St George Illawarra Dragons Community and High-Performance Training Centre (CHPC)

Noise and Vibration Development Assessment

St George Illawarra Dragons

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Document prepared by:

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
Level 11, 73 Miller Street
North Sydney 2060 Australia
PO Box 1319
North Sydney NSW 2059
Australia

T +61 2 9465 5599
F +61 2 9465 5598
E sydney@aurecongroup.com
W aurecongroup.com

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Author signature		Approver signature	
Name	Adrian Pinto	Name	Andy Mak
Title	Engineer, Acoustic and Vibration	Title	Technical Director, Building Structures

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Abbreviations

Term	Definition
ABL	Assessment background level
AGL	Above ground level
AVATG	Assessing Vibration: A technical Guideline
AS	Australian Standard
CEMP	Construction environmental management plan
CNVMP	Construction noise and vibration management plan
dB	decibel
dB(A)	A-weighted decibel level
dB(C)	C-weighted decibel level
DPE	Department of Planning & Environment, NSW. Previous environment authority/office/departments in NSW were: ■ Department of Environment and Conservation (DEC) ■ Department of Environment and Climate Change (DECC) ■ Department of Environment Climate Change & Water (DECCW) ■ Office of Environment and Heritage (OEH) ■ Department of Planning, Industry & Environment (DPIE)
DEFRA	Department for Environment Food and Rural Affairs, UK
EPA	Environment Protection Authority, NSW
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EPI	Environmental Planning Instrument
EPL	Environment Protection License
EWP	Elevated work platforms
Heritage Act	Heritage Act 1977 (NSW)
ICNG	NSW Interim Construction Noise Guidelines (DECC 2009)
mm/s	Millimetres per second
m/s	Metres per second
NATA	National Association of Testing Authorities – This is the recognised national accreditation authority for analytical laboratories and testing service providers in Australia.
NCA	Noise catchment area
NML	Noise management level
NPfI	New South Wales Noise Policy for Industry (2017)
NSW	New South Wales
OOHW	Out of Hours Works
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
PPV	Peak Particle Velocity
REF	Review of Environmental Factors
RBL	Rating background level
RNP	Road Noise Policy (DECCW 2011)

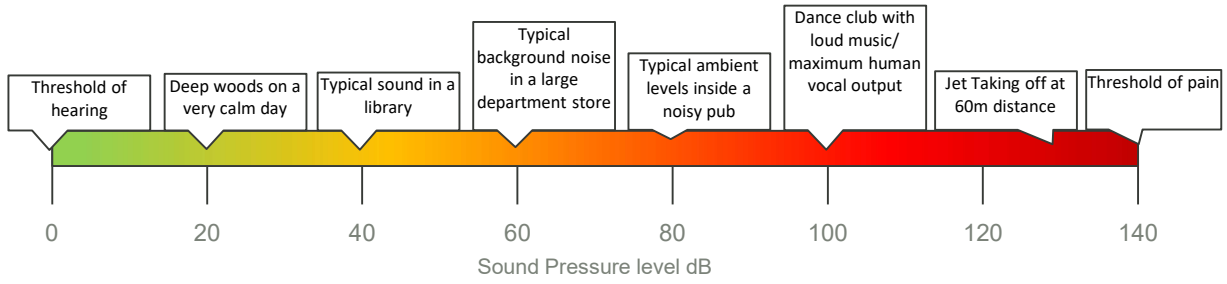
Glossary of acoustic terms

Term	Definition
Assessment Background Level (ABL)	The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night-time) for each day. It is determined in accordance with the methods described in Fact Sheet B of the Noise Policy for Industry (NSW) by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.
Ambient Noise Level	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far. Generally measured as a dB(A) noise level.
Background Noise Level	The A-weighted sound pressure level that is exceeded for 90 percent of the measurement period, L_{A90}.
Background relevant area	A noise sensitive area within a rural area where background levels may be higher than usual. This includes areas where freeway or highway traffic is a significant audible background noise source.
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context.
Decibel	The decibel is a logarithmic way of describing a ratio. The ratio may be power, sound pressure, voltage, intensity or other parameters.
dB(A)	The A-weighted sound pressure level in decibels, denoted dB(A) is the unit generally used for the measurement of environmental, transportation or industrial noise. The A-weighting scale approximates the sensitivity of the human ear when exposed to normal levels and correlates well with subjective perception of typical sounds. An increase or decrease in sound level of approximately 10 dB(A) corresponds to a subjective doubling or halving in loudness. A change in sound level of 3 dB(A) is considered subjectively just noticeable and a change of 1 to 2 dB(A) is subjectively not noticeable.
dB (C)	C-weighting is an adjustment made to sound-level measurements that takes account of low-frequency components of noise within the audibility range of humans.
Frequency	The rate of repetition of a sound wave. The unit of frequency is Hertz (Hz), defined as one cycle per second. Human hearing ranges approximately from 20 Hz to 20,000 Hz. Octave bands are the most used frequency bands. For more detailed analysis each octave band may be split into three one-third octave bands or narrow frequency bands.
Habitable Room	Any room of a dwelling or residential building other than a bathroom, laundry, toilet, pantry, walk-in wardrobe, corridor, stair, lobby, photographic darkroom, clothes drying room and other space of a specialised nature occupied neither frequently nor for extended periods.
$L_{Aeq,\ T}$	The equivalent continuous A-weighted sound pressure level is the value of the A-weighted sound pressure level of a continuous steady sound that has the same mean square sound pressure level as a sound under consideration with a level that varies with time when determined over the same measurement period.
$L_{Aeq,15min}$ dB	A-weighted energy averaged noise level over a 15-minute period. Used in the EPA Interim Construction Noise Guideline (ICNG).
L_{AFmax}	The maximum sound pressure level of an event measured with a sound level meter satisfying AS IEC 61672.1-2004 set to 'A' frequency weighting and fast time weighting
$L_{A10,\ 15min}$ dB	The A-weighted sound pressure level that is exceeded for 10% of the 15-minute measurement period.
$L_{A90,\ 15min}$ dB	The A-weighted sound pressure level measured using fast time weighting that is exceeded for 90% of the time over a 15-minute assessment period. This is a measure of background noise.
$L_{AF90,(day,\ evening,\ night)}$ dB	The A-weighted sound pressure level measured using fast time weighting that is exceeded for 90% of the time over a day, evening or night-time assessment period. This is a measure of background noise.

Term	Definition
Low frequency	Noise containing major components in the low-frequency range (10 hertz [Hz]to 160 Hz) of the frequency spectrum.
Median	The middle value in a number of values sorted in ascending or descending order. Hence, for an odd number of values, the value of the median is simply the middle value. If there is an even number of values, the median is the arithmetic average of the two middle values.
Meteorological conditions	Wind and temperature-inversion conditions.
Noise	Noise is unwanted, harmful or inharmonious (discordant) sound. Sound is wave motion within matter, be it gaseous, liquid or solid.
Noise impact assessment (NIA)	The component of an Environmental Impact Statement, Environmental Assessment, Statement of Environmental Effects, or licence application that considers the impacts of noise resulting from a development or activity.
Noise limits	Enforceable noise levels that appear in conditions on consents and licences. The noise limits are based on achievable noise levels which the proponent has predicted can be met during the environmental assessment.
Noise-sensitive land uses	Land uses that are sensitive to noise, such as residential areas, churches, schools and recreation areas.
Noise catchment area (NCA)	NCAs are areas where receivers have a similar land use and ambient noise environment and are applicable to residential receivers only.
Noise Management Level (NML)	These are the guidance noise levels for airborne noise at sensitive land uses during any construction work as prescribed in the Interim Construction Noise Guideline.
Non-compliance	Any exceedance of a consent/licence limit is considered a non-compliance. However, the type of regulatory action taken by a regulatory authority will depend on a number of factors, in accordance with the authority's prosecution policies and guidelines.
1/1 Octave Band	Band of frequencies in which the upper limit of the band is twice the frequency of the lower limit. For example, the 1000 Hz (1 kHz) octave band contains noise energy at all frequencies from 707 to 1414 Hz.
1/3 Octave Band	The one-third octave bands are subintervals of one octave. An octave is spanned by three 1/3-octave bands.
Project noise trigger levels	Target noise levels for a particular noise-generating facility during its operational phase. They are based on the most stringent of the project intrusiveness noise level or the project amenity noise level.
POEO Act	Protection of the Environment Operations Act 1997 (POEO)
Rating Background Level (RBL)	The Rating Background Level for each period is the median value of the ABL values for the period over all the days measured. There is therefore an RBL value for each period – daytime, evening and night-time.
Residence	A lawful and permanent structure erected in a land-use zone that permits residential use (or for which existing use rights under the EP&A Act apply) where a person/s permanently reside and is not, nor associated with, a commercial undertaking such as caretakers' quarters, hotel, motel, transient holiday accommodation or caravan park.
Reasonably most affected location	Locations that experience (or will experience) the greatest noise impact from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source location(s), distance from source (or proposed source) to receiver, and any shielding between source and receiver. This should not be construed to mean that limits only apply at the worst, most-affected location
Receiver	The noise-sensitive land use at which noise from a development can be heard.

Term	Definition
Sound Power	The total airborne sound energy emitted by a sound source per unit time. The unit of sound power is Watts (W). The sound power level allows us to objectively compare the sound output of different devices, without any knowledge of the environment in which they were tested or the distance at which measurements were taken.
Sound pressure or acoustic pressure	Sound pressure at a point is the local pressure deviation from the ambient (average or equilibrium) atmospheric pressure, caused by a sound wave. In air, sound pressure can be measured using a microphone, and in water with a hydrophone. The SI unit of sound pressure is the pascal (Pa).
Sound Pressure Level (SPL or L_p)	Sound pressure level is equal to 10 times the logarithm (to base 10) of the ratio of the rms sound pressure squared to a reference sound pressure squared. The reference value for sound pressure levels is 20 µPa. $L_p = 10 \log_{10} \frac{p^2}{p_0^2}$
Sound Power Level (SWL or L_w)	Sound power level is equal to 10 times the logarithm (to base 10) of the ratio of the rms sound power to a reference sound power. the reference value for sound power levels is 1 pW. $L_w = 10 \log_{10} \frac{W}{W_0}$
Tenth (10^{th}) percentile method	Method to establish the rating background levels as described in the Fact Sheet B of the NSW Noise Policy for Industry
Tonality	Sound containing a prominent discrete frequency or frequencies and characterised by a definite pitch.

Indicative noise levels of typical sources



Glossary of vibration terms

Term	Definition
Amplitude	The measurement of energy or movement in a vibrating object. Amplitude is measured and expressed in three ways: ■ Displacement (commonly in mm Pk-Pk); ■ Velocity (commonly in mm/s Pk); and ■ Acceleration (commonly in m/s^2 RMS). Amplitude is also the y-axis of the vibration time waveform and spectrum; it helps define the severity of the vibration.
Frequency	The repetition rate of a periodic vibration, per unit of time, determined by taking the reciprocal of the period (T). Frequency is expressed in: Hz (how many cycles per second); Frequency is also the x-axis of the vibration spectrum.
Hertz (Hz)	Vibration can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. The frequency of vibration and sound is measured in hertz (Hz). Once hertz is one cycle per second. Structural Vibration is generally measured over the frequency range from 1Hz to 500Hz (0.5kHz).
Peak to Peak (Pk-Pk)	This is the measure of the vibration amplitude, maximum to minimum, equal to twice of the RMS value of a sine wave.
Peak particle velocity (PPV or $V_{i\ max}$)	The maximum resultant particle velocity $V_{i\ max}$ characterizes the vibration severity
Peak vector sum	The resultant particle velocity magnitude or vector sum of the transverse, vertical and longitudinal particle velocity components.
RMS velocity	For most applications where there is continuous vibration, vibration is measured in terms of root mean square RMS velocity (mm/s).

Executive Summary

Aurecon has been engaged by Populous to undertake an acoustic assessment of the potential impacts associated with the development of the St George Illawarra Dragons Community and High-performance Centre (CHPC) to be located within the University of Wollongong Innovation Campus, 7 – 9 Squires Way, Fairy Meadow, Wollongong NSW. The development at this stage is proposed to include the construction of two new sporting fields, a new indoor training facility with function spaces and a new external parking facility.

Nearby noise and vibration sensitive receivers were identified, and unattended measurements were completed to characterise the existing ambient noise environment. The results of the noise survey were used to establish operational and construction noise emission limits.

In general terms noise levels emitted from the operations of the development, will be able to meet the relevant project operational noise limits and requirements without mitigation based on the latest design and information provided.

Operational noise emissions

Operational Training Noise

An assessment of the operational training noise emissions has been undertaken for the development. Several assumptions have been made with respect to the noise emissions from NRL training sessions, with a combination of whistling and shouting for specific time periods incorporated into the overall predicted noise emissions.

From the assessment, compliance with the noise criteria derived for training operations has been achieved.

It is suggested that for subsequent stages of the project, source noise measurements of an NRL team session or a professional sporting team training session would be beneficial in predicting and understanding of noise emissions from these training sessions.

Building Services Operations

An assessment of the rooftop mechanical plant has been undertaken as the plant is exposed to the surrounding environment and sensitive receivers. Two scenarios were assessed based on the operation of the development during the day period and the evening period. All rooftop plant is assumed to be in operation during the day period and only specific rooftop plant in operation when the development is being used in the evening. Compliance with the Noise Policy for Industry (NPfI) for noise intrusiveness and project amenity is achieved for the operation of the rooftop plant for both scenarios.

It should be noted that if the rooftop plant design changes, additional assessments may be required in future stages of the design of the project to ensure compliance with the NPfI is achieved.

Carpark Assessment

A carpark assessment has been undertaken on the new carpark located south of the development. The assessment is based on *Bavarian State Agency for the Environment 2007, Parking Area Noise, 6th Edition, Bavarian State Ministry for the Environment, Germany* (Bavarian Standard) methodology and the criteria is based upon the NPfI for noise intrusiveness and project amenity. Based on the inputs provided, the predicted sound power level of the car park operations was 40 dBA, which would present no issues to nearby noise sensitive receivers with respect the NPfI daytime noise criteria.

Additional Traffic Noise Assessment

A review of the additional traffic induced by the project was undertaken to ascertain whether increase in induced traffic would exceed the 2 dBA change in noise level criteria as detailed in the Road Noise Policy (RNP), as the development would not be changing the design of surrounding roads.

The greatest change in traffic volumes was approximately 6% for Elliots Road and Cowper St due to the development. This change in traffic would not induce a change in road traffic noise of 2 dBA.

As a result of this comparison, it is expected that there are no noise impacts of the additional generated traffic due to the development.

Construction noise and vibration

No construction noise and vibration assessment has been undertaken at this stage of the project, as no construction methodology has been developed. However, construction noise and vibration criteria has been developed based on the long-term unattended noise monitoring which is detailed in Section 5 and indicative construction noise and vibration management methods are detailed in Section 7.

It is recommended that a detailed construction noise and vibration impact study is undertaken during subsequent stages of the project (when a detailed programme and construction methodology is developed), to accurately determine the level of impact on surrounding affected receivers and develop site-specific management strategies.

1 Introduction

Aurecon has been engaged by Populous to provide technical services for the Development Application (DA) and design of the St George Illawarra Dragons Community and High-performance Centre (CHPC) project to be located within the University of Wollongong Innovation Campus, 7 – 9 Squires Way, Fairy Meadow, Wollongong NSW .

The development has been prepared with respect to the St George Illawarra Dragons High-performance & community Centre Brief & Scope of Services dates 15th of September 2015.

The development comprises of two new sporting fields, a new indoor training facility with function spaces and a new external parking facility.

1.1 Reference documentation

- *Assessing Vibration: A Technical Guideline* (DEC, 2006)
- *Construction Noise and Vibration Strategy (TfNSW, 2020)*
- *Interim Construction Noise Guideline* (NSW DECC, 2009)
- *Noise Policy for Industry* (NSW EPA, 2017)
- *Road Noise Policy (NSW DECCW, 2011)*
- *St George Illawarra Dragons CHPC, Transport Impact Assessment, Aurecon, July 2023 (Reference: P520547)*
- *Chapter D14: Wollongong Development Control Plan 2009 – in force 24 May 2017, Section 15.1 Acoustics*
- *Prediction of Parking Area Noise in Australian Conditions, Renzo Tonin, November 2011*
- *Bavarian State Agency for the Environment 2007, Parking Area Noise, 6th Edition, Bavarian State Ministry for the Environment, Germany (Bavarian Standard, 2007)*
- *Kai Tak Multi-Purpose Sports Complex, Environmental Impact Assessment Report, Programme No. 272 RS, Appendix 5.4B, Human Noise Level Determination, Hong Kong, 2014*
- *Referee whistles Part II—Outdoor sound power assessment, The Journal of the Acoustical Society of America 145, 1816, William J. Murphy, 2019*

2 Project Overview

2.1 Key noise and vibration risks

The key noise and vibration risks assessed within this DA report are detailed below. Operational noise has been considered and is split into the following assessments,

- Operational Training Noise
- Building Services Noise
- Carpark operation noise
- Additional traffic noise to surrounding noise sensitive areas.

At this point in the design, Construction Noise and Vibration noise management limits have been considered and indicative management measures have been detailed. Once an agreed construction methodology is developed, a complete construction noise and vibration assessment is to be undertaken.

3 Site Description

The development is located on the University of Wollongong Innovation campus, 7 – 9 Squires Way, Fairy Meadow. The site area is approximately 70,000 m^2 comprising of the northern section of the university campus.

A site plan is shown below in Figure 3-1.

Figure 3-1 Site plan of the development

3.1 Surrounding sensitive receivers

Noise and vibration sensitive receivers are generally categorised by the type of occupancy and/or the activities performed within the property boundary. This includes:

- Residences (including multi-floor dwellings): Each floor of a multi-floor dwelling is considered to be a separate sensitive receiver as each floor could have separate property owners and/or land uses (e.g. commercial ground floor and residential first floor)
- Educational institutes
- Hospitals and medical facilities
- Places of worship
- Commercial or industrial premises
- Childcare Centre

The potentially nearest affected noise sensitive areas in relation to the facility are listed below. Table 3-1 and Figure 3-2 detail the sensitive receivers and their locality to the development.

Table 3-1 Nearest noise sensitive areas

ID	Receiver type	Location
R1	Residential	North of the development location (Elliots Road, Rann St, Storey St, Carters Lane)
R2	Residential	West of the development site location (2A to 29 Montague St, Bourke St and Cowper St)
E1	Educational	South of the development (Existing University of Wollongong South of the facility location) comprising student accommodation to the west of the Field 1 and classrooms to the south of the proposed development.
C1	Commercial	Commercial/Industrial developments south-west of the facility location (38 – 73 Montague St)
CC	Childcare	Kids Uni, Innovation campus (Chilcare Centre), Nissen Hut, Fairy Meadow NSW 2500

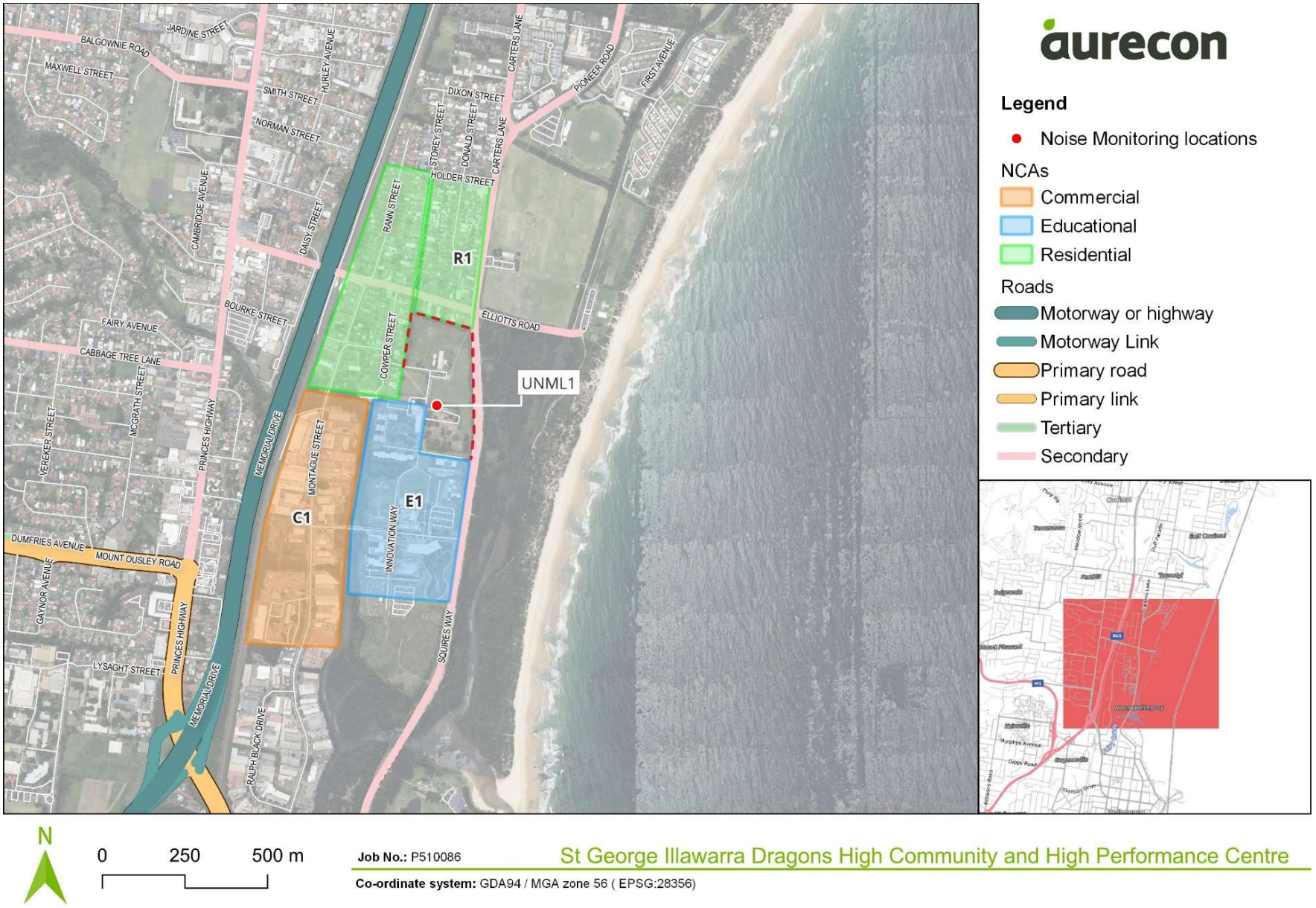


Figure 3-2 **Project area, surrounding sensitive receivers and noise measurement locations**

4 Ambient Noise Survey

A survey of the existing ambient noise levels around the project site was conducted using both unattended measurements. All instruments used have current calibration from a NATA accredited laboratory and comply with Australian Standard AS-1259: *Sound Level Meters*. Noise measurements were conducted between 29th November and 7th December 2021 and located in Figure 3-2.

Measured noise levels during COVID19 pandemic would have been lower than typical background and ambient noise levels (due to less road traffic and aircraft noise), resulting in potentially conservative operational noise emission criteria.

4.1.1 Methodology

Baseline noise measurement location considerations included land topography, distance from facility to surrounding sensitive residencies and contribution from other environmental noise sources.

The long-term noise logging location proposed for the development was selected at UNML 1 (refer Figure 3-2). The noise levels measured at this location would be representative of the noise levels at other residential properties around the development site (to the north and west).

All measurements were performed in accordance with the Australian Standard AS1055 2018 '*Acoustics – Description and measurement of environmental noise*'.

4.1.2 Unattended noise measurements

Long-term unattended noise monitoring was carried out using a NGARA environmental noise logger, installed with microphone at a height of 1.5m. The location of the noise logger was away from buildings that may provide shielding and/or reflections. Monitoring was conducted from 29th November to 7th December 2021, with the logger set to measure continuously using an A-weighted fast response mode. The monitors were calibrated before and after the monitoring period and no calibration drift exceeding ±1 dB(A) was observed.

The data collected by the noise monitors was analysed, and any invalid data was removed. Invalid data generally refers to periods where average wind speeds were greater than 5m/s and/or when rainfall occurred, in accordance with the requirements of *Noise Policy for Industry* (NPfI) (NSW EPA, 2017). Concurrent weather data was sourced from the Bureau of Meteorology's Bellambi (station ID: 068228) automatic weather station (AWS), to identify any periods of weather which may have affected the monitoring results.

A summary of the unattended continuous noise monitoring is presented in Table 4-1. Detailed noise monitoring data is attached in Appendix A.

Table 4-1 Unattended noise monitoring results

Location	Rating background noise level (RBL) $L_{90(period)}$ dB(A)			Average noise level $L_{eq(period)}$ dB(A)				
	Day	Evening	Night	Day	Evening	Night	Day (15hr)	Night (9hr)
UNML1	46	44	37	60	51	51	57	50

Note 1: RBL is the median of the measured LA90 noise level during the day, evening and nigh-time periods of the monitoring programme.
Note 2: For the rating background and ambient noise levels, the periods are defined as per the NPI (EPA, 2017):

- *Day: the period from 7.00 am to 6.00 pm Monday to Saturday or 8.00 am to 6.00 pm on Sundays and public holidays*
- *Evening: the period from 6.00 pm to 10.00 pm*
- *Night: the remaining periods.*

For the 15-hour and 9-hour ambient noise levels, as per the Development Near Rail Corridors and Busy Roads – Interim Guideline (NSW DoP, 2008), day refers to the 7am to 10pm while night refers to 10pm to 7am.

5 Noise and Vibration Criteria

5.1 Operational noise emissions

Upon review of the existing Development Control Plan (DCP) for the Wollongong Innovation Campus implemented on March 2017, specific acoustic performance guidelines are outlined for operational noise emissions from the campus. *Chapter D14, Section 15.1 Acoustics* details the following operational noise limits for the day, evening and night periods.

- Day, 40 dB(A)
- Evening, 38 dB(A)
- Night, 35 dB(A)

It is noted that the unattended noise measurement results summarised in Table 4-1 for average noise levels for day, evening and night significantly exceeds the limitations set out in the DCP. Even without the proposed development, the campus does not comply with the DCP requirements. Therefore, the proposed development has not been assessed with respect to the DCP.

There are no other specific provisions in NSW, under a noise policy, standard or guideline, that provides guidance on noise impacts associated with sporting facilities. The *Noise Policy for Industry* (NPfI) (NSW EPA, 2017) is generally referenced for the assessment of environmental noise emissions; however this policy is specifically aimed at assessing noise from industrial sources scheduled under the Protection of Environment Operations Act (POEOA) (NSW EPA, 1997).

- While the NPfI is not strictly applicable for noise emissions from sporting facilities, it provides a useful framework for the assessment of operational noise emissions, whether they are intrusive or non-intrusive.
- The NSW Land & Environment Court (NSWLEC) has provided context on acceptable levels of noise impacts from outdoor play areas in its decision's history. As outdoor play areas are used periodically and generally for timed durations (recess/lunch break vs PE classes and sports days), a decision of background level + 10dB(A) noise criterion was reached for impacts associated with use of outdoor play areas, for a two hours maximum use, on several NSWLEC decisions (*Meriden School v Pedavoli* (2009) NSWLEC 183 and *Bankstown City Council v Mohamad El Dana* (2009) NSWLEC 68). CHPC outdoor playing field usage will be similar to any outdoor school play area with intermittent playing and respite periods. The noise criteria from the activities of a playing field for CHPC should be similar to a school playing field.
- The Association of Australasian Acoustical Consultants (AAAC) provides guidance for the assessment of noise impacts from proposed childcare centre developments, in its publication *Guideline for Child Care Centre Acoustic Assessment* (Version 3.0, 2020). Although this guideline applies for childcare centre developments, there are similarities in noise emission from uses of outdoor training fields and childcare centres. As students do not play outdoors continuously for extended periods of time, as the duration of time students playing outside reduces, so does the overall noise annoyance. Therefore, it is reasonable to allow for a marginally higher noise level requirement as that adopted for steady and continuous noise source assessments (i.e background + 5 dB or amenity levels as per the NSWE EPA NPfI). The AAAC guideline states that if the total outdoor play time is limited to no more than 2 hours in the morning and 2 hours in the afternoon, the contributed $L_{eq,15minute}$ noise level emitter from the outdoor play shall not exceed the background noise level by 10dB. This is similar to an average rugby training session, as each session would approximately run for up to 2 hours, with sessions running during the morning and afternoon.

Based on this information relevant guidelines/polices referenced for the assessment of operational noise emissions are as follows:

- **Operational Noise Criteria for an outdoor training space** – NSWLEC decision of background noise level + 10 dB(A).

5.1.1 NSW EPA Noise Policy for Industry

The NPfI provides the framework and process for deriving the noise limits for assessments under the *Protection of the Environment Operations Act* 1997. The guideline specifies that there are two aspects of environmental noise that require assessment. The first relates to the intrusiveness of a noise source, and allows for the noise under assessment to be a margin above the background, whilst the other procedure relates to the acceptability of the resulting noise, in relation to maintaining the amenity of the surrounding area. The more stringent of the amenity or intrusive criteria would define the appropriate criteria for a project.

Project intrusiveness noise level

The intrusiveness noise level seeks to limit the degree of change a new noise source introduces to an existing environment. A noise source would generally be considered non-intrusive, if the monitored average noise level (L_{Aeq}) for a period does not exceed the RBL by more than 5 dB(A). Intrusive noise levels are only applied to residential receivers (residences).

Based on the results of noise monitoring detailed in Section 4, the following project intrusive noise criteria have been calculated.

Table 5-1 Project intrusiveness noise criteria

Location	Time period	Rating background noise level (RBL) $L_{90(period)}$[1] dB(A)	Allowance	Intrusiveness noise level $L_{eq(15min)}$ dB(A)
Any affected surrounding residential receivers	Daytime (7am – 6pm)	46	+5dB	51
	Evening (6pm – 10pm)	44		49
	Night-time (10pm – 7am)	37		42
Childcare Centre (Similar to residential)	When in use (8am – 6pm)	46	+5dB	51

Project amenity noise level

To limit continuing increases in noise levels from the application of intrusiveness objective alone, this guideline recommends amenity noise levels for different receivers within a study area (Table 2.2 of the NPfI), to ensure ambient levels from all sources combined within this area are suitably controlled. To ensure the noise levels (existing + new) remain within the recommended amenity noise levels for an area, the project amenity noise level is defined by the recommended noise levels minus 5 dB(A).

Whilst the land zoning for the residential receivers around the development is R3 (Medium Density Residential), the area is characterised by an urban 'hum' due to the constant traffic on Memorial Drive. Further, the measured background noise levels are representative of an urban area. Hence, for this project, all residential receivers adjacent to the proposed development have been defined as 'Urban'.

Table 5-2 Project amenity noise criteria

Receiver	Time of day	NPfI recommended amenity noise level $L_{eq(period)}$ dB(A)	Project amenity noise level $L_{eq(15min)}$[1] dB(A)
Residential – suburban	Daytime (7am – 6pm)	60	58
	Evening (6pm – 10pm)	50	48
	Night-time (10pm – 7am)	45	43
	Daytime (7am – 6pm)	65	63

Receiver	Time of day	NPfI recommended amenity noise level $L_{eq(period)}$ dB(A)	Project amenity noise level $L_{eq(15min)}$[1] dB(A)
Student accommodation[2]	Evening (6pm – 10pm)	55	53
	Night-time (10pm – 7am)	50	48
Classroom – external[3]	Noisiest 1 hour period when in use	45	43
Commercial premises	When in use	65	63
Childcare Centre (Similar to residential)	When in use (8am – 6pm)	60	58

Note 1: Converted from $L_{Aeq(period)}$ to $L_{Aeq(15min)}$ for consistence and ease of comparison with intrusiveness noise level requirement. This conversion is in accordance with the guidance provided in Fact Sheet E of the NPfI.

Note 2: Amenity noise levels for student accommodation has been set to be the corresponding residential amenity noise criteria + 5 dB in accordance with the NPfI.

Note 3: A conservative 10 dB has been added to the NPfI recommended indoor amenity levels to estimate the outdoor amenity levels.

5.1.2 Noise from increased traffic generation on surrounding public road network

The redevelopment project is proposed to increase the traffic volumes from the facility as detailed in Table 6-6. This will result in increased traffic volumes on the surrounding public road network, which in turn has the potential for noise impacts to the surrounding residential properties.

For land use developments with the potential to create additional traffic on public streets, guidance is provided in the *Road Noise Policy* (RNP) (NSW DECCW, 2011). Section 2.3.1 of this policy sets out road traffic noise assessment criteria for residential land uses. Criteria relevant to this project are summarised in Table 5-3.

Table 5-3 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment criteria, dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Sub-arterial roads	Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 50 (external)
Local roads		$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

In addition to the assessment criteria outlined in Table 5-3, any increase in the total traffic noise level at a location due to a proposed project must be considered. Where existing traffic noise levels are above the noise assessment criteria, Section 3.4 of the RNP outlines that the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. An increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

5.1.3 Sleep disturbance criteria during operations

The proposed after-hours use of some areas of the redevelopment project will be restricted to the daytime and evening period (7am – 10pm). No operations are proposed during the night-time period (10pm – 7am), hence assessment of sleep disturbance impacts to surrounding residential receivers is not required.

5.1.4 Summary of operational noise criteria

The relevant project specific operational noise criteria are summarised in Table 5-4 below.

Table 5-4 Project operational noise criteria for surrounding affected residences

Operational noise element	Time period	Project operational noise criteria[1]
Outdoor training areas	Daytime (7am – 6pm)	56 dB
	Evening (6 pm – 10 pm)	54 dB
Building Services	Daytime (7am – 6pm)	51 dB
	Evening (6pm – 10pm)	48 dB
Car Park Operation	Daytime (7am – 6pm)	51 dB
Additional traffic on surrounding public roads	Daytime (7am – 6pm)	Less than a change of 2 dB

Note 1: Project noise trigger levels are to be assessed at the reasonably most-affected point on or within the residential property boundary or, if the property boundary 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.

5.2 Construction noise and vibration

The *Interim Construction Noise Guideline* (ICNG) (NSW DECC 2009) generally applies to the management of construction noise in NSW. This guideline provides recommendations on standard construction hours and construction noise management levels (NMLs).

5.2.1 Recommended standard hours of work

Section 2.2. of the ICNG recommends standard hours for construction work as follows:

- Monday to Friday: 7am to 6pm,
- Saturday: 8am to 1pm, and
- No work on Sundays or public holidays

The ICNG notes that the recommended standard hours of work are not mandatory and acknowledges that some activities could be undertaken outside the recommended standard hours of work, assuming all feasible and reasonable mitigation measures are implemented to minimise the impacts to any surrounding sensitive land uses. These activities include:

- the delivery of oversized plant or structures that police or other authorities determine requires special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- public infrastructure works that shorten the length of the project and are supported by the affected community
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- works which maintain noise levels at receivers to below the noise management levels outside of the recommended standard construction hours.

5.2.2 Construction noise management levels

Recommended construction NMLs for residential receivers and non-residential receivers are presented in Table 5-5 and Table 5-6 respectively. The NMLs represent a noise level that, if exceeded, would require management measures including the following:

- reasonable and feasible work practices
- contact with residences to inform them of the nature of works to be carried out, the expected noise levels and durations and contact details.

The management measures aim to reduce noise impacts on the residential receivers; however, it may not be reasonable and feasible to reduce noise levels to below the noise affected management level. The construction NMLs during recommended standard hours of work are not intended as a noise limit but rather a level where noise management is required. The construction NMLs outside of recommended standard hours would be considered as noise limits unless a private agreement has been reached with the affected residential receivers.

Table 5-5 ICNG recommended construction noise criteria for residential receivers

Time of day	Management level $Leq_{(15min)}$[1] dB(A)	How to apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays.	Noise affected RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15min)}$ 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 75dB(A)	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 for works near schools, or mid-morning or mid-afternoon for works near residences) ■ if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours (OOHW)[2]	Noise affected RBL + 5 dB(A)	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 practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Note 1: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metres above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Note 2: OOHW hours are as defined in the ICNG

- *OOHW Period 1 (Day) – Saturdays 7am to 8am and 1pm to 6pm; Sundays and public holidays 8am to 6pm.*
- *OOHW Period 1 (Evening) – Monday to Saturday 6pm to 10pm.*
- *OOHW Period 2 – Monday to Saturday 10pm to 7am; Sundays and public holidays 6pm to 8am.*

Table 5-6 ICNG recommended construction noise criteria for non-residential receivers

Receiver type	Time of day	Management level $Leq_{(15min)}$[1] dB(A)
Commercial properties	When in use (typically, daytime only, during standard business hours)	70 (external)
Industrial properties		75 (external)
Educational institutes		45 (internal) 55 (external)[4]
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)		75 (external)
Childcare Centre	When in use (8am – 6pm)	RBL + 10 dB(A)

Note 1: Internal noise levels are to be assessed at the centre of the occupied room. External noise levels are to be assessed at the most affected point within 50 metres of the area boundary. Where internal noise levels cannot be measured, external noise levels may be used. A conservative estimate of the difference between internal and external noise levels is 10 dB. Some buildings may achieve greater performance, such as where windows are fixed (that is, cannot be opened).

5.2.3 Sleep disturbance impacts during construction

Construction works associated with the development are suggested to be undertaken during the recommended standard hours of work. Hence assessment of sleep disturbance impacts to surrounding residential receivers should not be required. If construction works is required to be undertaken outside standard hours of work, a sleep disturbance assessment will be required.

5.2.4 Project construction noise criteria

The relevant specific construction NMLs are presented in Table 5-7 for residential receivers and Table 5-8 for non-residential receivers. The NMLs have been calculated based on the ambient noise survey results (see Section 4) and the guidance in Section 5.2.2.

Table 5-7 Residential construction NML

Location	Recommended standard hours NML $L_{eq(15min)}$ dB(A)	Outside of standard hours NML $L_{eq(15min)}$ dB(A)			Highly affected NML $L_{eq(15min)}$ dB(A)
		OOHW period 1 (day)	OOHW period 1 (evening)	OOHW period 2 (night)	
All affected surrounding residential receivers (see Figure 3-2)	56	51	49	42	75
Childcare Centre (8am to 6pm)	56	N/A			75

Table 5-8 Non-residential construction NMLs

Receiver type	Noise management level (NML) $Leq_{(15min)}$ dB(A)
All commercial properties (including retail, offices etc.)	70 (external)
All industrial properties	75 (external)
Educational institutes	55 (external)
Active recreation areas	65 (external)

5.3 Construction Vibration criteria

The effects of vibration impacts on buildings and structures can be divided into two categories:

- Human comfort impacts – where the occupants or users of the affected building are possibly disturbed
- Structural impacts – effects on building contents and structural integrity

The ICNG makes a reference to *Assessing Vibration: A Technical Guideline* (AVTG) (NSW DEC, 2006), for consideration of acceptable vibration levels.

5.3.1 Human comfort

Construction vibration can adversely affect the amenity of occupants inside buildings as it may affect their quality of life or working efficiency. Human comfort impacts are experienced at levels well below those that can damage of affect a structure and its contents. Though it may not always be possible to comply with the more stringent human comfort criterion for infrastructure projects in close proximity to residential dwellings, human comfort should always be used as the objective to aim for and be the basis of assessment.

Guidance in relation to acceptable vibration levels for human comfort are provided in AVTG, which in turn is based on the guidelines contained in British Standard *BS 6472 – 1992*, *Guide to Evaluation of Human Exposure to Vibration in Buildings (1 hertz (Hz) to 80 Hz)*. *BS 6472-1:2008* superseded this British Standard in 2008. Although a new version of BS 6472 has been published, AVTG still references the 1992 version of this standard and the EPA still advises vibration to be assessed in accordance with this version of the standard.

AVTG classifies vibration as one of three types:

- Continuous – where vibration occurs uninterrupted and can include sources such as machinery and constant road traffic.
- Impulsive – where vibration occurs over a short duration (typically less than two seconds) and occurs less than three times during an assessment period. This may include activities such as occasional dropping of heavy equipment or loading / unloading activities.
- Intermittent – occurs where continuous vibration activities are regularly interrupted, or where impulsive activities recur. This may include activities such as rock hammering, drilling, pile driving and pavement breakers.

Construction activities typically generate ground vibrations of an impulsive or intermittent nature and are assessed using Peak Particle velocity. The vibration limits relevant to the surrounding sensitive receiver types are presented in Table 5-9.

Table 5-9 Human comfort intermittent vibration limits

Receiver type	Assessment Period	Peak particle velocity mm/s	
		Preferred values	Maximum values
Residences	Daytime[1]	8.6	17
Offices, schools, educational institutions and places of worship		18	36
Workshops		18	36

Note 1: The NSW EPA's Assessing Vibration guideline defines daytime period as 7am – 10pm.

5.3.2 Structural damage (including impact to heritage structures)

Vibration transmission through the ground can cause a structure and structure coupled elements (walls, windows, roof etc.) to radiate. The transmitted vibration energy has the potential to damage and compromise the integrity of a structure as well as increase the risk of damage to building contents.

There is no current Australian Standard that sets criteria for the assessment of building damage caused by vibrations. Guidance on limiting vibration values with the potential to cause structural damage is typically referenced from the German Standard DIN 4150: Part 3 – 2016 *Effects of Vibration on Structures* (DIN guideline).

The DIN guideline recommended maximum permissible levels of vibration (expressed as peak particle velocity or PPV) that reduce the likelihood of building damage caused by vibration and are presented in Table 5-10. PPV is the absolute value of the maximum of any of the three orthogonal component particle velocities as measured at the foundation, and the maximum levels measured in the x- and y-horizontal directions in the plane of the floor of the uppermost storey.

It should be noted that heritage structures should be considered on a case-by-case basis, as a heritage listed structure may not necessarily be more sensitive to vibration than a standard structure. Where a historic heritage structure is deemed to be sensitive to damage, the criteria in Line 3 of Table 5-10, should be considered.

Table 5-10 Guideline values for short-term vibration on structures

Line	Type of Structure	Peak Particle Velocity (PPV) $v_{i, max}$, mm/s			Topmost floor, horizontal direction, i = x,y All Frequencies	Floor slabs, vertical direction, i = z All frequencies
		Foundation, all directions, i = x, y, z at a frequency of				
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]		
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15	20
3	Structure that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 **and** are of great intrinsic value (e.g. listed buildings)	3	3 to 8	8 to 10	8	20

Note 1: At frequencies above 100 Hz, the values given in this column may be used as minimum values.

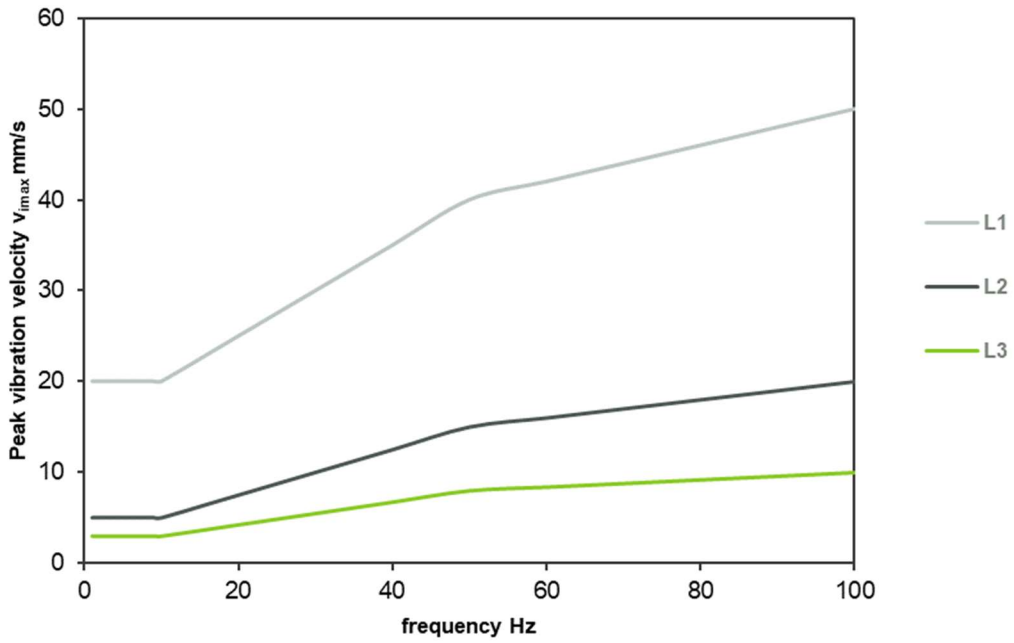


Figure 5-1 Graphical representation of guideline values specified in Table 5-10 for velocities measured at the foundation

6 Operational Noise Assessment

6.1 Training Operations Noise Assessment

The assessment of training operations for the sporting fields considers specific noise sources and their frequency over a specific time-period. At this point in time, no specific source noise levels have been acquired for NRL training sessions. Indicative noise source levels have been estimated based on acoustic data from international studies. These noise source levels and estimated exposure times are detailed in Section 6.1.1 below.

6.1.1 Source Noise Levels

Source noise levels have been extracted from a whistle acoustic study undertaken in the United States of America[2] which details the sound power level of a whistle blown at full effort, whilst the sound power level for a human shout has been extracted from a sporting facility assessment in Hong Kong[3]. Table 6-1 details the sound power levels of the training noise sources utilised for the assessment.

Table 6-1 Source noise levels for training activities

Type	Estimated exposure time during a training session	SWL[1] dB(A)	Linear SWL dB at Octave Band Centre Frequency, Hz							
			63	125	250	500	1000	2000	4000	8000
Whistle	1 second over a 30 second period	**110**	110 dBA @ 4KHz							
Human Shout	1 second over a 15 second period	**91**	52	63	73	84	89	82	75	64

Note 1: SWL stands for Sound Power Level

6.1.2 Field Use

The use of the fields has been detailed below by St George Illawarra Dragons management[4], forwarded on from Bridge 42.

The most consistent teams/programs that would utilise the field through winter are as follows:

- **NRLW** – 2 to 3 nights per week, 5:30 pm to 7:00 pm, between May to September.
- **NSW Cup** – 2 nights per week, 5:30 to 7.00 pm, between November to September (will sometimes share with NRLW)
- **SCORE Dragons (All Abilities team)** – 1 night per week, 4:15pm to 5:30pm, between April to October.
- **Dragons Academy** – 1 night per week, 5:00pm to 6:30pm, between February to September

Community Use:

- **NRL Development Coaching Courses** - 6 sessions, 5:30 pm to 8:30 pm, between April to June.
- **Dragons Coach the Coach Night** - 2 sessions, 6:00 pm to 8:00 pm, between April to June.
- **NRL RISE Program**:
  - Boys x 5 sessions, U13s to U15s, 5:30 pm to 8.30 pm, between July to August.
  - Girls x 5 sessions, U13s to U15s, 5:30 pm to 8.30 pm, between July to August.

[2] *Referee whistles Part II—Outdoor sound power assessment, The Journal of the Acoustical Society of America 145, 1816 (2019), William J. Murphy*
[3] *Kai Tak Multi-Purpose Sports Complex, Environmental Impact Assessment Report, Programme No. 272 RS, Appendix 5.4B, Human Noise Level Determination, Hong Kong, 2014*
[4] *Email from Bridge42, Nick Allen, 15 July 2022 12:19 PM.*

6.1.3 Assessment

The assessment for the training operations has been based on the following assumptions,

- Both fields are being utilised simultaneously, with two training sessions being undertaken.
- Each of the training sessions consist of whistles and human shouting as per the exposure time detailed in Table 6-1**Error! Reference source not found.**.
- The propagation of the noise emissions from the training activities have been assumed from the middle of each of the fields as an average location of the training activities.
- The training sessions are to occur during the day period and evening period, with the worst case being in the evening based on the use detailed in Section 6.1.2.

The predicted noise levels to the closest residences north and east of the development are detailed in Table 6-2. The table compared the predicted noise levels to the developed noise criteria for the training operations.

Table 6-2 Predicted operational noise levels for the training operations

Receiver type	Field Use Noise Prediction $L_{eq(15min)}$ dB(A)	Noise Criteria (Day) $L_{eq(15min)}$ dB(A)	Noise Criteria (Evening) $L_{eq(15min)}$ dB(A)
R1 – 9A Elliots Road (North)	52	56	54
R2 – 17 Cowper St (West)	52		
Student accommodation	47	63	53
Commercial premises	35	63	63
Classroom (external)	38	43	43
Childcare Centre (8am – 6pm)	54	56	N/A

The predicted noise levels for the training operations are within derived noise criteria for the day period and evening period for the training assumptions made above. Compliance with the derived noise criteria is achieved for both the day and evening periods, based on the source noise levels in Table 6-1 and assumptions above.

It is recommended that for future stages of design, source noise measurements be undertaken for NRL training sessions to better understand and predict noise emanating from training activities.

6.2 Building Services Noise Assessment

The assessment of operational building services noise has been assessed with respect to the concept design. The concept design details the mechanical plant being placed on the roof of the development which is exposed to the environment. An assessment of rooftop building services is required to ensure compliance with the NPfI.

6.2.1 Assumptions and methodology

The following assumptions and methodologies have been utilised in the assessment of the rooftop building services.

- The prediction methodology used is ISO9613-2 *Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation.* The prediction considers distance propagation loss, atmospheric attenuation and ground attenuation.

- Shielding has been taken into consideration for the predictions.
- Predictions to the closest receivers north and west of the development was undertaken.
- All sound data was acquired from supplier catalogues.
- Where radiated sound power levels were not provided by the supplier, the exhaust sound power level was utilised, with a casing adjustment incorporated into the calculation to generate a radiated sound power levels for the mechanical equipment.

Two scenarios have been assessed for the mechanical plant; these are detailed below.

- Scenario 1: Day period, all rooftop plant is operation, all at full capacity
- Scenario 2: Evening period, where rooftop plant associated with the foyer, function, and kitchen space are in operation.

6.2.2 Source Noise Levels

The schedule of the rooftop plant has been detailed in **Error! Reference source not found.** below which also details what rooftop plant operated during the daytime and evening period.

Table 6-3 Schedule of rooftop mechanical plant

Brand	Model	Equipment #	Type	Total SWL dBA	Radiated Sound Power Levels Octave Band Centre Frequency, Hz								Source of Data
					63	125	250	500	1k	2 k	4 k	8 k	
Scenario 1: Daytime													
Trane	CMAC 400	CH-RF-01	Air-Cooled Chiller	95	81	85	97	94	90	85	80	78	Supplier Data
Trane	CMAC 400	CH-RF-02	Air-Cooled Chiller	95	81	85	97	94	90	85	80	78	Supplier Data
Airchange	ACPP2000	PAC-RF-01	PoolPAC Unit - Intake	75	52	64	61	63	72	64	70	57	Supplier Data
			PoolPAC Unit - Exhaust	87	64	76	73	75	84	76	82	69	Supplier Data
Armcor	AHU3000P3	AHU-RF-01	Rooftop AHU	72	58	70	64	68	70	55	54	40	Supplier Data
Armcor	AHU3000P3	AHU-RF-02	Rooftop AHU	72	58	70	64	68	70	55	54	40	Supplier Data
Armcor	AHU3000P3	AHU-RF-03	Rooftop AHU	72	58	70	64	68	70	55	54	40	Supplier Data
Armcor	AHU1200P3	AHU-RF-04	Rooftop AHU	66	58	56	63	66	62	52	40	36	Supplier Data
Armcor	AHU3000P3	AHU-RF-05	Rooftop AHU	72	58	70	64	68	70	55	54	40	Supplier Data
Armcor	AHU2500P3	AHU-RF-06	Rooftop AHU	69	61	62	66	70	64	54	44	38	Supplier Data
Armcor	AHU1200P3	AHU-RF-07	Rooftop AHU	66	58	56	63	66	62	52	40	36	Supplier Data
Armcor	AHU4000P3	AHU-RF-08	Rooftop AHU	66	60	65	64	67	62	52	41	34	Supplier Data
Armcor	AHU1200P3	AHU-RF-09	Rooftop AHU	66	58	56	63	66	62	52	40	36	Supplier Data
Armcor	AHU2500P3	AHU-RF-10	Rooftop AHU	69	61	62	66	70	64	54	44	38	Supplier Data
Armcor	AHU2500P3	AHU-RF-11	Rooftop AHU	69	61	62	66	70	64	54	44	38	Supplier Data
Armcor	AHU2500P3	AHU-RF-12	Rooftop AHU	69	61	62	66	70	64	54	44	38	Supplier Data
Fantech	GUD636V	KEF-RF-01	Roof Kitchen Exhaust Fan	78	59	74	76	75	74	70	64	52	Supplier Data
Scenario 2: Evening													
Trane	CMAC 400	CH-RF-01	Air-Cooled Chiller	95	81	85	97	94	90	85	80	78	Supplier Data
Armcor	AHU1200P3	AHU-RF-04	Rooftop AHU	66	58	56	63	66	62	52	40	36	Supplier Data
Armcor	AHU3000P3	AHU-RF-05	Rooftop AHU	72	58	70	64	68	70	55	54	40	Supplier Data
Armcor	AHU2500P3	AHU-RF-06	Rooftop AHU	69	61	62	66	70	64	54	44	38	Supplier Data
Armcor	AHU1200P3	AHU-RF-07	Rooftop AHU	66	58	56	63	66	62	52	40	36	Supplier Data
Armcor	AHU4000P3	AHU-RF-08	Rooftop AHU	66	60	65	64	67	62	52	41	34	Supplier Data
Fantech	GUD636V	KEF-RF-01	Roof Kitchen Exhaust Fan	78	59	74	76	75	74	70	64	52	Supplier Data

6.2.3 Assessment

The two scenarios have been assessed with respect to the intrusive and project amenity noise criteria. The predicted noise levels are detailed in Table 6-4 and Table 6-5**Error! Reference source not found.Error! Reference source not found.**.

Table 6-4 Daytime scenario predicted noise levels for rooftop mechanical plant

Receiver Location	Predicted levels – Day Period Scenario $Leq_{(15min)}$ dB(A)	Intrusiveness Noise criteria $Leq_{(15min)}$ dB(A)	Project Amenity Noise criteria $Leq_{(15min)}$ dB(A)
R1 – 9 A Elliots Road	39	51	58
R2 – 29 Cowper St	44		
Student accommodation	39	-	63
Classroom (external)	40	-	43
Commercial premises	39	-	63
Childcare Centre (8am – 6pm)	51	51	58

Table 6-5 Evening scenario predicted noise levels for rooftop mechanical plant

Receiver Location	Predicted levels – Evening Period Scenario $Leq_{(15min)}$ dB(A)	Intrusiveness Noise criteria $Leq_{(15min)}$ dB(A)	Project Amenity Noise criteria $Leq_{(15min)}$ dB(A)
R1 – 9 A Elliots Road	36	49	48
R2 – 29 Cowper St	40		
Student accommodation	36	-	53
Classroom (external)	36	-	43
Commercial premises	36	-	63

The predicted noise levels for both the day and evening scenarios comply with both the intrusiveness noise criteria and the project amenity noise criteria and no mitigation is required. If the plant schedule changes, additional assessments will be required.

6.3 Car Park Assessment

An operational carpark assessment has been undertaken for the new carpark south of the development. The carpark contains 60 car park spaces, which includes 58 bays and 2 disabled bays. The carpark area is approximately 1360 sq metres.

6.3.1 Assumptions and methodology

The following assumptions and methodologies have been made with respect to the use of the carpark, see below for details.

- The sound power level of the carpark has been calculated based on the *Bavarian State Agency for the Environment 2007, Parking Area Noise, 6th Edition, Bavarian State Ministry for the Environment, Germany.* This standard derives sound power levels for carparks of various uses based on the number of carpark spaces, area of the carpark and number of movements during certain time periods.
- A total of 336 daily trips is estimated for the car park, with 43% of the trips generated during peak hours
- The new carpark is assumed to has an asphalt surface finish.
- The training sessions are to occur during the day period and is to be assessed for the daytime NPfl noise criterion.

6.3.2 Source Noise Levels

The derived source noise level for the carpark is 40 dBA. This sound power level of the operation of the carpark is less than the daytime intrusiveness and project amenity levels of 51 dB(A)$L_{eq(15min)}$ and 58 dB(A)$L_{eq(15min)}$ respectively. The propagation of the carpark noise to nearby sensitive receivers would not exceed the NPfl noise criterion and noise emanating from the car park would not be an issue.

6.4 Additional Traffic Noise Assessment

The Aurecon traffic team has provided an assessment of the additional traffic induced by the development. Table 6-6 below details the number of additional vehicles generated by the development in 2024 compared to the existing

Table 6-6 Additional Vehicles on key intersections and roads due to development

Intersection	AM Peak			PM Peak		
	2023 Existing	2024 With Development	%Δ	2023 Existing	2024 With Development	%Δ
Carters Lane/Elliots Road/Squires Way	1,189	1,259	6%	1,440	1,489	3%
Squires Way/Puckey Avenue	1,804	1,877	4%	2,030	2,103	4%
Elliots Road/Cowper Street	1,592	1,659	4%	1,606	1,691	5%
Puckey Avenue/Innovation Way	363	404	11%	273	322	18%

The increase of traffic on Carters Lane, Elliots Road, Squires Way, Puckey Avenue and Cowper Streets for the peak AM and PM periods for the existing and proposed future scenarios is approximately up to 6% for Elliots Road and Cowper St. A significant increase in traffic volumes would be needed in order to increase road traffic noise by 2 dBA and a 6% increase in traffic flow will not induce a 2dBA increase in road traffic noise levels

As a result of this comparison, it is expected that there are no noise impacts of the additional generated traffic due to the development.

7 Construction Noise and Vibration Management

At the DA stage of the development, no construction methodology has been developed for the construction of the development, however indicative management measures can be considered to reduce the impact of construction noise and vibration. These potential mitigation measures are detailed in Sections 7.1 and 7.2 of this report. Once a construction methodology is developed, a detailed construction noise and vibration can be undertaken to understand what mitigation may be required for the construction of the development.

Construction works including building piling will be 100m away from childcare centre and residential properties and envisaged that noisy works will be managed with minimal impact on childcare centre and residential properties.

7.1 Potential Construction Noise Management

7.1.1 Standard Mitigation Measures

Section 8.1 of the Transport's Construction Noise and Vibration Guideline (CNVG) details standard mitigation measures that should be applied to the overall proposal to minimise construction noise where feasible and reasonable to do so, prior to additional mitigation measures are considered further. These standard mitigation measures are detailed in Table 7-1.

Table 7-1 Standard Construction Noise Mitigation

Action Required	Details
Management measures	
Implement community consultation and notification measures	Periodic notification (3-monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: ■ Project Specific Website ■ Project Infoline ■ Construction Response Line ■ Email Distribution List ■ Web-based Surveys ■ Social Media ■ Community and Stakeholder Meetings and ■ Community Based Forums (if required by approval conditions).
Register of noise and vibration sensitive receivers	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: ■ Address of receiver ■ Category of receiver (e.g. Residential, Commercial etc.) ■ Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.

Action Required	Details
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise levels should be scheduled during less sensitive time periods.
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: ■ all project specific and relevant standard noise and vibration mitigation measures ■ relevant licence and approval conditions ■ permissible hours of work ■ any limitations on high noise generating activities ■ location of nearest sensitive receivers ■ construction employee parking areas ■ designated loading/unloading areas and procedures ■ site opening/closing times (including deliveries) ■ environmental incident procedures.
Behavioural practices	■ No unnecessary shouting or loud stereos/radios on site. ■ No dropping of materials from height, throwing of metal items and slamming of doors. ■ No excessive revving of plant and vehicle engines. ■ Controlled release of compressed air.
Monitoring	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Update Construction Environmental Management Plans	The CEMP must be regularly updated to account for changes in noise management issues and strategies
Source Controls	
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Equipment selection	Use quieter and less noise emitting construction methods where feasible and reasonable.
Maximum Noise Levels	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels in APPENDIX C of the CNVG.
Rental plant and equipment	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the allowable noise levels in APPENDIX C of the CNVG

Action Required	Details
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Non-tonal and ambient sensitive reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of material/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Construction Related Traffic	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on Mobile Plant	Where possible reduce noise from mobile plant through additional fittings including: Residential grade mufflers Damped hammers such as “City” Model Rammer Hammers Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression braking	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘in-service test procedure’ and standard.
Path Controls	
Shield stationary noise sources such as pumps, compressors, fans etc.	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable); noise curtains and consideration of site topography when situating plant.

7.1.2 Additional Mitigation Measures

Section 8.2 of the CNVG details additional noise mitigation measures that could be implemented where the standard noise mitigation measures are not sufficient in reducing the construction noise impacts. These additional noise mitigation measures are:

- Project Notification (PN)
- Specific notifications (SN)
- Respite Period (RP)
- Duration Respite (DR)
- Alternative Accommodation (AA)
- Project Specific Respite Offer (RO)
- Verification (V)

Table 7-2 below, details the triggers for additional mitigation measures for construction noise.

Table 7-2 Implementation of additional airborne noise management measures (Table 9, CNVG)

Construction Hours	Receiver Perception	dB(A) above RBL[1]	dB(A) above ANML	Additional Management Measures
Standard Hours Monday – Friday (7am – 6 pm) Saturday (8am – 1pm)	Noticeable	5 to 10	0	-
	Clearly Audible	>10 to 20	<10	-
	Moderately Intrusive	>20 to 30	>10 to 20	PN, V
	Highly Intrusive	>30	> 20	PN, V
	75dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday-Friday (6pm-10pm) Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Noticeable	5 to 10	<5	-
	Clearly Audible	>10 to 20	5 to 15	PN
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RO
	Highly Intrusive	>30	>25	PN, V, SN, RO, RP[2], DR[2]
OOHW Period 2 Monday-Saturday (12am-7am 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Noticeable	0 to 10	<5	PN
	Clearly Audible	>10 to 20	5 to 15	PN, V
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RP, DR
	Highly Intrusive	>30	>25	PN, V, SN, AA, RP, DR

[1]SWLs used for the purpose of estimating noise impact shall be increased by 5dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock

hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics. It is noted that this correction factor is automatically calculated under Step 2 of the Construction Noise Estimator Tool.

[2] Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

The perception at the receivers is dependent on what construction activity as well as the distance of the receiver to the construction footprint.

A detailed construction noise assessment is required to be undertaken once the construction methodology is known.

7.2 Potential Construction Vibration Management

Section 8.1 of the CNVG details standard mitigation measures for construction vibration affecting human comfort as well as cosmetic building damage. These specific vibration details have been summarised in Table 7-3. These measures should be considered where vibration works would be undertaken in proximity of structures. There are numerous sensitive structures within proximity of the development and an assessment of construction vibration to those structures will be required to understand the vibration impacts.

Table 7-3 Vibration Management Measures

Action Required	Details
Management measures	
Implement community consultation or notification measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: ▪ Project Specific Website ▪ Project Infoline ▪ Construction Response Line ▪ Email Distribution List ▪ Web-based Surveys ▪ Social Media ▪ Community and Stakeholder Meetings and ▪ Community Based Forums (if required by approval conditions).
Register of noise and vibration sensitive receivers	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: ▪ Address of receiver ▪ Category of receiver (e.g. Residential, Commercial etc.) ▪ Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.
Construction hours and scheduling	Where feasible and reasonable, vibration intensive operations should be carried out during the standard daytime working hours. This will reduce the potential for human comfort impacts during the evening and night-time, periods with a higher likelihood of receiver occupancy and hence higher change of complaints.

Action Required	Details
Construction respite period	Vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1-hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: ■ all project specific and relevant standard noise and vibration mitigation measures ■ relevant licence and approval conditions ■ permissible hours of work ■ location of nearest sensitive receivers and structures ■ construction employee parking areas ■ designated loading/unloading areas and procedures ■ site opening/closing times (including deliveries) ■ environmental incident procedures.
Attended Vibration Measurements	Attended vibration measurements shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	The CEMP must be regularly updated to account for changes in noise management issues and strategies
Building Condition Surveys	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage.
Source Controls	
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Equipment selection	Use quieter and less noise emitting construction methods where feasible and reasonable.

8 Conclusion

Aurecon was engaged by Populous to undertake an acoustic assessment of the potential noise and vibration impacts associated with the development of the St George Illawarra Dragons Community and High-performance Centre (CHPC) project in Wollongong NSW. The assessment is to assist in the Development Application required for the project.

In general terms noise levels emitted from the operations of the development, will be able to meet the relevant project operational noise limits and requirements without mitigation. If the operation of the development does change, reassessment may be required to ensure compliance with the noise limits can be achieved.

- The relevant noise and vibration criteria applicable to the development are detailed in Section 5, with project operational noise emissions and construction noise criteria presented in Table 5-4 to Table 5-10.
- Operational noise impacts associated with the development were also assessed in Section 6, for the following key noise sources:
  - Training Activities
  - Building services rooftop plant
  - Carpark
  - Additional traffic on surrounding public road network
- No construction noise and vibration assessment has been undertaken at this point in time as no construction methodology has been developed. However, construction noise and vibration criteria has been developed based on the long-term unattended noise monitoring. Construction works including building piling will be 100m away from childcare centre and residential properties and envisaged that noisy works will be managed with minimal impact on childcare centre and residential properties.

  A detailed construction noise and vibration impact study is recommended during subsequent stages of the project (when a detailed programme and construction methodology is developed), to accurately determine the level of impact on surrounding affected receivers and develop site-specific management strategies. Typical mitigation measures and management procedures that are to be considered are presented in Section 7.

A

Unattended noise monitoring

This section provides details on the noise monitoring

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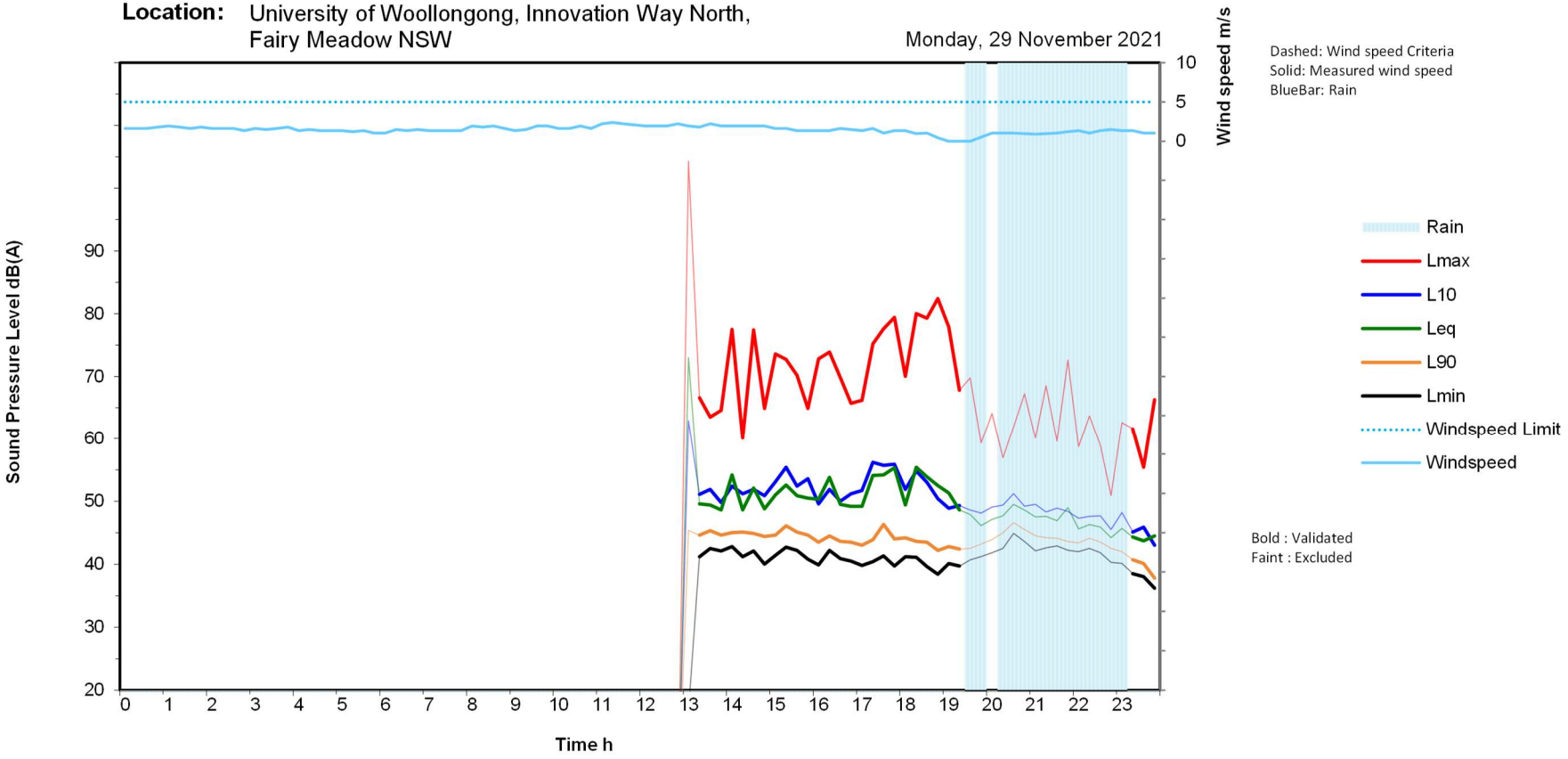

Logger ID UNML1

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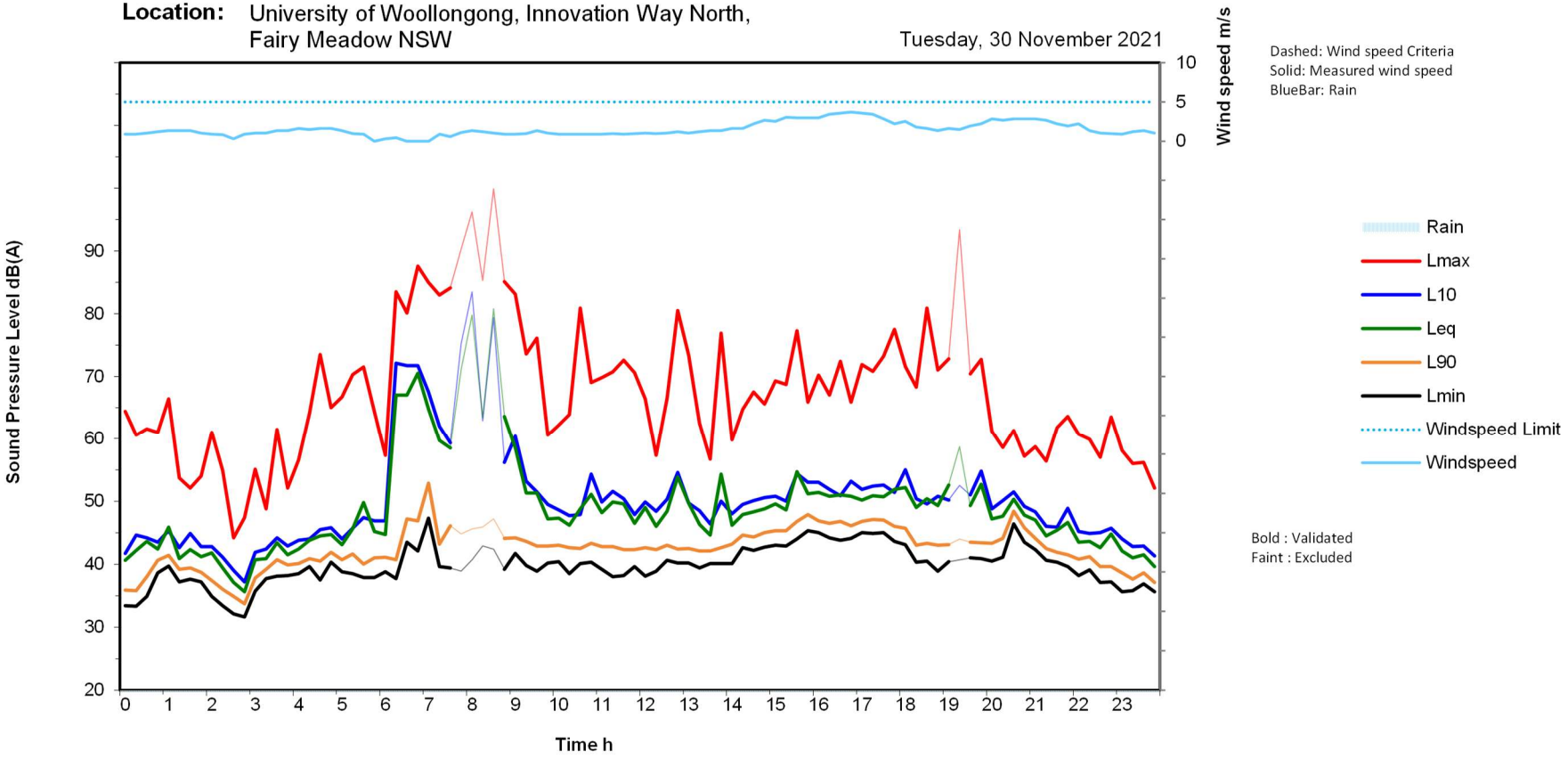

Logger ID UNML1

Location: University of Woollongong, Innovation Way North, Fairy Meadow NSW

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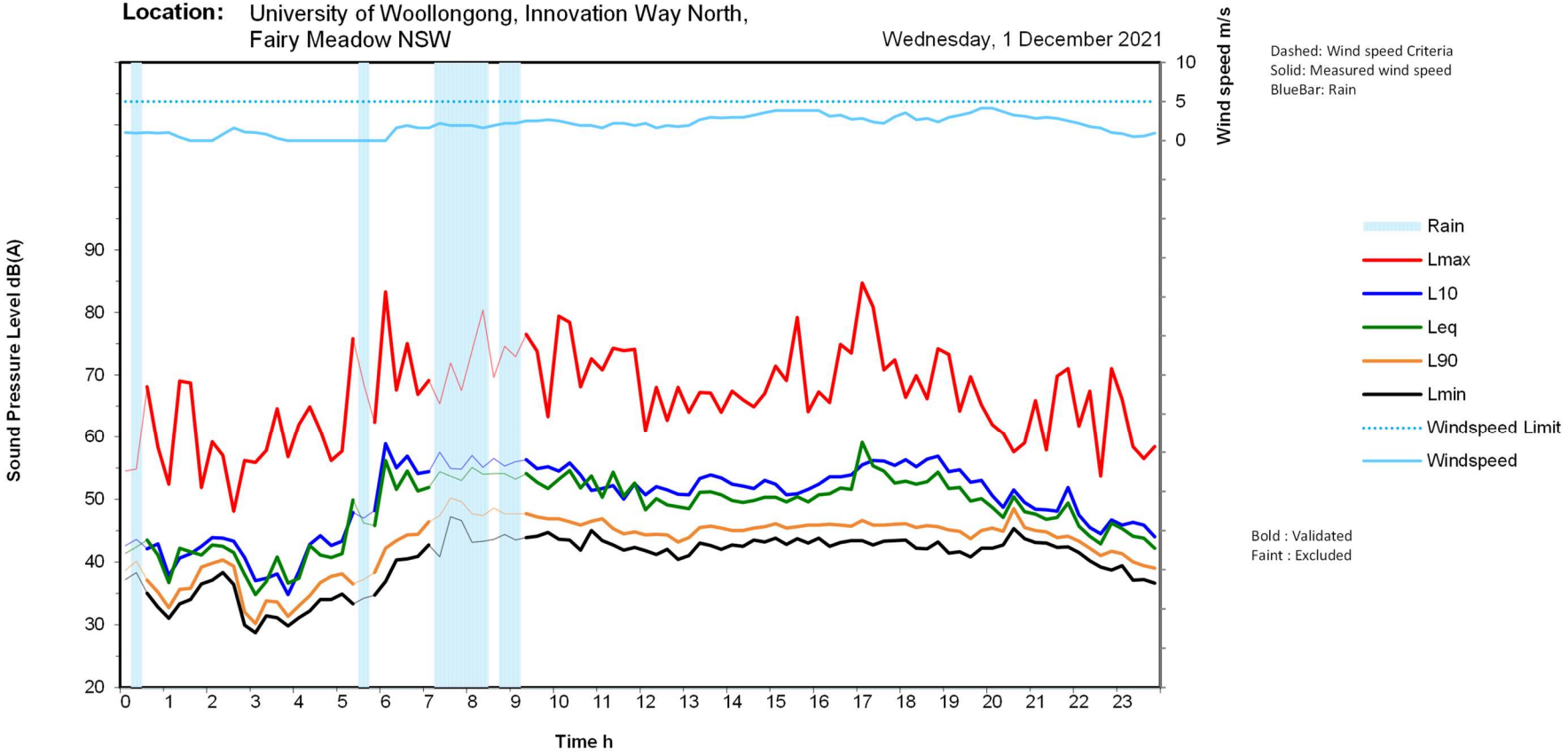

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Location: University of Woollongong, Innovation Way North, Fairy Meadow NSW

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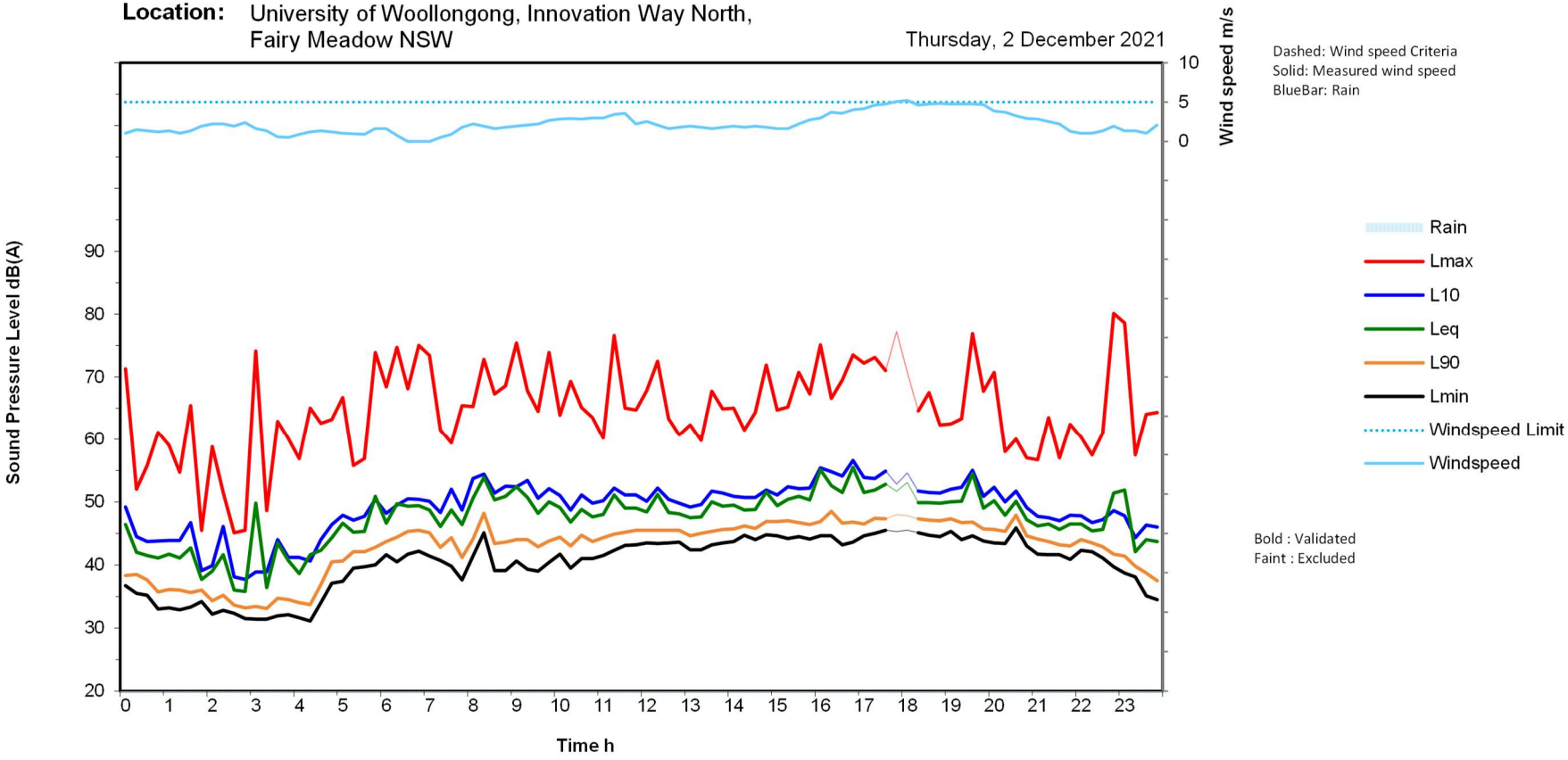

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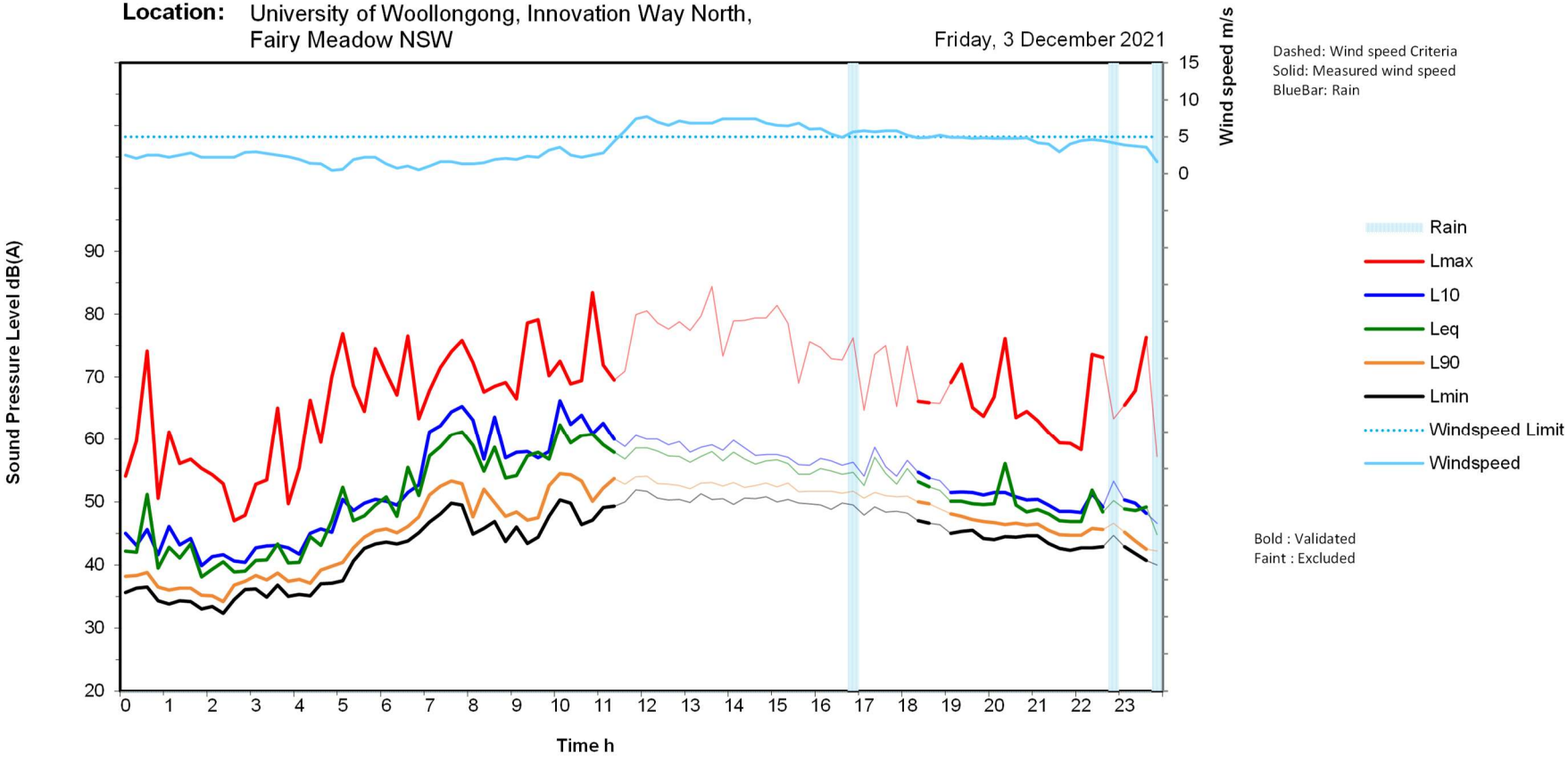

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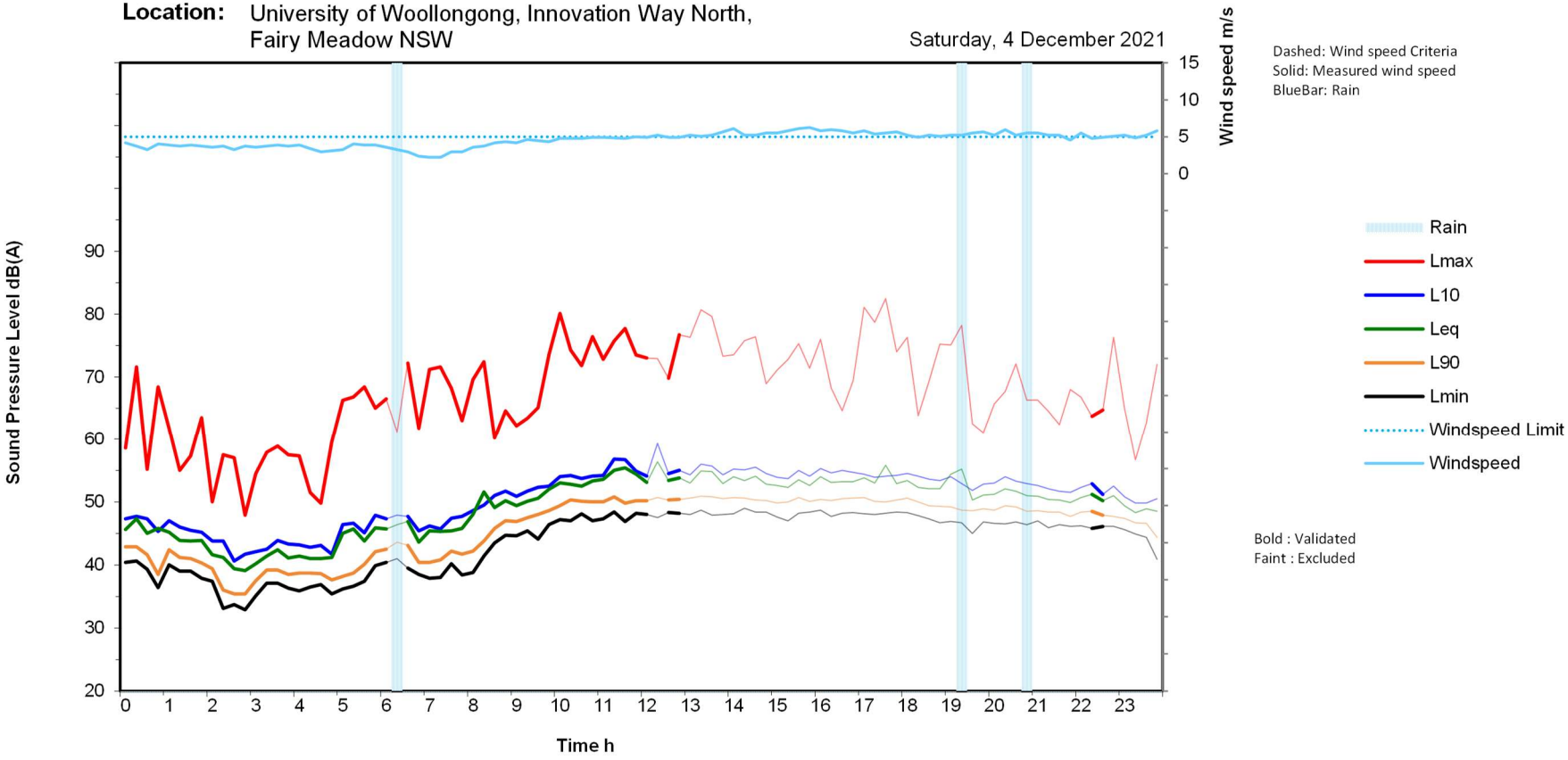

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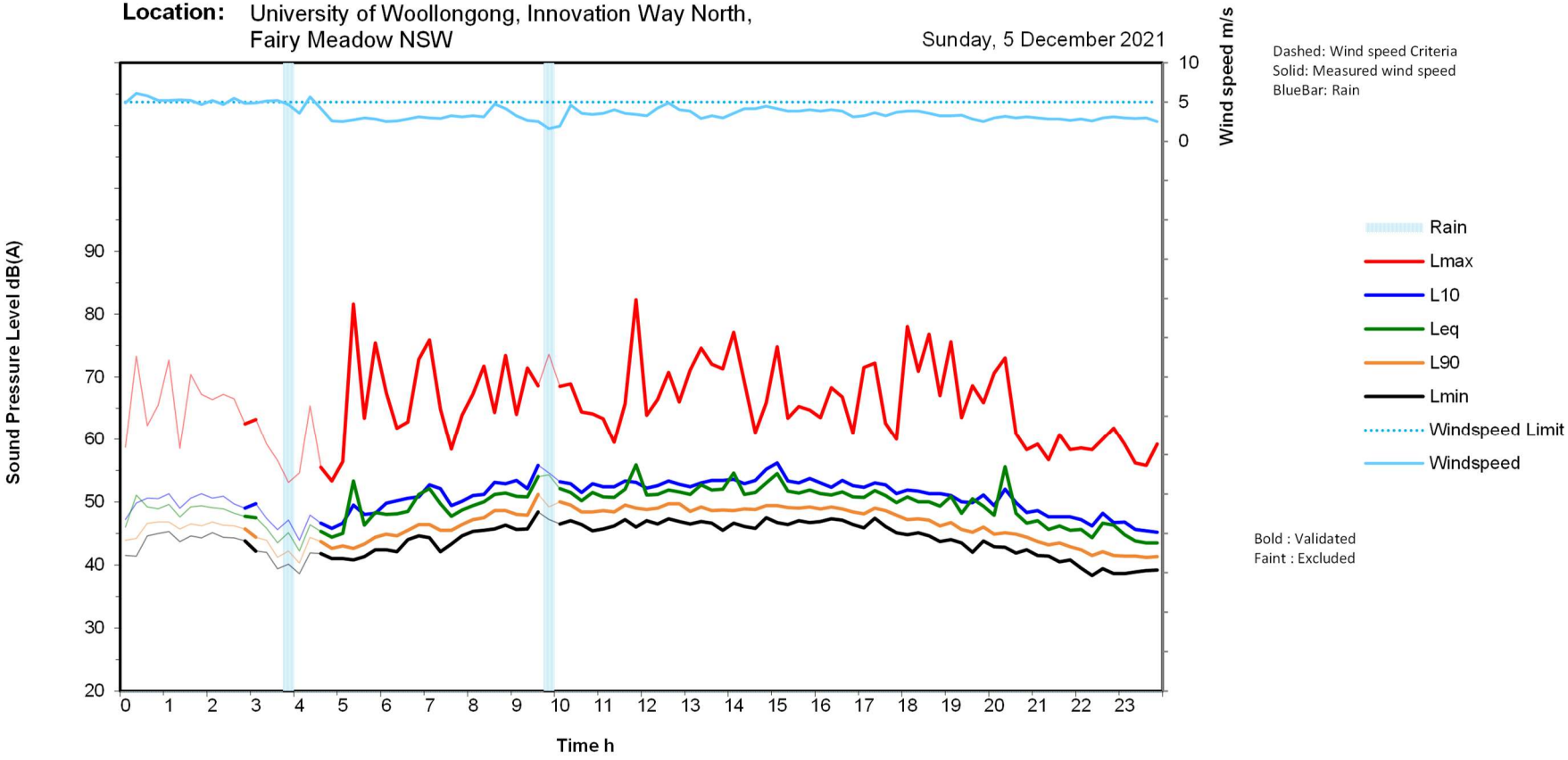


Dashed: Wind speed Criteria
Solid: Measured wind speed
BlueBar: Rain

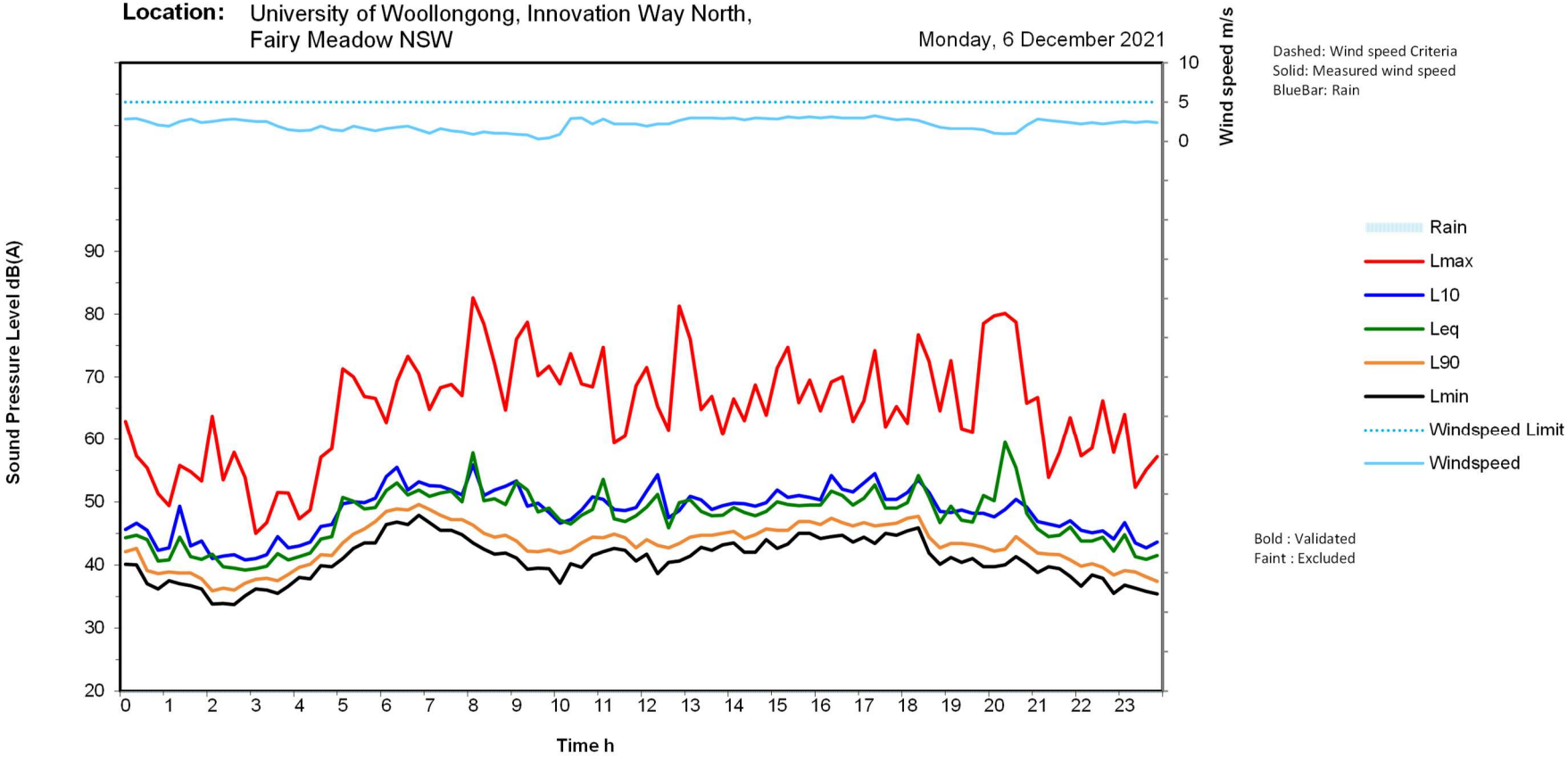
Rain
Lmax
L10
Leq
L90
Lmin
Windspeed Limit
Windspeed

Bold : Validated
Faint : Excluded

Logger ID UNML1

Location: University of Woollongong, Innovation Way North, Fairy Meadow NSW

Monday, 6 December 2021



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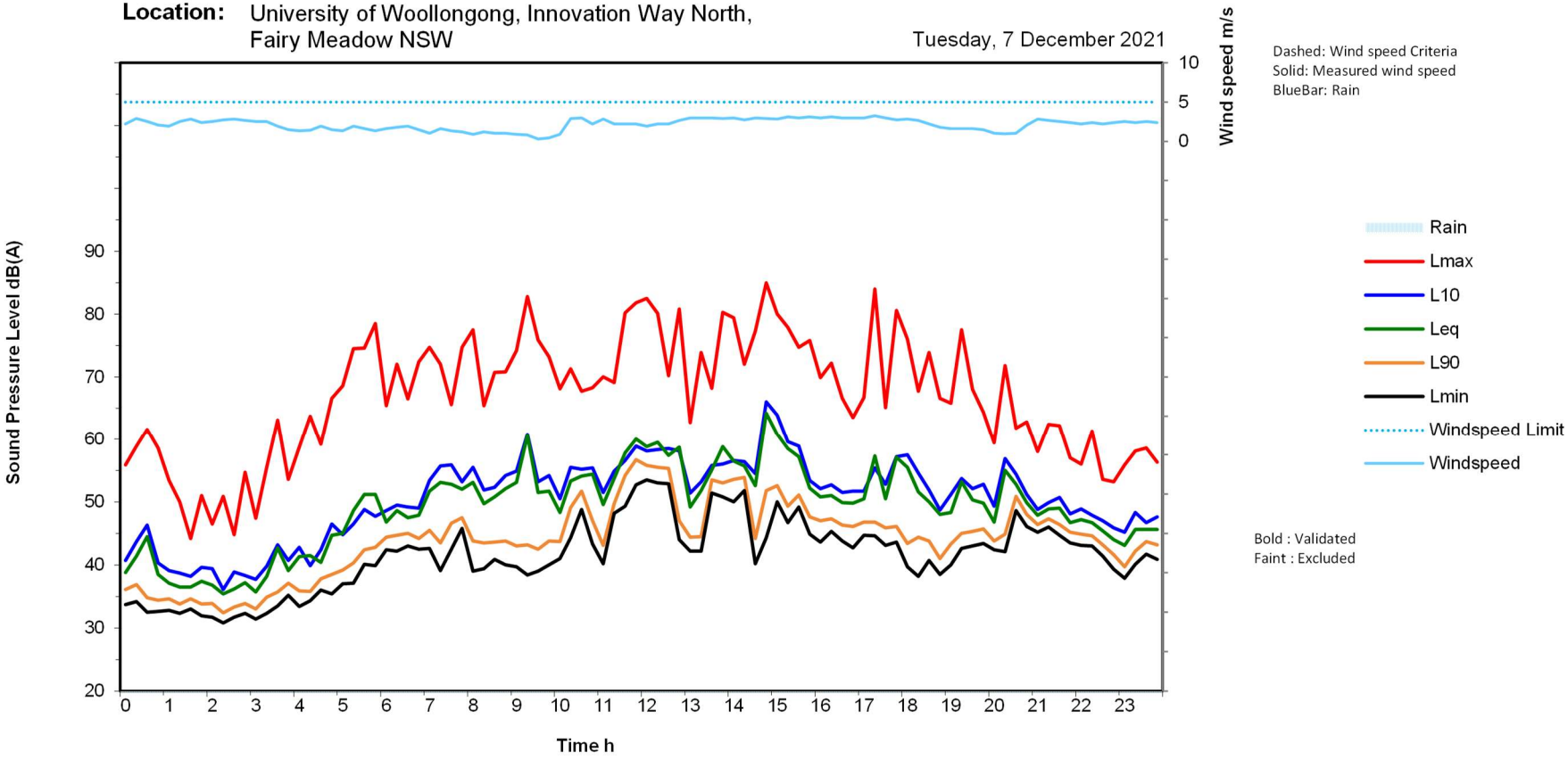

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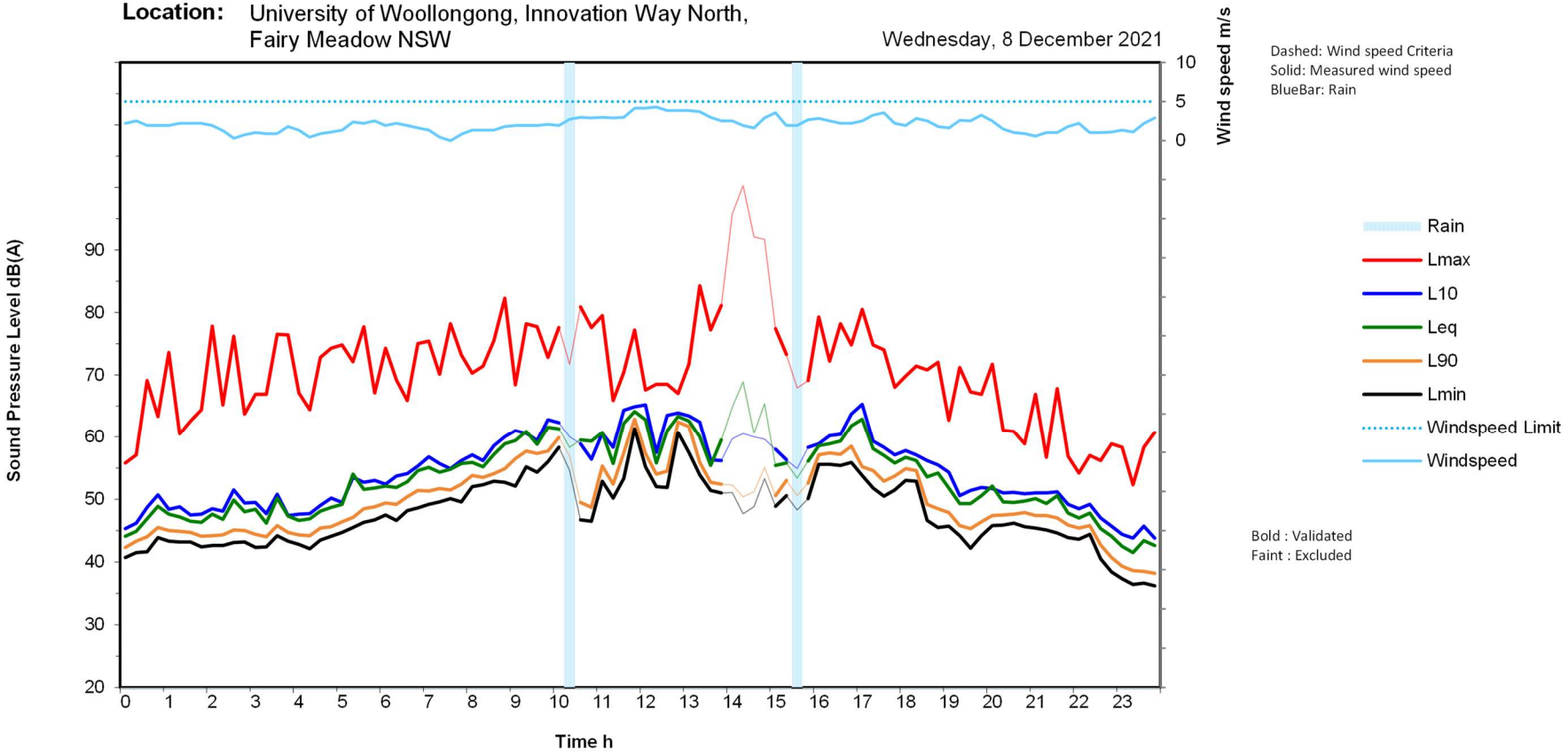

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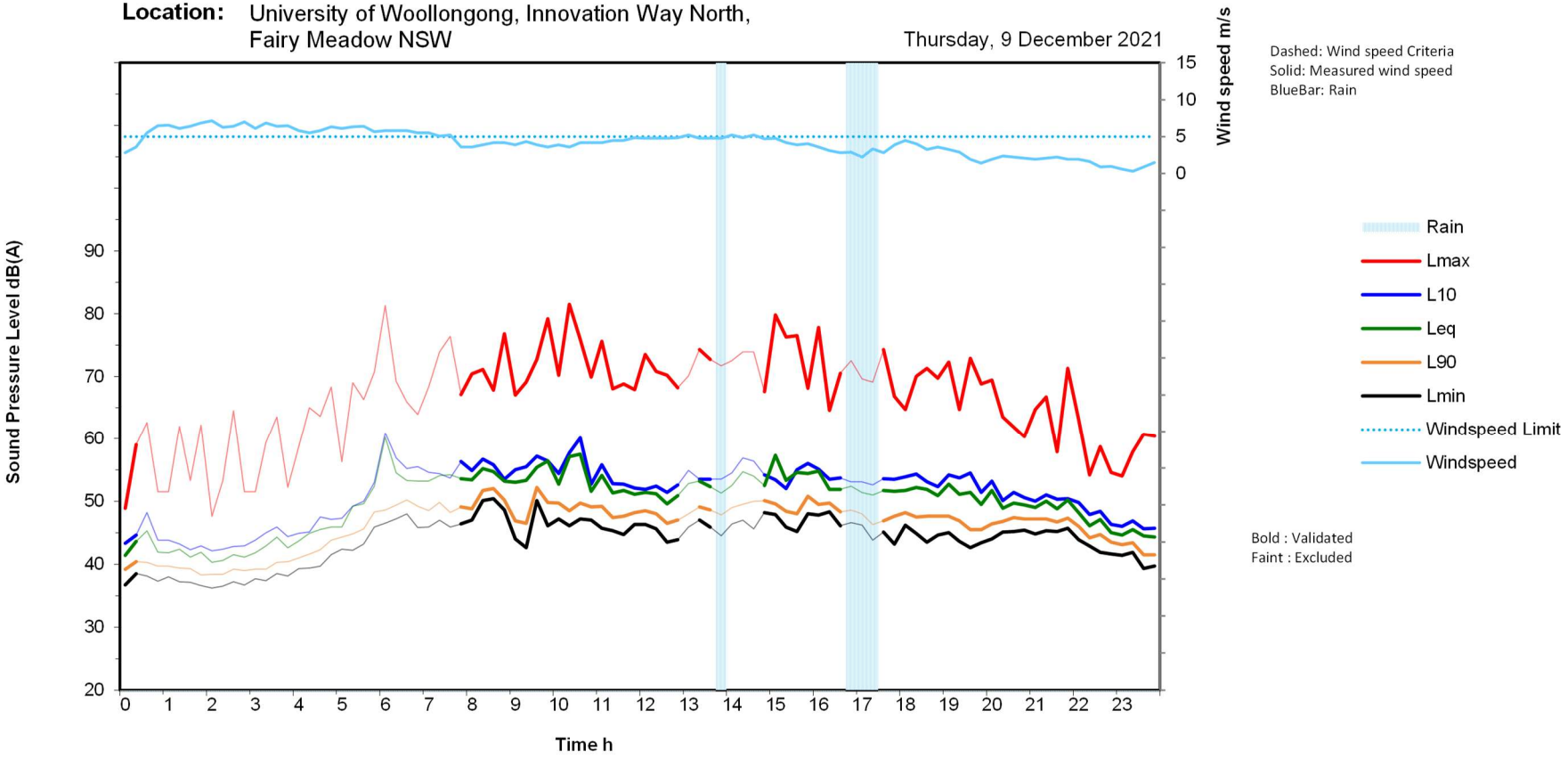

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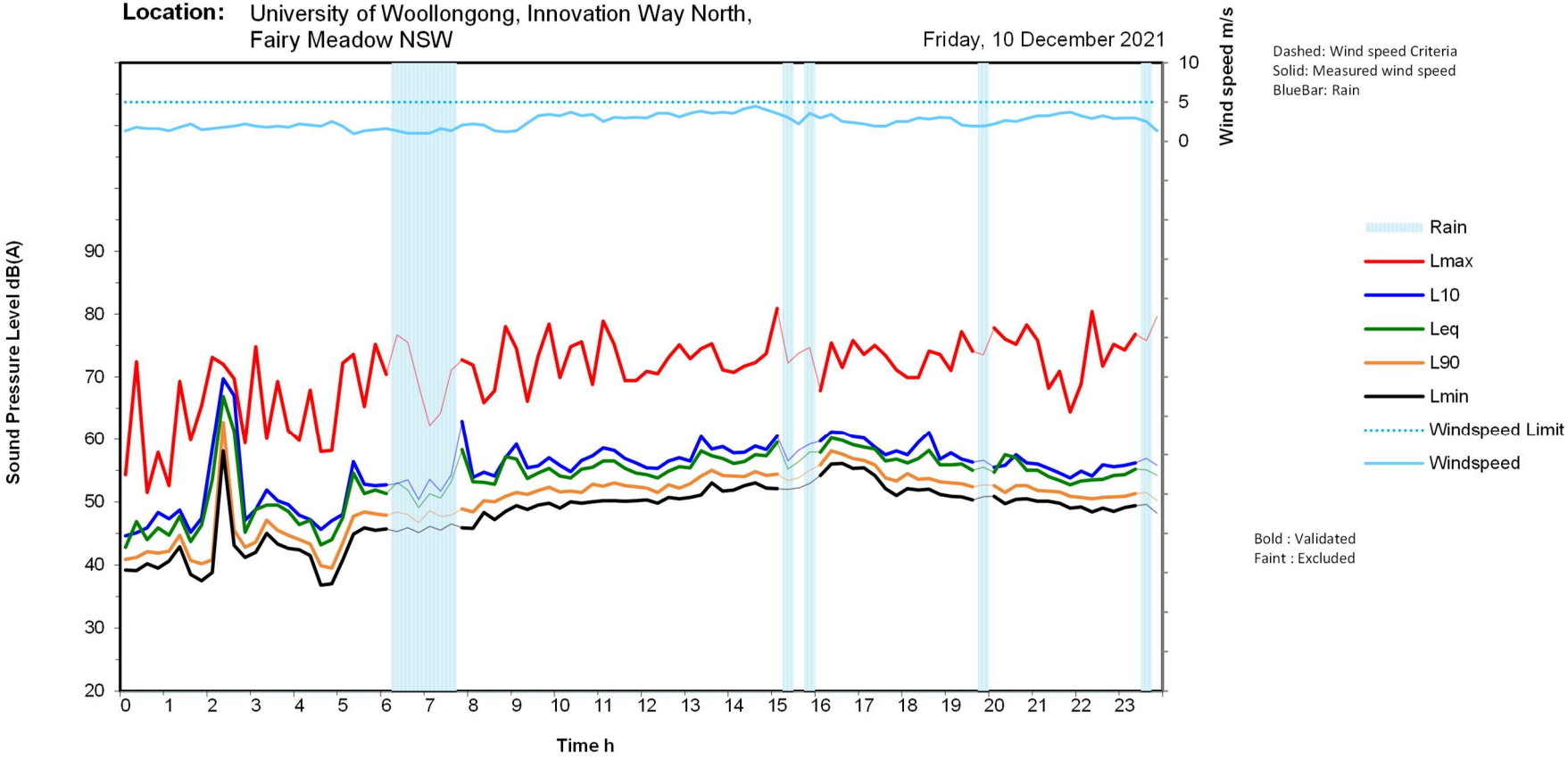

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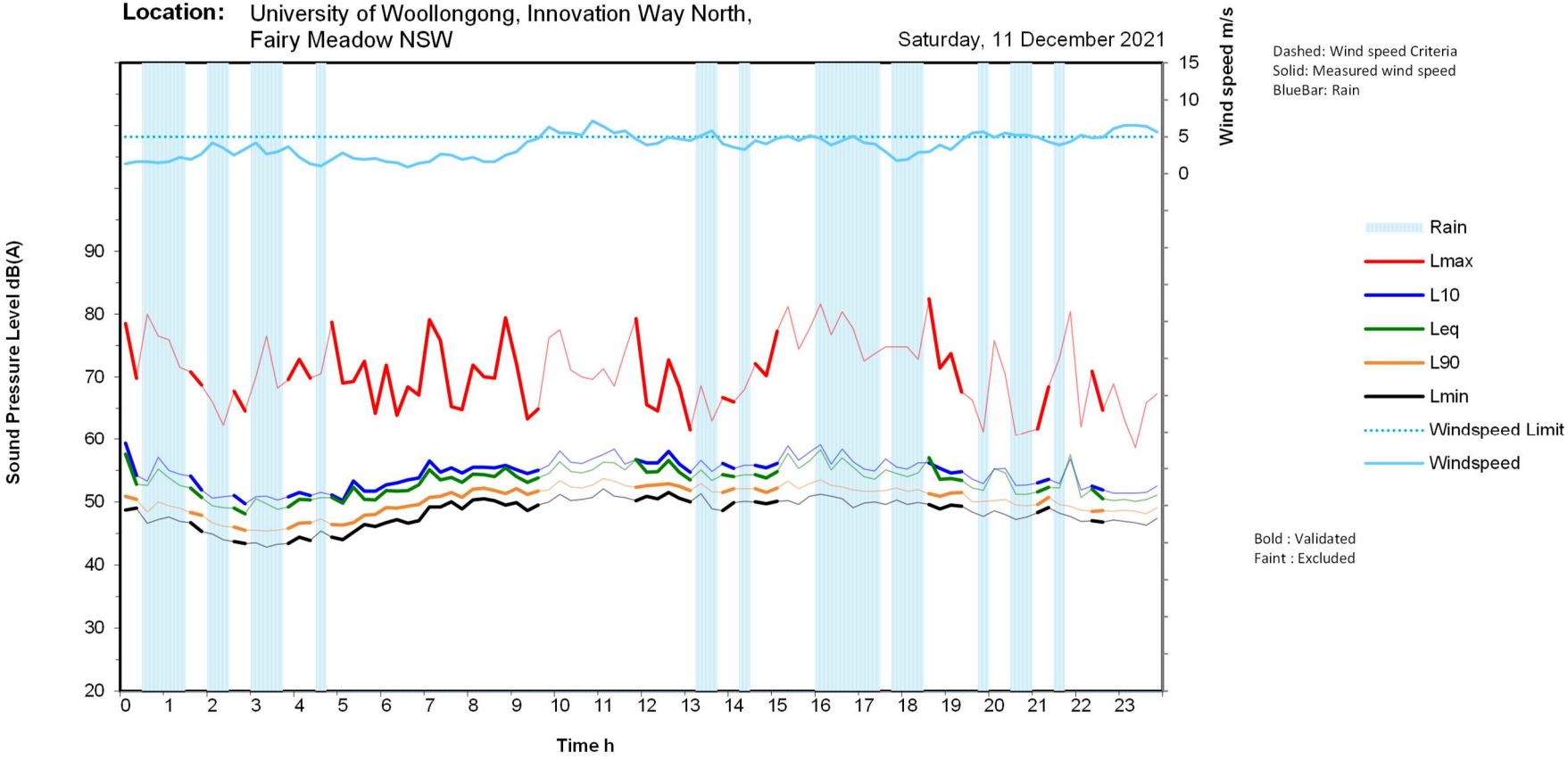

Document prepared by

Aurecon Australasia Pty Ltd
ABN 54 005 139 873
Level 11, 73 Miller Street
North Sydney 2060 Australia
PO Box 1319
North Sydney NSW 2059
Australia

T +61 2 9465 5599
F +61 2 9465 5598
E sydney@aurecongroup.com
W aurecongroup.com

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