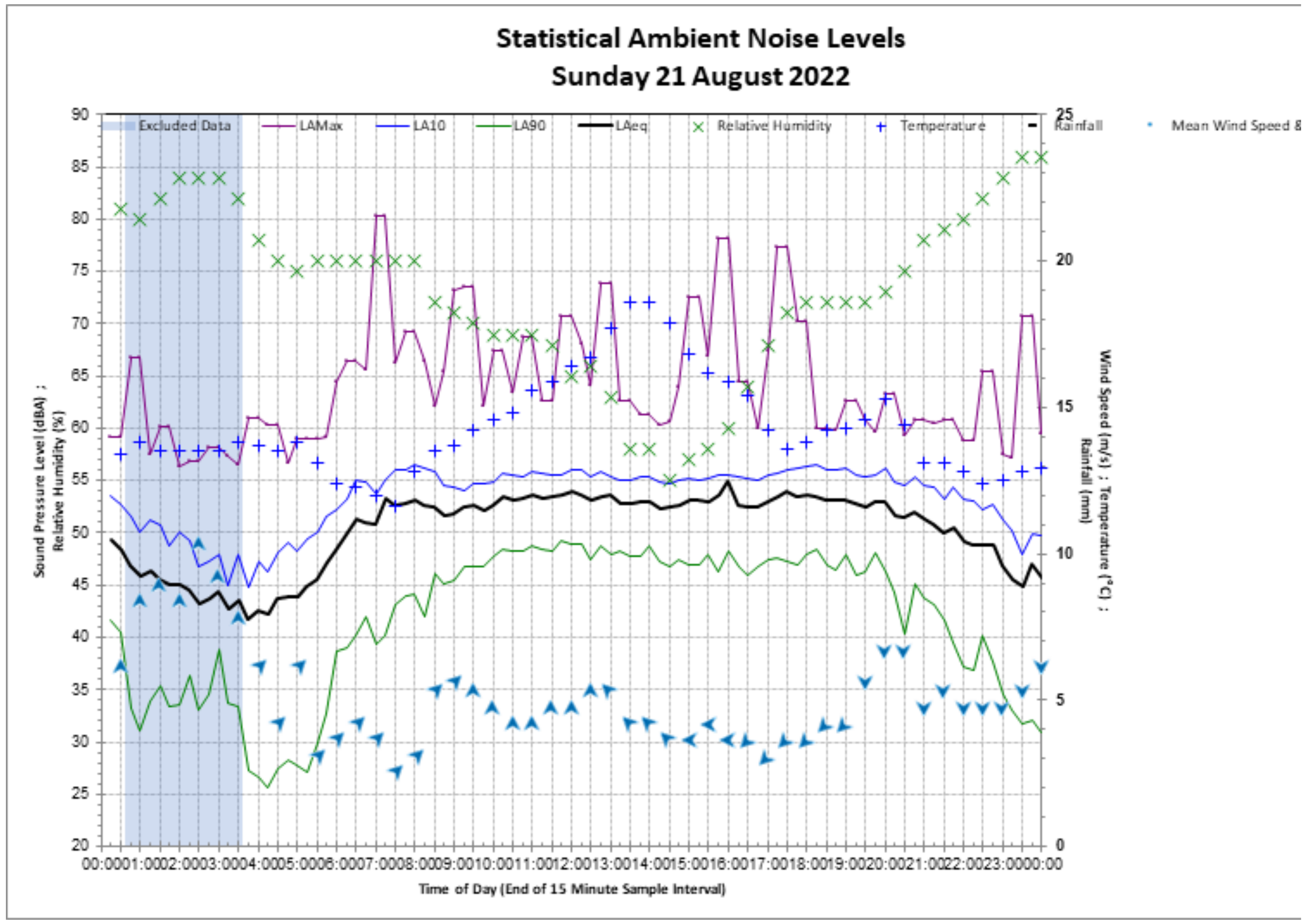
Logger location

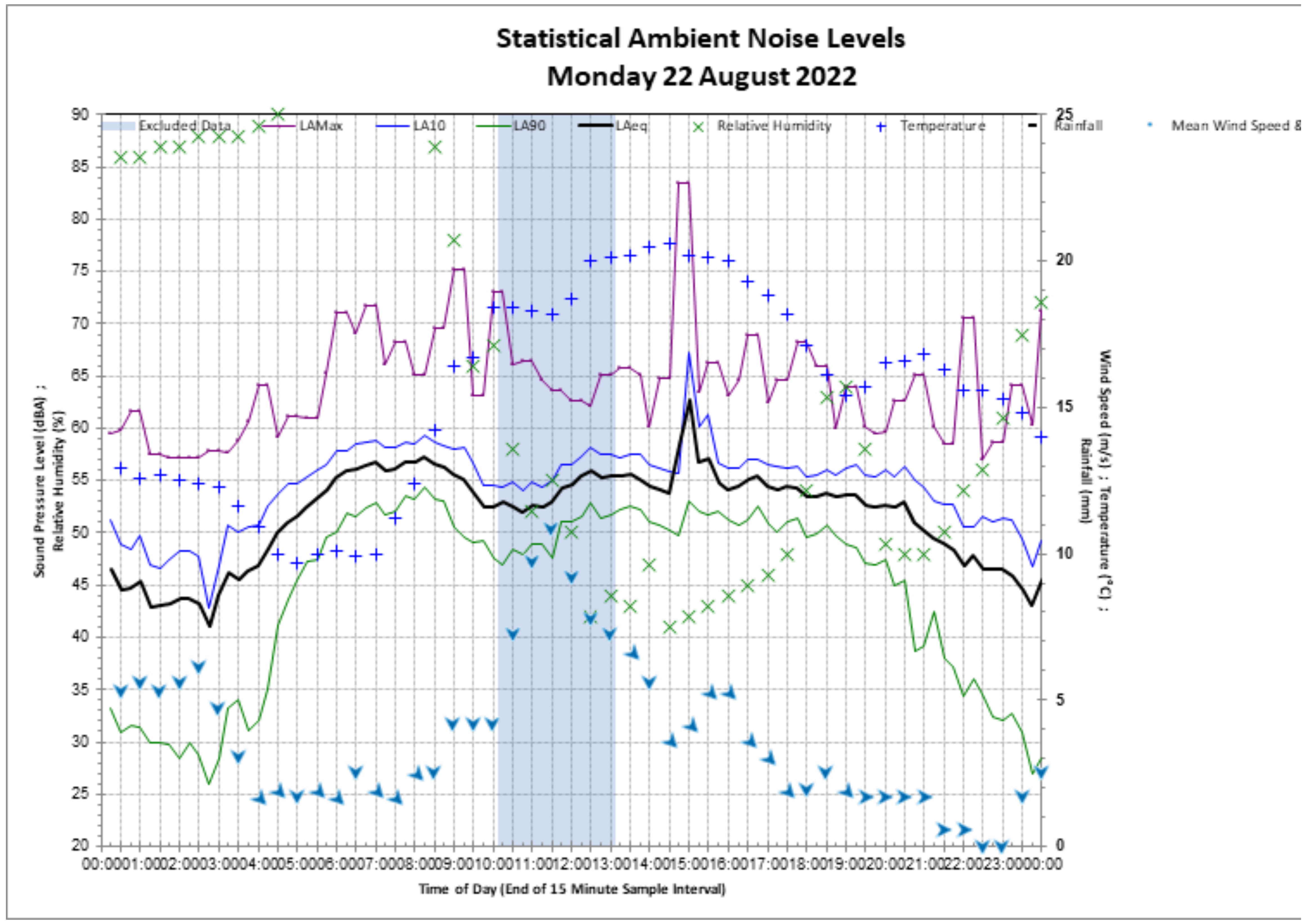

Statistical Ambient Noise Levels
Wednesday 17 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

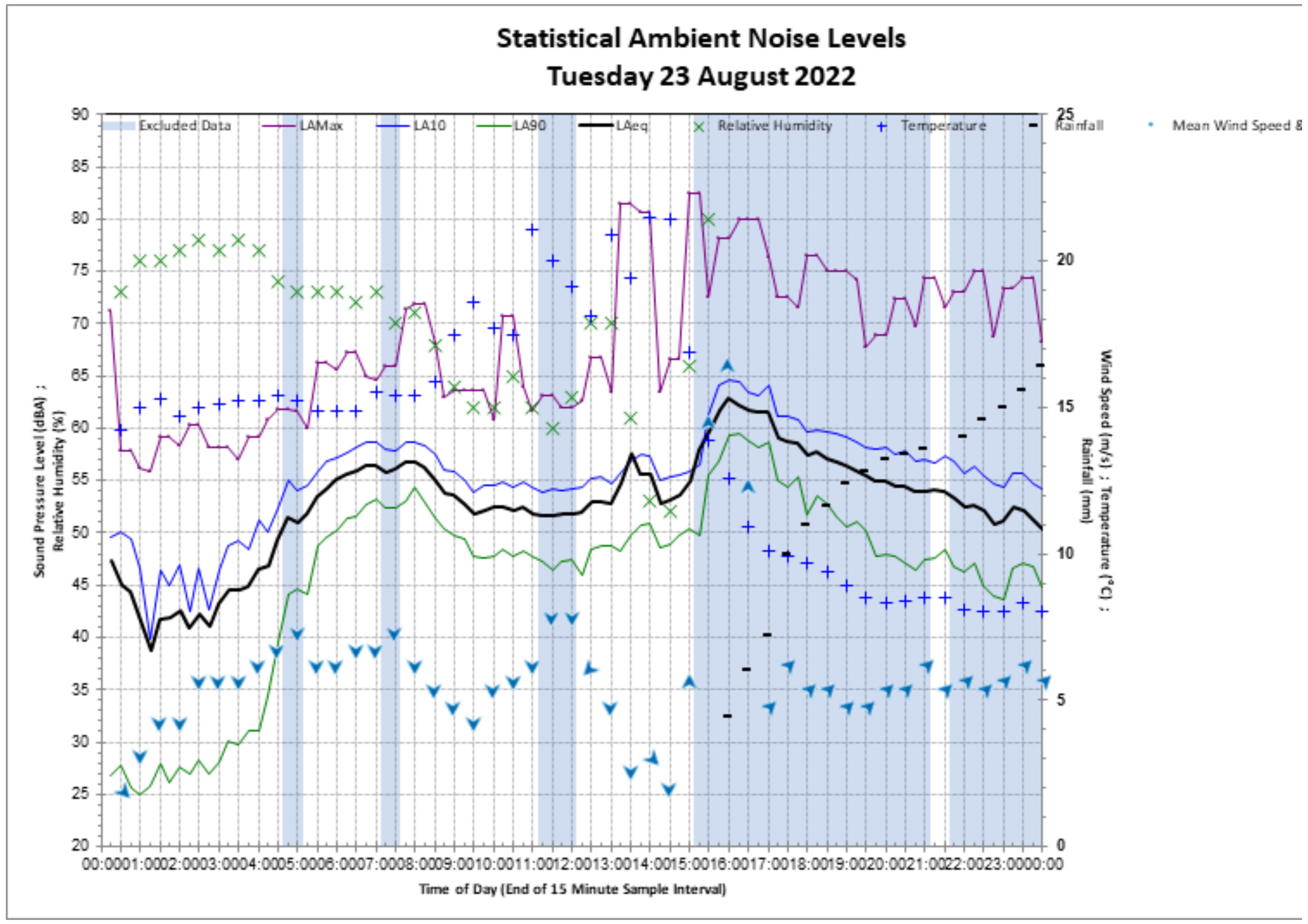

Statistical Ambient Noise Levels
Thursday 18 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

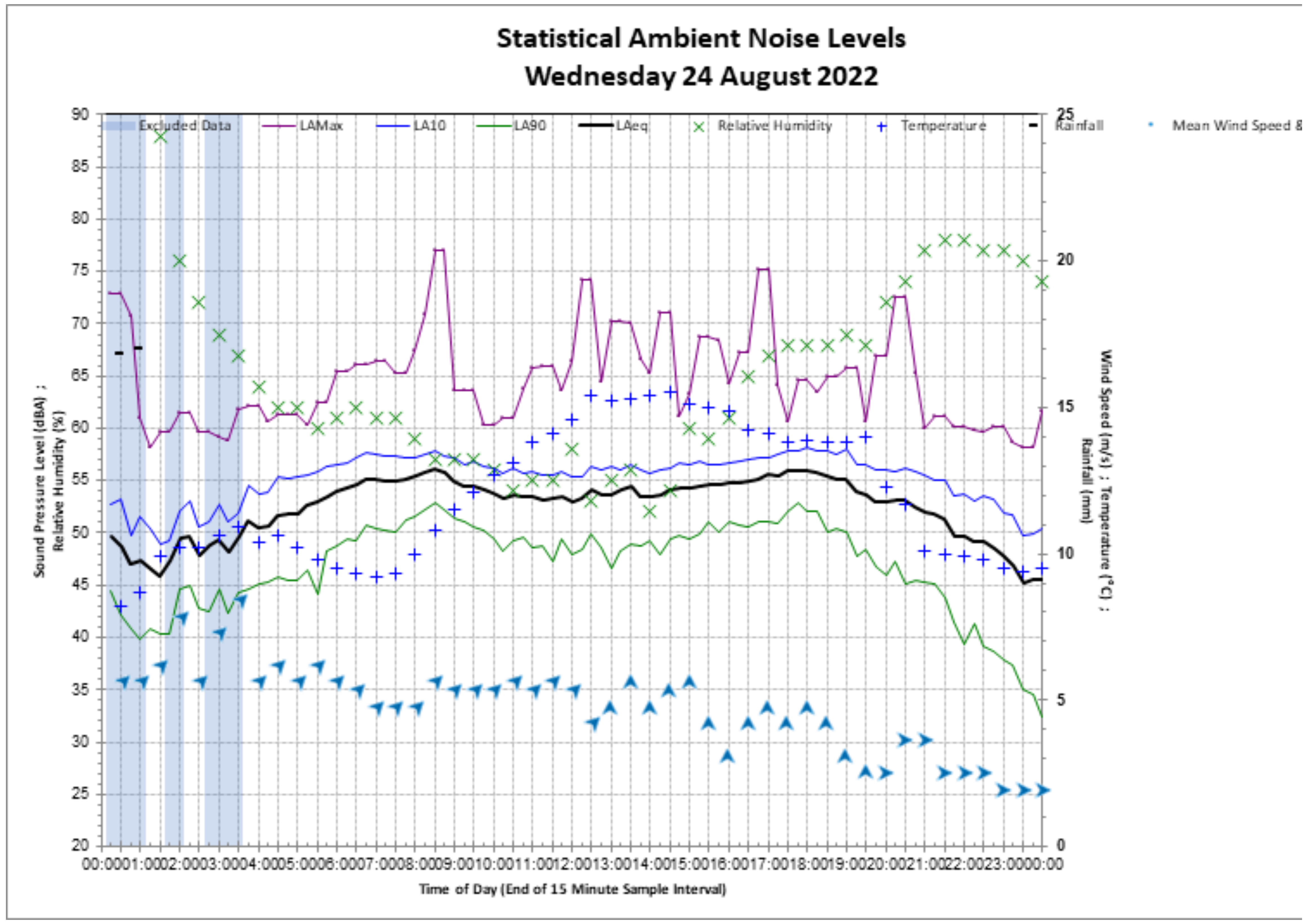

Statistical Ambient Noise Levels
Friday 19 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

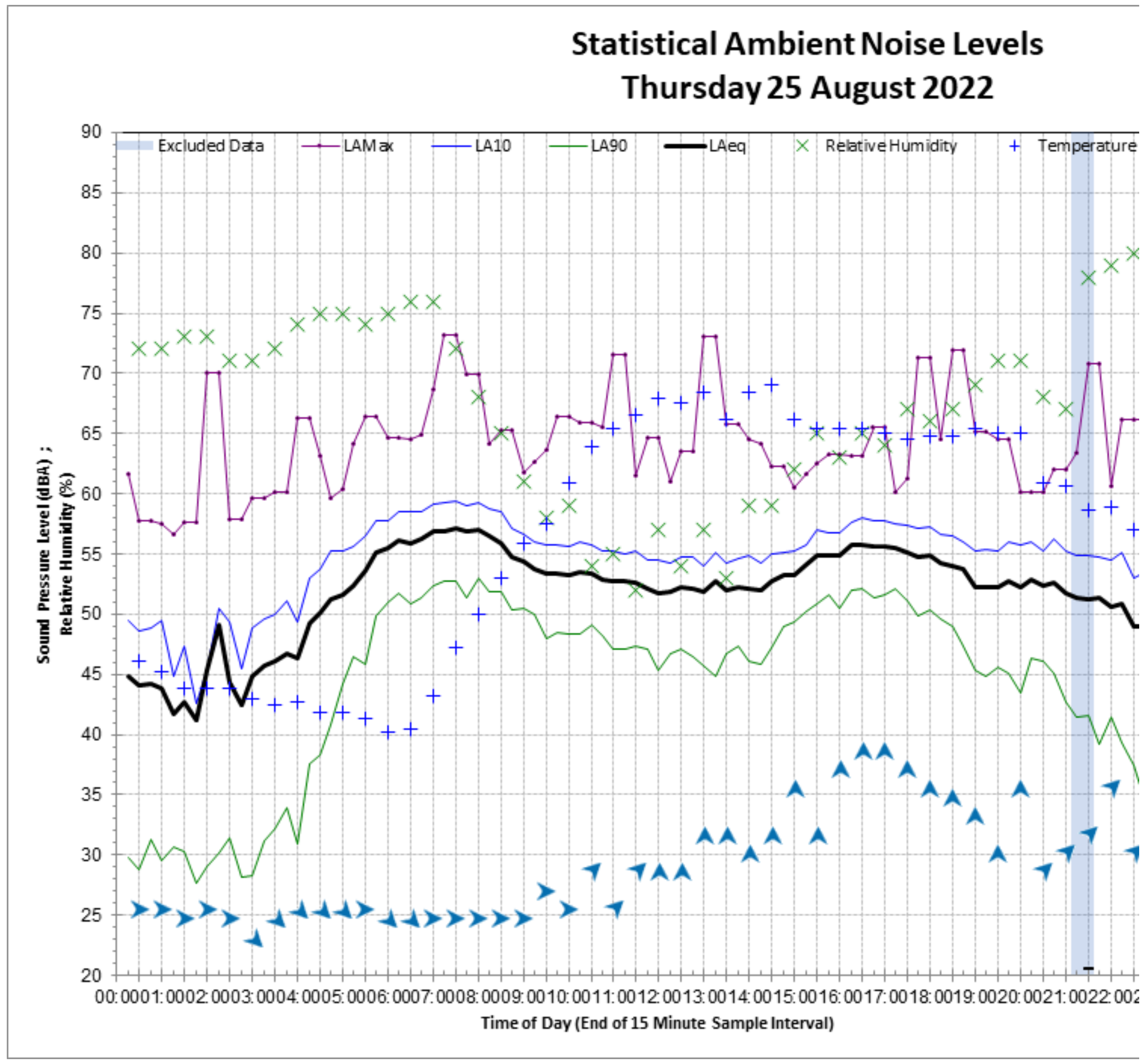

Statistical Ambient Noise Levels
Saturday 20 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

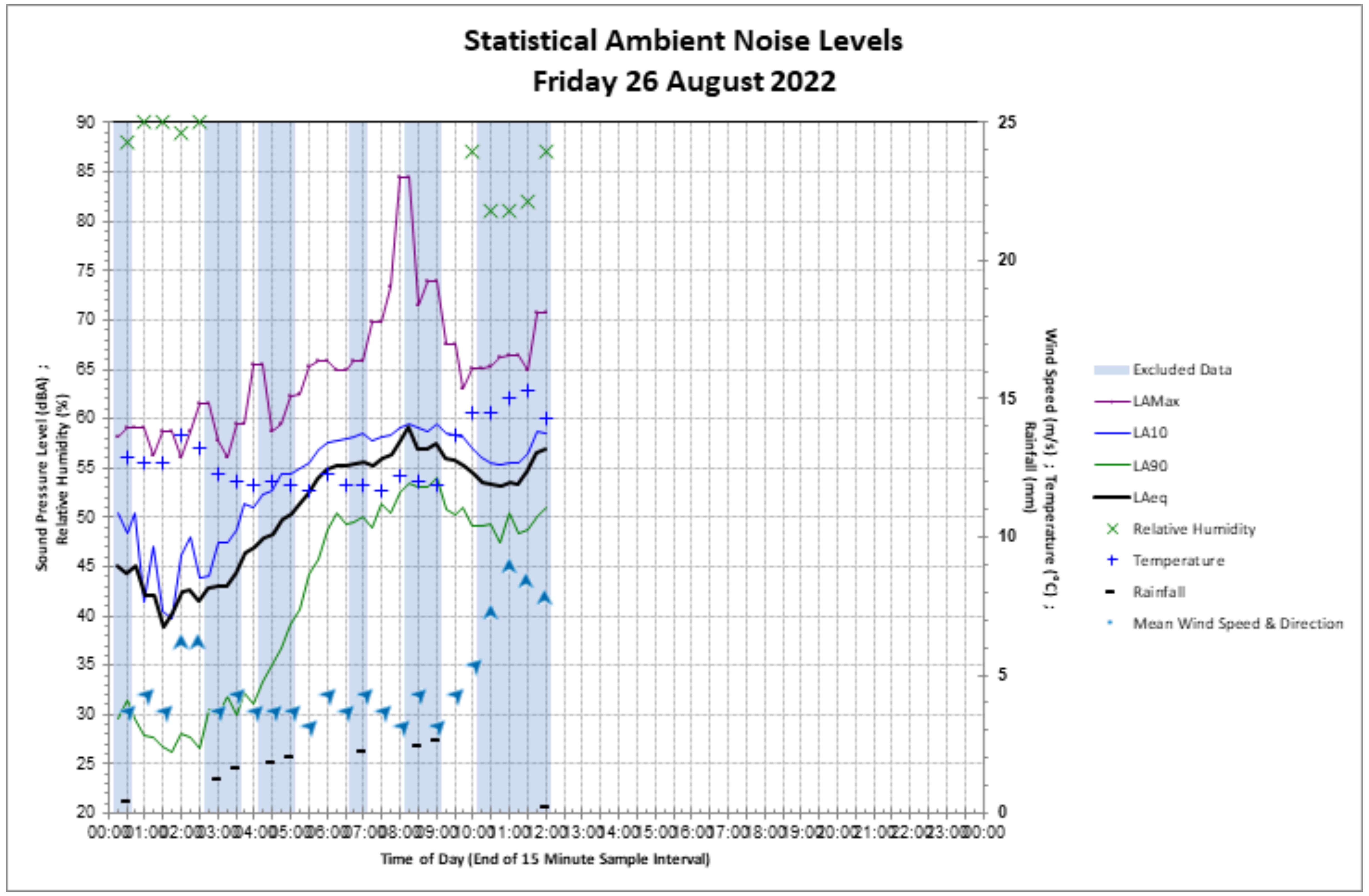

Statistical Ambient Noise Levels
Sunday 21 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Monday 22 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Tuesday 23 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)

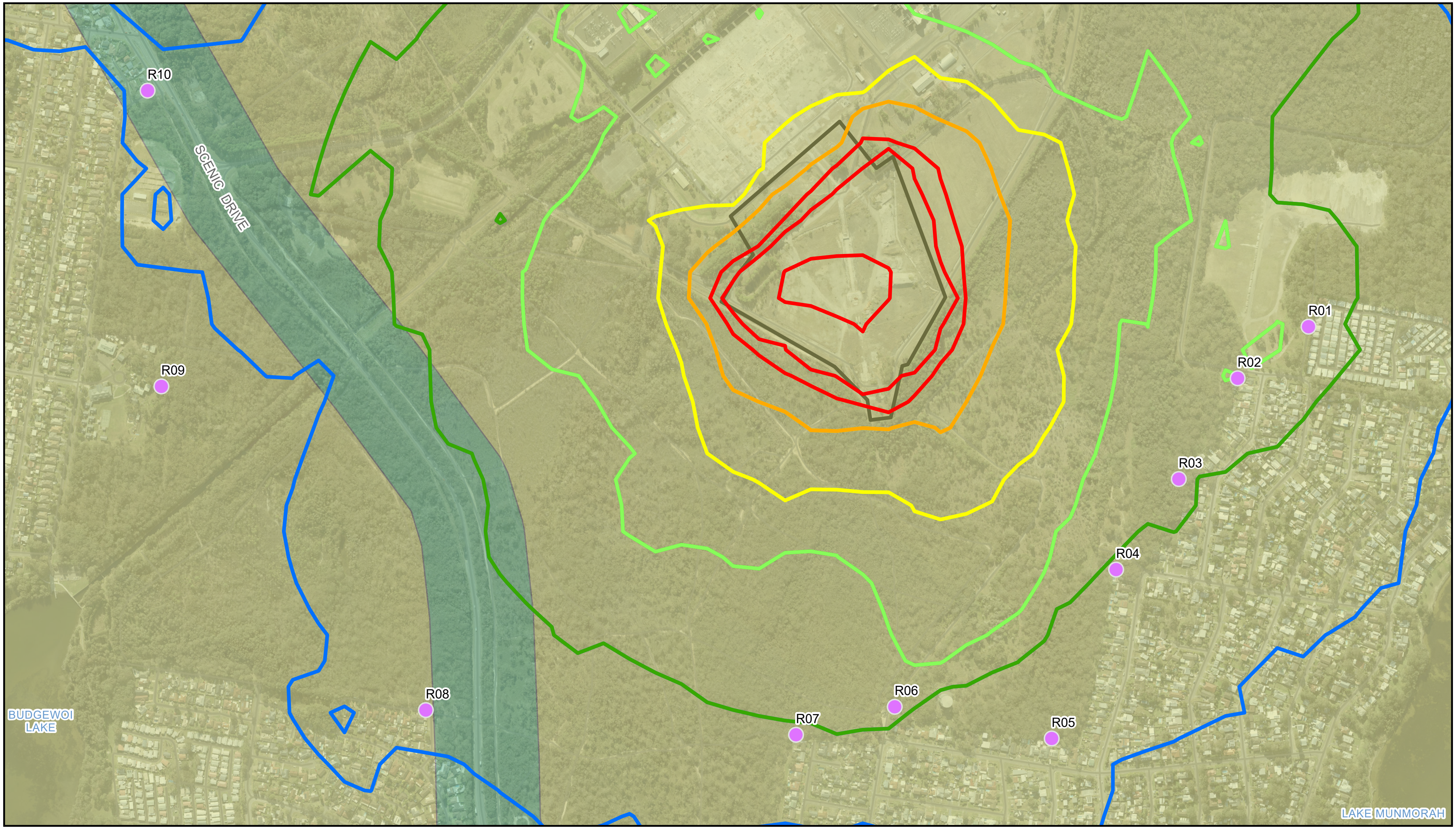

Statistical Ambient Noise Levels
Wednesday 24 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed 8
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Thursday 25 August 2022
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Sound Pressure Level (dBA) ; Relative Humidity (%)
Time of Day (End of 15 Minute Sample Interval)


Statistical Ambient Noise Levels
Friday 26 August 2022
Sound Pressure Level (dBA) ; Relative Humidity (%)
Wind Speed (m/s) ; Temperature (°C) ; Rainfall (mm)
Excluded Data
LAMax
LA10
LA90
LAeq
Relative Humidity
Temperature
Rainfall
Mean Wind Speed & Direction
Time of Day (End of 15 Minute Sample Interval)

Appendix C

Construction noise contours



Legend

- Receivers
- NCA1
- NCA2
- Project Site

Leq(15 min) dBA

- 25
- 30
- 35
- 40
- 45
- 50
- Roads

Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Energy Co
Waratah Super Battery
NVIA

Construction noise contours, Leq(15 min) dBA

Project No. **12582669**
Revision No. **0**
Date **26/10/2022**

APPENDIX C.1

\\ghdnet\ghd\AU\Newcastle\Projects\21\12582669\GIS\Maps\Deliverables\12582669_NVIA.aprx
Print date: 26 Oct 2022 - 12:14

Data source: Metromap Tile Service: . Created by: mfredle

Appendix D

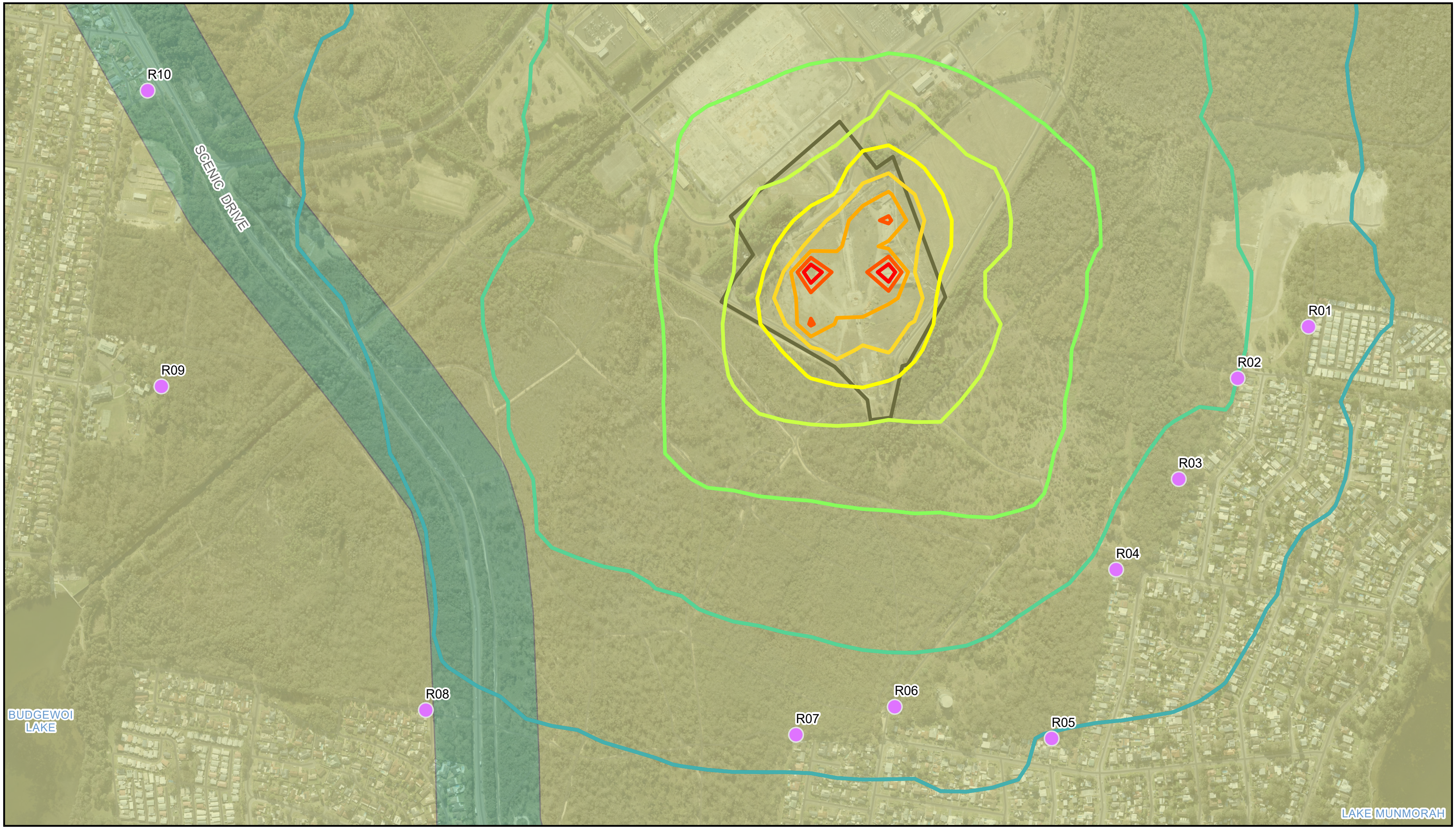
Detailed operational noise results

Receiver ID			R01	R02	R03	R04	R05	R06	R07	R08	R09	R10
X coordinate (m)			365160.2	365023.45	364909.87	364788.91	364664.58	364361.72	364171.22	363456.87	362946.56	362919.98
Y coordinate (m)			6323844.9	6323745.3	6323550.8	6323376.1	6323050.2	6323111.3	6323057.3	6323105	6323729.6	6324300.4
Scenario 1	Overall noise level, dBA		27	29	28	28	24	27	26	22	19	20
	Overall noise level, dBC		47	48	46	47	44	46	45	42	40	42
	Overall noise level, dBZ		46	47	45	46	43	45	44	41	39	42
	Octave-band noise level (Frequency, Hz), dBZ	25	37	38	37	38	35	38	38	33	31	32
		31.5	40	41	40	41	38	42	41	36	34	35
		40	35	37	36	36	33	37	36	31	29	31
		50	35	36	33	34	30	34	33	29	26	30
		63	32	33	32	33	30	33	32	28	25	27
		80	36	37	32	33	30	33	32	28	26	32
		100	44	46	43	43	41	42	42	39	38	40
		125	27	28	27	28	25	27	26	23	21	22
		160	21	23	22	23	19	22	21	18	15	17
		200	25	27	26	27	24	26	25	22	19	21
		250	20	21	21	22	18	21	20	16	14	15
		315	22	23	22	23	19	22	21	18	15	17
		400	18	19	19	20	16	18	18	14	11	13
		500	19	21	19	20	16	19	19	14	11	13
		630	18	20	19	20	15	19	18	13	9	12
		800	17	19	18	19	14	18	17	12	8	10
		1000	18	20	19	20	15	19	18	12	8	10
		1250	16	18	17	17	12	17	16	10	5	7
		1600	16	18	17	17	12	16	15	9	3	6
		2000	14	17	16	16	10	15	14	7	1	3
		2500	9	12	11	11	4	10	8	1	0	0
		3150	1	4	3	3	0	2	0	0	0	0
		4000	0	0	0	0	0	0	0	0	0	0
		5000	0	0	0	0	0	0	0	0	0	0
		6300	0	0	0	0	0	0	0	0	0	0
		8000	0	0	0	0	0	0	0	0	0	0
		10000	0	0	0	0	0	0	0	0	0	0
Scenario 2	Overall noise level, dBA		31	33	33	33	30	32	31	27	25	25
	Overall noise level, dBC		58	59	59	59	57	59	58	55	54	54
	Overall noise level, dBZ		55	57	57	57	55	56	55	53	51	51
	Octave-band noise level (Frequency, Hz), dBZ	25	55	57	57	57	55	56	56	53	52	51
		31.5	57	58	58	58	56	58	57	54	53	52
		40	48	49	49	49	47	49	48	45	44	43
		50	44	45	45	45	43	45	44	41	40	40
		63	41	42	42	42	40	42	41	38	37	37
		80	40	42	41	41	38	40	39	37	35	36
		100	45	46	45	44	42	43	43	40	39	41
		125	35	36	36	36	34	35	35	32	31	30
		160	37	38	38	38	36	38	37	34	33	32
		200	31	33	33	33	31	32	32	29	27	27
		250	28	29	29	29	27	29	28	25	23	23
		315	27	28	28	29	26	28	27	24	22	22
		400	23	24	25	25	22	24	23	20	17	18
		500	23	25	25	25	22	24	23	20	17	17
		630	22	24	24	24	21	23	22	18	16	16
		800	20	22	21	22	18	21	20	15	12	13
		1000	19	21	20	20	16	20	19	13	9	11
		1250	19	21	20	20	16	20	19	14	10	10
		1600	17	19	18	18	13	17	16	10	5	7
		2000	16	18	17	17	12	16	15	8	3	4
		2500	11	13	13	12	7	11	10	3	0	0
		3150	4	7	6	6	0	5	3	0	0	0
		4000	0	0	0	0	0	0	0	0	0	0
		5000	0	0	0	0	0	0	0	0	0	0
		6300	0	0	0	0	0	0	0	0	0	0
		8000	0	0	0	0	0	0	0	0	0	0
		10000	0	0	0	0	0	0	0	0	0	0

Receiver ID			R01	R02	R03	R04	R05	R06	R07	R08	R09	R10
X coordinate (m)			365160.2	365023.45	364909.87	364788.91	364664.58	364361.72	364171.22	363456.87	362946.56	362919.98
Y coordinate (m)			6323844.9	6323745.3	6323550.8	6323376.1	6323050.2	6323111.3	6323057.3	6323105	6323729.6	6324300.4
Scenario 3	Overall noise level, dBA		34	35	36	35	32	35	34	30	28	28
	Overall noise level, dBC		49	50	49	49	46	49	48	45	43	44
	Overall noise level, dBZ		48	49	48	48	45	47	47	44	42	43
	Octave-band noise level (Frequency, Hz), dBZ	25	40	41	41	41	39	41	41	37	35	36
		31.5	43	44	44	44	41	44	43	40	38	38
		40	37	38	38	38	36	38	38	34	32	32
		50	36	37	35	35	33	35	34	31	29	31
		63	33	34	34	34	32	34	34	30	28	29
		80	36	38	33	34	30	33	32	29	27	32
		100	45	46	44	44	42	43	42	40	38	40
		125	32	33	33	34	31	33	32	29	28	28
		160	30	32	32	32	30	31	30	28	26	26
		200	31	33	33	33	30	32	31	28	27	27
		250	37	39	39	39	37	39	38	35	33	33
		315	25	27	26	27	24	26	25	22	20	20
		400	23	24	24	25	22	24	23	19	17	17
		500	28	30	30	30	27	29	29	25	23	23
		630	27	29	29	29	26	28	28	24	21	21
		800	24	26	26	26	23	25	25	20	18	18
		1000	21	23	22	22	18	22	21	16	13	13
		1250	22	24	24	24	20	23	22	17	14	14
		1600	19	21	21	21	17	20	19	14	10	10
		2000	18	20	20	19	15	19	18	11	7	7
		2500	14	16	16	15	10	14	13	6	1	1
		3150	10	13	13	12	6	11	10	1	0	0
		4000	4	7	7	6	0	5	3	0	0	0
		5000	0	0	0	0	0	0	0	0	0	0
		6300	0	0	0	0	0	0	0	0	0	0
		8000	0	0	0	0	0	0	0	0	0	0
		10000	0	0	0	0	0	0	0	0	0	0
Scenario 4	Overall noise level, dBA		37	39	39	39	36	38	37	33	31	31
	Overall noise level, dBC		48	49	48	48	46	48	47	44	42	43
	Overall noise level, dBZ		48	50	49	49	46	48	48	44	43	44
	Octave-band noise level (Frequency, Hz), dBZ	25	37	38	37	38	35	38	38	33	31	32
		31.5	40	41	40	41	38	42	41	36	34	35
		40	35	37	36	36	33	37	36	31	29	31
		50	35	36	33	34	30	34	33	29	26	30
		63	32	33	32	33	30	33	32	28	25	27
		80	36	37	32	33	30	33	32	28	26	32
		100	45	46	44	44	42	43	43	40	39	40
		125	36	37	37	37	35	37	36	33	32	31
		160	33	35	35	35	33	35	34	31	30	29
		200	32	33	33	33	31	33	32	29	27	27
		250	32	33	34	34	31	33	32	29	28	27
		315	35	36	37	37	34	36	35	32	30	30
		400	26	27	28	28	25	27	26	23	21	20
		500	30	31	32	32	29	31	30	26	24	24
		630	34	36	36	36	33	35	34	31	28	28
		800	29	31	31	31	28	30	29	25	23	22
		1000	24	26	26	26	22	25	24	19	17	16
		1250	27	29	29	29	25	28	27	22	20	19
		1600	23	25	25	25	21	24	23	18	15	14
		2000	23	25	25	24	20	23	22	16	13	12
		2500	18	21	20	20	15	19	18	11	7	6
		3150	14	17	17	16	10	15	13	5	0	0
		4000	11	15	14	13	7	13	11	0	0	0
		5000	1	6	6	4	0	4	1	0	0	0
		6300	0	0	0	0	0	0	0	0	0	0
		8000	0	0	0	0	0	0	0	0	0	0
		10000	0	0	0	0	0	0	0	0	0	0

Appendix E

Operational noise contours



Legend

- Receivers
- NCA1
- NCA2
- Project Site
- Roads

Leq(15 min) dBA

- 25
- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70

Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Energy Co
Waratah Super Battery
NVIA

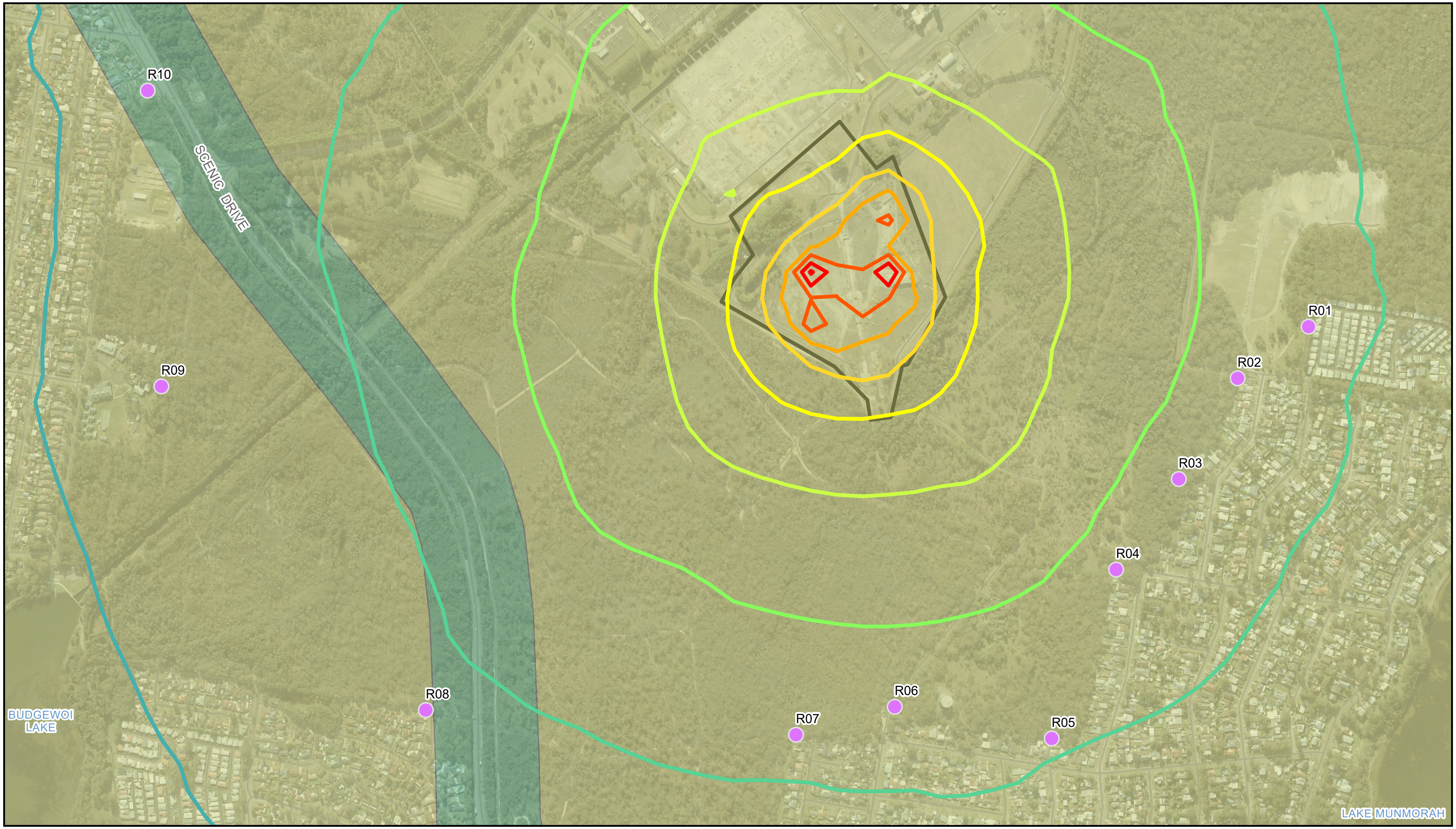
Operational noise contours, Leq(15 min) dBA – Scenario 1

Project No. 12582669
Revision No. 0
Date 26/10/2022

APPENDIX E.1

\\ghdnet\ghd\AU\Newcastle\Projects\21\12582669\GIS\Maps\Deliverables\12582669_NVIA.aprx
Print date: 26 Oct 2022 - 12:14

Data source: Metromap Tile Service: . Created by: mfredle



Legend

- Receivers
- NCA1
- NCA2
- Project Site
- Roads

Leq(15 min) dBA

25, 30, 35, 40, 45, 50, 55, 60, 65, 70

Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Energy Co
Waratah Super Battery
NVIA

Operational noise contours, Leq(15 min) dBA – Scenario 2

Project No. 12582669
Revision No. 0
Date 26/10/2022

APPENDIX E.2

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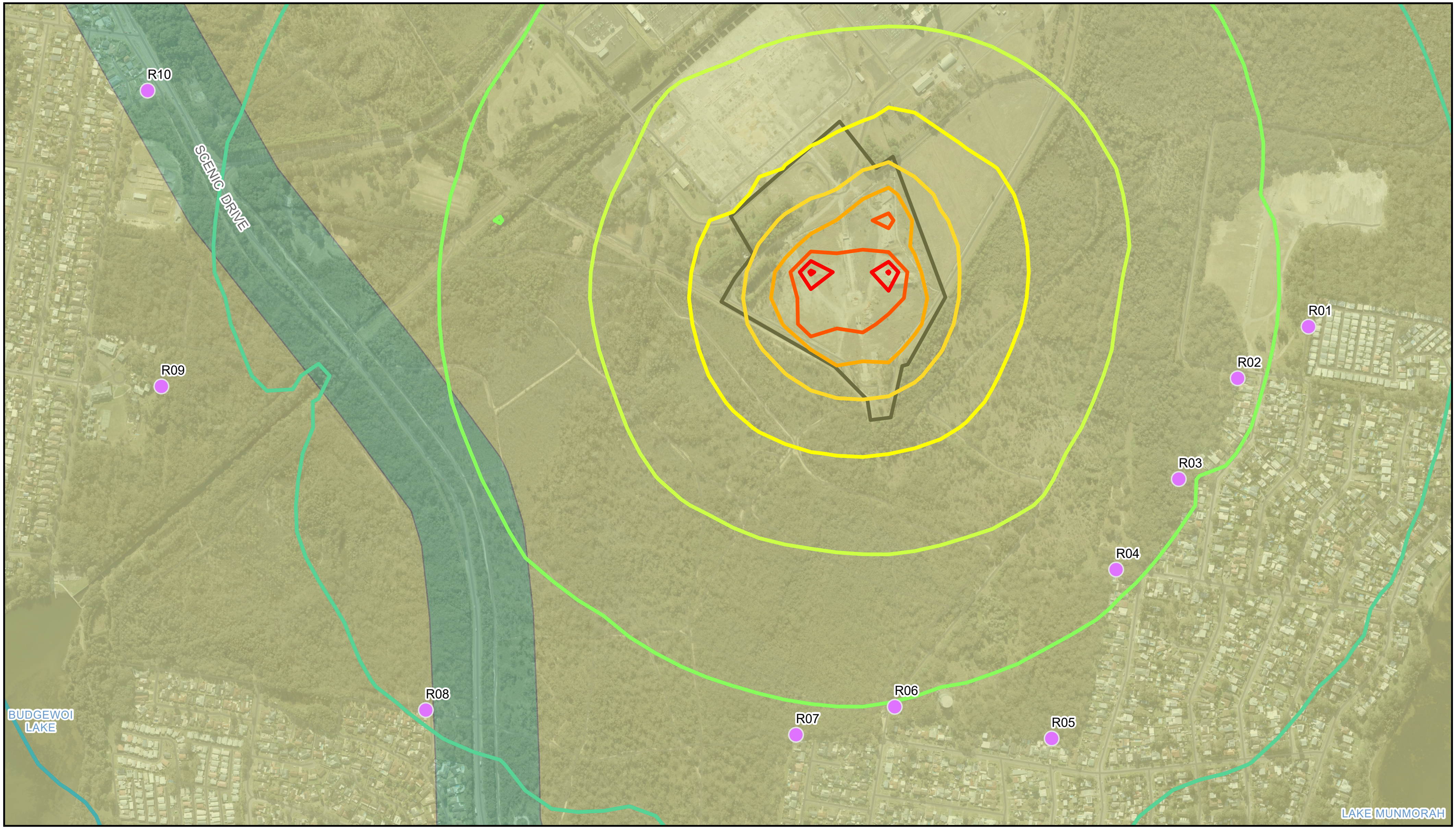
Data source: Metromap Tile Service: . Created by: mfredle



Legend

- Receivers
- NCA1
- NCA2
- Project Site
- Roads

Leq(15 min) dBA

- 25
- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70

Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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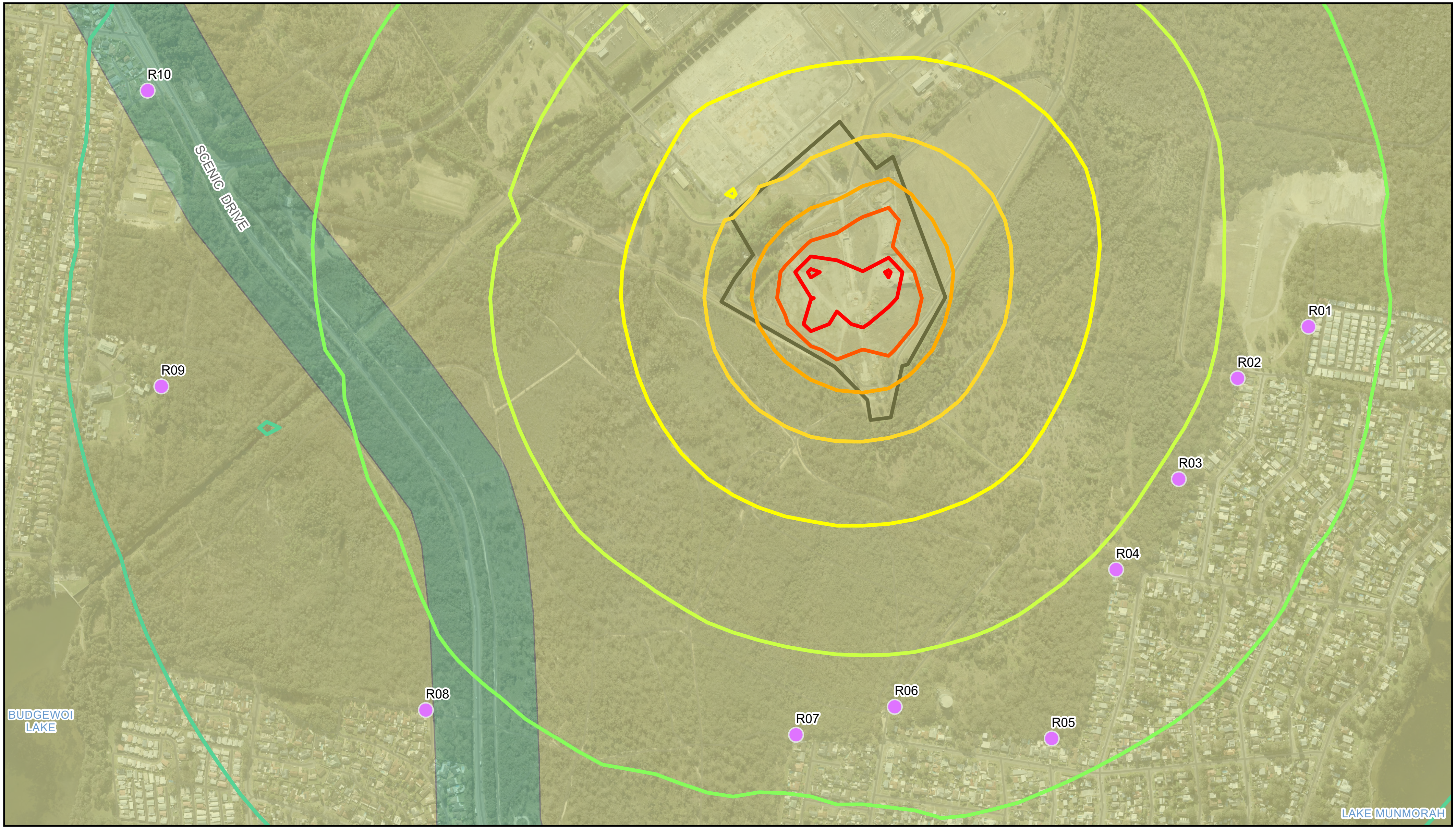
Operational noise contours, Leq(15 min) dBA – Scenario 3

Project No. **12582669**
Revision No. **0**
Date **26/10/2022**

APPENDIX E.3

\\ghdnet\ghd\AU\Newcastle\Projects\21\12582669\GIS\Maps\Deliverables\12582669_NVIA.aprx
Print date: 26 Oct 2022 - 12:15

Data source: Metromap Tile Service: . Created by: mfredle



Legend

- Receivers
- NCA1
- NCA2
- Project Site
- Roads

Leq(15 min) dBA

- 25
- 30
- 35
- 40
- 45
- 50
- 55
- 60
- 65
- 70

Paper Size ISO A4

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Energy Co
Waratah Super Battery
NVIA

Operational noise contours, Leq(15 min) dBA – Scenario 4

Project No. **12582669**
Revision No. **0**
Date **26/10/2022**

APPENDIX E.4

\\ghdnet\ghd\AU\Newcastle\Projects\21\12582669\GIS\Maps\Deliverables\12582669_NVIA.aprx
Print date: 26 Oct 2022 - 12:15

Data source: Metromap Tile Service: . Created by: mfredle

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