Sydney Children's Hospital Stage 1 and Children's Comprehensive Cancer Centre (SCH1/CCCC) – SSDA Acoustic Assessment

Health Infrastructure NSW

1 Reserve Road, St Leonards NSW 2065

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20087 SCH1-CCCC – SSD Acoustic Assessment – R4

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Sydney Children's Hospital Stage 1 and Children's Comprehensive Cancer Centre (SCH1/CCCC) – SSDA Acoustic Assessment

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1 INTRODUCTION

The purpose of this Report is to support the State Significant Development Application (SSDA) for the Sydney Children's Hospital Stage 1 and Children's Comprehensive Cancer Centre (SCH1/CCCC) as part of the Randwick Campus Redevelopment (RCR) within the Randwick Hospital Campus (RHC). This report responds to item 12 *Noise and Vibration* as well as item 14 *Infrastructure* of the Secretary's Environmental Assessment Requirements (SEARs) issued 2 December 2020 for State Significant Development Application (SSDA) 10831778.

The Randwick Health and Education Precinct (RHEP) is one of the most comprehensive health innovation districts in Australia. While health care at RHEP has been evolving for over 160 years, the last five years has seen a strengthening of collaboration amongst a wide range of organisations in the precinct, including with government, universities, and community.

The project seeks to strengthen the precinct as a world-class centre for health, research and education, driving cutting edge, compassionate and holistic healthcare and wellness programs for the local community and other residents of NSW. The project will deliver brand new, state-of-the-art paediatric health, medical research and education facilities and will assist to transform paediatric services and be a key step in realising the vision for the RHEP.

This assessment will address the following:

- Potential surrounding environmental noise and vibration intrusion impacts on the development (i.e., traffic, light rail, aircraft, and other environmental external noise sources).
- Operational noise emissions from the development to nearby receivers from building services (i.e., mechanical, hydraulic, electrical, etc.) and other sources such as the use of the loading dock and vehicle entry and exit points; and
- Construction noise and vibration impacts associated with the construction of the proposed building on surrounding residential, commercial, educational and health institutions.

A list of acoustic terminology used in this report is included in Appendix A of this report.

1.1 Planning *Secretary's Environmental Assessment Requirements* (SEAR)

As mentioned above this report responds to item 12 *Noise and Vibration* as well as item 14 *Infrastructure* of the SEARs issued 2 December 2020 for SSDA 10831778. These are detailed below.

12. Noise and Vibration

- *Provide a noise and vibration impact assessment that:*
  - *includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction*
  - *details the proposed construction hours and provide details of, and justification for, instances where it is expected that works would be carried out outside standard construction hours*
  - *includes a quantitative assessment of the main sources of operational noise, including consideration of any mechanical services (e.g., air conditioning plant)*

- *outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers*
- *considers sources of external noise intrusion and vibration in proximity to the site (including, road, light rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards*
- *demonstrates that the assessment has been prepared in accordance with polices and guidelines relevant to the context of the site and the nature of the proposed development.*

Relevant Policies and Guidelines:

- *NSW Noise Policy for Industry 2017 NSW Environment Protection Authority (EPA)*
- *Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)*
- *Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)*
- *Australian Standard 2363 Acoustics - Measurement of noise from helicopter operations (AS 2363).*

14. Infrastructure

- *Identify the impacts of existing transport infrastructure (Sydney light rail) adjacent to the site on the proposed development, in particular on medical and laboratory equipment / apparatus, and any necessary mitigation measures.*

1.2 Relevant Guidelines

Acoustic criteria which have been adopted in this assessment include requirements from the following guidelines or legislative documents:

- Randwick City Council *Local Environmental Plan (LEP) 2013*;
- Randwick City Council *Development Control Plan (DCP) 2013, section E2 - Randwick Education and Health E2 Specialised Centre*;
- NSW Health Infrastructure *Engineering Services Guidelines (ESG) August 2006*.
- NSW EPA *Noise Policy for Industry (NPI) 2017*;
- NSW EPA *Road Noise Policy (RNP) 2011*;
- NSW EPA *Environmental Noise Control Manual (ENCM) 1994;*
- NSW EPA (formerly, Department of Environment and Climate Change) *Assessing Vibration: a technical guideline 2006 (AV-TG)*;
- Australian Standard AS 2670.2 1990 - *Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*

- British Standard BS 6472 - 2008 - *Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)*
- Australian & New Zealand Standard AS/NZS 2107:2016 *Acoustics–Recommended design sound levels and reverberation times for building interiors*;
- Australian Standard AS 2021:2015 *Acoustics–Aircraft noise intrusion–Building siting and construction.*
- Australian Standard AS 2363-1999 *Acoustics - Measurement of noise from helicopter operations (AS 2363).*
- British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993);
- German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999); and
- ASHRAE *"Sound and Vibration Control" 2007.*

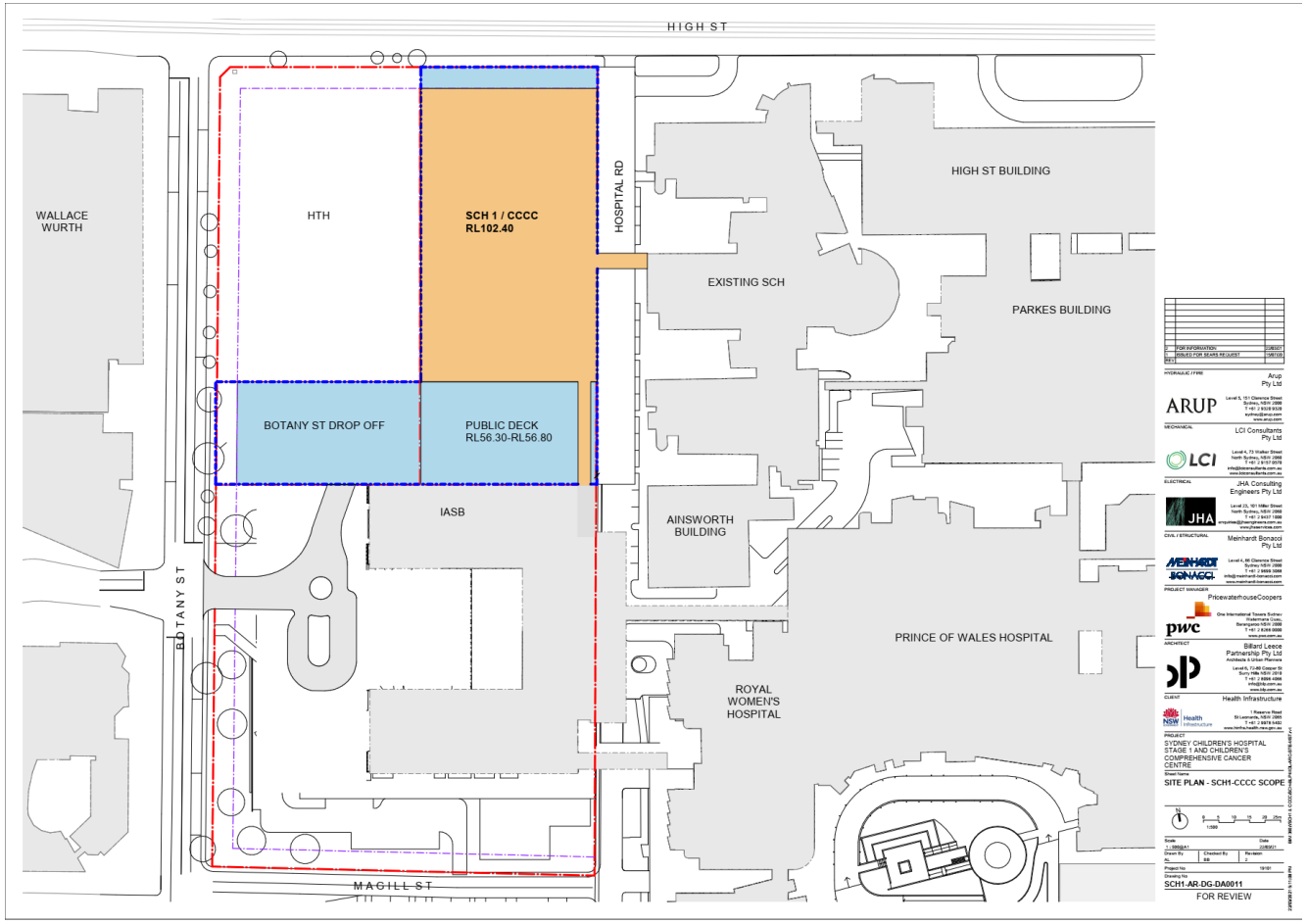
1.3 Background

The project scope includes construction and operation of a new 9 storey building plus 2 basement levels and a plant room to provide:

- A new Emergency Department
- A new Intensive Care Unit
- Short Stay Unit
- Day and Inpatient CCCC oncology units
- Children's Comprehensive Cancer Centre
- Ambulance access, parking, back of house and loading dock services
- Integration with the Prince of Wales Acute Services Building and Integrated Acute Services Building, both currently under construction
- Integration with the proposed Health Translation Hub (HTH) which is a facility being developed by The University of New South Wales (UNSW) for education, training and research
- Public domain and associated landscaping
- Site preparation and Civil works

The project is located on the corner of High Street and Hospital Road, Randwick. The figure below shows the project site plan.

Figure 1-1 Project Site Plan



2 SITE DESCRIPTION

The SCH1/CCCC redevelopment is located in the north-east corner of the new RCR precinct.

The future building is surrounded by the following:

- Along the northern façade boundary of the proposed building is High Street. High Street was recently redeveloped as part of the Stage 2 CBD South East Light Rail Project. Works associated with this project converted High Street from a typical roadway, to a roadway which accommodates both light rail vehicles and passenger vehicles. Located on the opposite side of High Street are existing multi-storey (2-3 levels) residential buildings. These receivers are the nearest receivers to the future building.

- Situated along the eastern boundary of site is Hospital Road which is subject to a separate Planning Approval Pathway and does not form part of this development application.

- To the south of the proposed building is the Price of Wales (POW) *Integrated Acute Services Building* (IASB), which is currently under construction. The IASB is a 13-storey building housing a range of critical services for the POW Hospital. Further south of the IASB is Magill Street with more residential receivers.

- Lastly, along the future western boundary of the site is the proposed UNSW HTH building. The proposed 15-storey HTH will accommodate new health related education, research and administrative facilities. It will allow health educators to work alongside clinic with a link bridge connection between the two proposed buildings. Further west of the proposed HTH is Botany Street.

The main vehicle access to the proposed SCH1/CCCC building will be via a new signalised intersection along Botany Street which serves the precinct. Located on the opposite side of Botany Street is the existing UNSW Kensington Campus.

The nearest sensitive receivers to the site are identified below.

Receiver 1: Single and multi-storey residential buildings/dwellings located to the north of the site across High Street. Receivers which are multi storey are typically four storeys in height. Receivers are located along the southern side of Blenheim Street (No. 2-34) and eastern side of Botany Street on the same block (no. 43-47). Receiver one will be known as *Blenheim Street Receivers* in this report.

Receiver 2: Single and multi-storey residential buildings/dwellings located to the north west of the site across High Street/Botany Street. Receivers which are multi storey are typically four storeys in height. Receivers are located along the northern side of High Street (No. 30-44) and western side of Botany Street on the same block (no. 26-38). Receiver two will be known as *Botany Street Receivers* in this report.

Receiver 3: Single and multi-storey residential dwellings located to the south of the new precinct (beyond the IASB) across Magill Street. Receivers which are multi storey are typically two storeys in height. Receivers are located along the southern side of Magill Street (No. 1-15), northern side of Hay Street within the same block (no. 2-16) and eastern side of Botany Street (no. 103-111A). Receiver three will be known as *Magill Street Receivers* in this report.

Receiver 4: Single and multi-storey residential dwellings located to the south west of the new precinct (beyond the IASB) across Botany Street. Receivers which are multi storey are typically two storeys in height. Receivers are located along the northern side of Norton Street (No. 10-34) and western side of Botany Street (no. 40-44). Receiver four will be known as *Norton Street Receivers* in this report.

Receiver 5: Hospital buildings are located on the eastern side of Hospital Road within the existing RHC. The closest is the existing SCH located on the corner of High Street and Hospital Road.

Receiver 6: Educational buildings located on the western side of Botany Street within the existing UNSW Kensington Campus. The closest of these include the Wallace Wurth (C27) building, Biological Sciences North and South buildings (D26 and E26) and Australian Graduate School of Management (AGSM) building (G27).

Receiver 7: Proposed UNSW HTH building to be constructed within the RHC along the western façade of the project building.

Receiver 8: Future POW IASB building currently under construction to the south of the project building.

A map showing the site location as well as nearest receivers is provided in Figure 2-1 below. Additionally, shown in Figure 2-2 are the onsite measurements which were conducted as part of this assessment.

Figure 2-1 Site Map and Surrounding Receivers

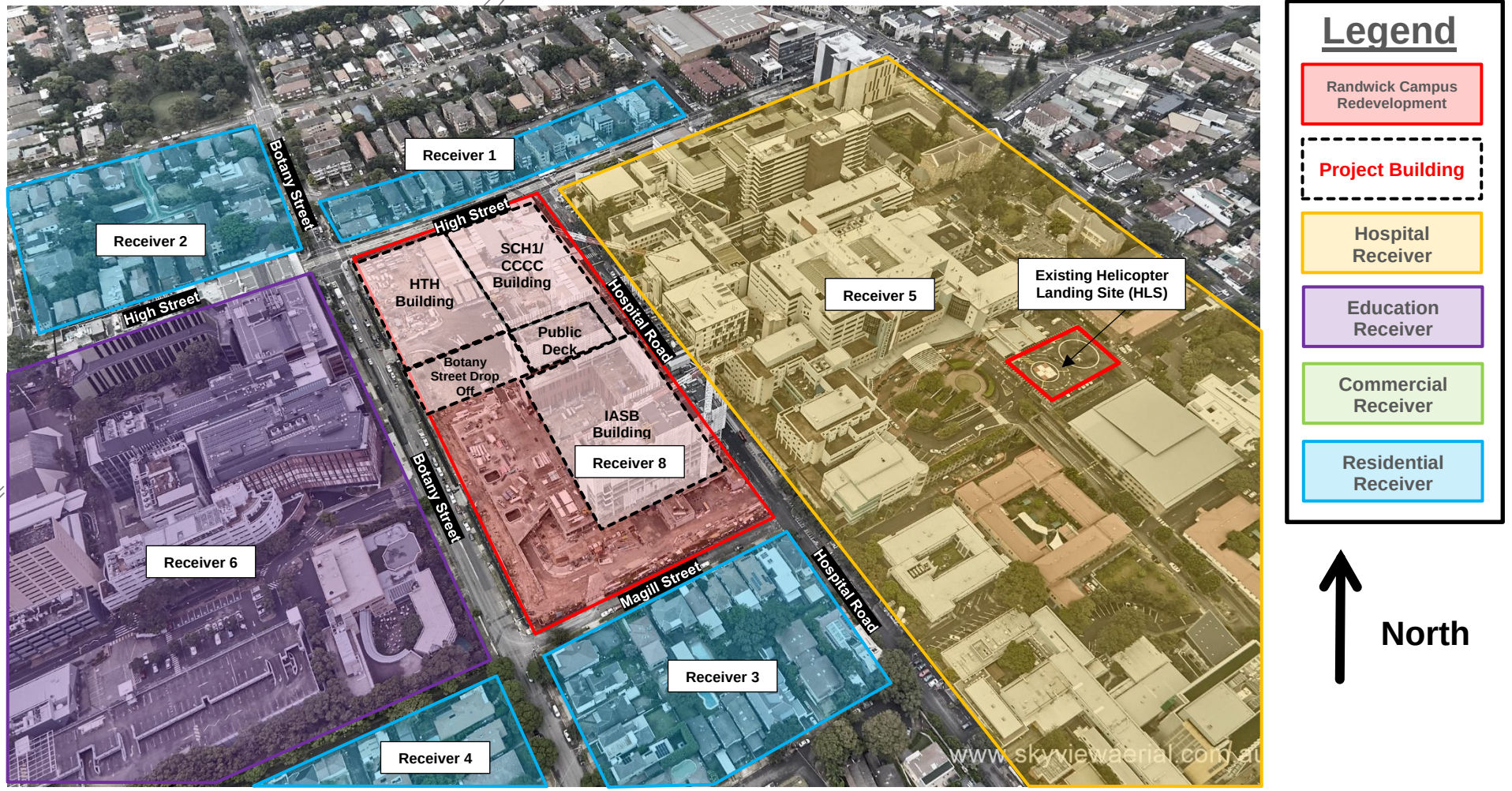


Figure 2-2 Site Map and Measurement Locations

3 ACOUSTIC NOISE AND VIBRATION SURVEY

3.1 Onsite Noise Measurements

Measured noise levels from both the unattended and attended noise surveys are outlined below.

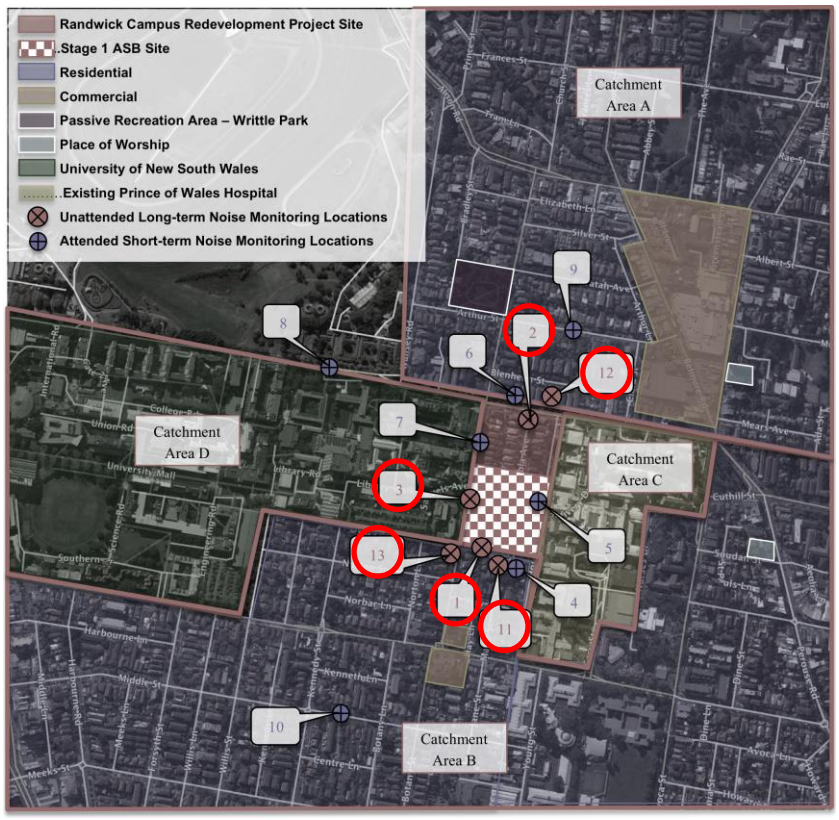
3.1.1 Unattended Noise Monitoring

Unattended noise monitoring has previously been undertaken around the site by Acoustic Studio (i.e., IASB Acoustic Consultant) during the SSDA stage for the IASB to the south. Details of the monitoring survey were presented in the *Noise and Vibration Impact Assessment for State Significant Development (SSD) – Acute Services Building (ASB)*, reference 20180808 AUR.0003.Rep.docx, dated 8th August 2018, prepared by Acoustic Studio.

Results of the Acoustic Studio unattended noise survey are detailed below.

Outlined in Figure 1 of the Acoustic Studio Report is a visual representation of the measurement locations. Figure 1 of the Acoustic Studio report has been reproduced below for information.

Figure 3-1 Acoustic Studio Measurement Locations – Figure 1 of Acoustic Report



Note: Relevant noise measurements have been circled in red below for ease of identification.

Figure 3-2 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 19

4 Existing Noise Environment

4.1 General Survey Information

A survey of the existing noise environment around the site perimeter bounded by Magill Street, Botany Street, High Street and Hospital Road was conducted with six individual unattended noise monitors used to continuously record the noise levels on the site. Unattended long-term noise monitoring was carried out from Wednesday 18th October to Friday 3rd November 2017 and Wednesday 18th to Wednesday 25th July 2018 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Unattended long-term noise monitoring was carried out with the following noise loggers:

- Logger 1: B&K 3659-B (Serial Number 3010119).
  - This logger was used at Location 1 from 18th to 22nd October 2017 and then from 26th October to 3rd November 2017.
  - This logger was used at Location 13 from 18th to 25th July 2018.
- Logger 2: Ngara (Serial Number 878197).
  - This logger was used at Location 2 from 18th to 25th October 2017.
- Logger 3: RTA 02 (Serial Number 038).
  - This logger was used at Location 3 from 23rd October to 3rd November 2017.
- Logger 4: Ngara (Serial Number 878000).
  - This logger was used at Location 11 from 18th to 25th July 2018.
- Logger 5: Ngara (Serial Number 87809E).
  - This logger was used at Location 12 from 18th to 24th July 2018.

The loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the 25-day measurement period. The calibrations of the loggers were checked before and after use and no variations were noted.

The unattended long-term noise monitoring locations are shown in Figure 1. The noise loggers at Locations 1, 2 and 3 were located at the street-side boundaries of existing residential and commercial properties at the site. At Locations 11, 12 and 13, the noise loggers were located within the front yards of residential properties in the vicinity of the proposed development. These locations were chosen as they:

- are secure places to leave the noise loggers unattended, and
- are representative of background and ambient noise levels (Location 11, 12 and 13) at the nearest and potentially most-affected noise sensitive residential

Figure 3-3 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 20

receivers, plus traffic noise levels (Location 1, 2 and 3) along roads surrounding the site.

Operator attended, short-term monitoring was also carried out on Wednesday 18th, Monday 23rd and Wednesday 25th of October and Friday 3rd of November 2017 in order to supplement the long-term outdoor data across the site and at key surrounding receivers, such as UNSW, POW Hospital and residences nearby, and to obtain spectral noise data for traffic noise at the proposed site.

Attended short-term measurements were made with two Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2832406 and 3010373). The calibrations of the analysers were checked before and after the surveys and no variation in levels occurred.

Windshields were used to protect the microphones of all the loggers and analysers. Weather conditions were calm and dry during the attended noise surveys.

Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The unattended long-term noise monitoring locations and attended short-term noise monitoring locations are shown in Figure 1.

The High Street residential receivers (Catchment A) are currently affected by construction noise associated with the Sydney CBD and South East Light Rail Project. Acoustic Studio has undertaken attended, short-term noise level measurements along High Street and on surrounding streets to establish:

a) the construction noise levels currently affecting the Catchment A residences on High Street; and
b) the likely Rating Background Level (RBL) for the Catchment A residences in the absence of the Sydney CBD and South East Light Rail Project construction works.

The results from these additional attended, short-term noise level measurements are included in Section 4.3.

4.2 Unattended Long-term Monitoring Results

The loggers were located at the proposed site at the following locations:

- Location 1 – at the backyard of the existing 101 Botany Street residential property (owned by UNSW) located in the southwestern corner of the site, to capture existing **traffic noise** levels along Magill Street.
- Location 2 – at the parking space east of the existing 1-3 Eurimbla Avenue commercial building to capture existing **traffic noise** levels along High Street.
- Location 3 – at the front yard of the existing 79 Botany Street residential building to capture existing **traffic noise** levels along Botany Street.
- Location 11 – at the front yard of 7 Magill Street residential property to capture a combination of **ambient and background noise** levels along Magill Street. This

Figure 3-4 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 21

logger location is representative of the background and ambient noise levels at the nearest residential receivers on Magill Street.

- Location 12 – at the front yard (High Street frontage) of 12 Blenheim Street residential property to capture existing **ambient and background noise** levels along High Street. This logger location is representative of the background and ambient noise levels at the nearest residential receivers on High Street.
- Location 13 – at the front yard of 40 Botany Street residential building to capture existing **ambient and background noise** levels along Botany Street. This logger location is representative of the background and ambient noise levels at the nearest residential receivers on Botany Street.

The unattended long-term noise monitoring locations are shown in Figure 1.

The detailed results of the unattended long-term noise monitoring at the six (6) logger locations are shown in Appendix B.

Figure 3-5 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 22

4.2.1 Traffic Noise

Traffic noise monitoring results are summarised in Table 1 below.

Location	Traffic Noise Levels[3], dB(A)			
	Period		Noisiest 1 Hour Period	
	Day $L_{eq,\ (15\ hr)}$	Night $L_{eq,\ (9\ hr)}$	Day $L_{eq,\ (1\ hr)}$	Night $L_{eq,\ (1\ hr)}$
Location 1[4] Traffic along Magill Street (Catchment B)	45	43	47	45
Location 2 Traffic along High Street (Catchment A)	58	52	59	54
Location 3 Traffic along Botany Street (Catchment D)	59	55	60	60

Table 1: Summary of measured long-term traffic noise levels

4.2.2 Background and Ambient Noise

The logged data shows the background and ambient noise levels representative of the area. The recorded background noise levels have been used to establish limiting criteria for noise emitted from the operation of the new building.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

Figure 3-6 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 22

The background sound levels have been established in general accordance with the methodology described in the NSW NPI, i.e. the 10th percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 2 below together with the L_{Aeq} ambient noise levels measured for each period.

In accordance with the NSW NPI, any data likely to be affected by rain, wind or other extraneous noise have been excluded from the calculations.

[3] Levels are adjusted to represent levels at facades, taking into consideration distance attenuation, façade reflection and shielding to the logger location.

[4] Levels are adjusted to exclude ambient noise levels which are not associated with traffic from Magill Street.

Figure 3-7 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 23

Location	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Location 3 79 Botany Street (Catchment D)	47	41	39	60	58	55
Logger Location 11 7 Magill Street (Catchment B)	46	44	43	55	51	51
Logger Location 12 12 Blenheim Street (Catchment A)	47	45	43	59	53	55
Logger Location 13 40 Botany Street (Catchment B)	49	46	43	65	64	59

Table 2: Long-term background and ambient noise levels

Based on our observations during the site inspections, both ambient and background noise levels around the proposed site are generally dominated by traffic noise around the site at all six locations and also by construction noise at Locations 2, 3 and 12.

Since the period in which Acoustic Studio undertook the detailed unattended noise surveys outlined above, the surrounding area has been subject to significant change. Between the dates of monitoring outlined above, the construction of the CBD and South East Light Rail (CSELR) for the L2 Randwick Line and L3 Kingsford Line has been completed and become operational. Existing vehicle movements along the previous roadways have been altered with the operation of the CSELR. Significant amounts of demolition, bulk excavation, and part construction of the new IASB building has occurred/occurring on the two blocks of land between Hospital Road and Botany Street from High Street to Magill Street, including the closure decommissioning of Eurimbla Avenue.

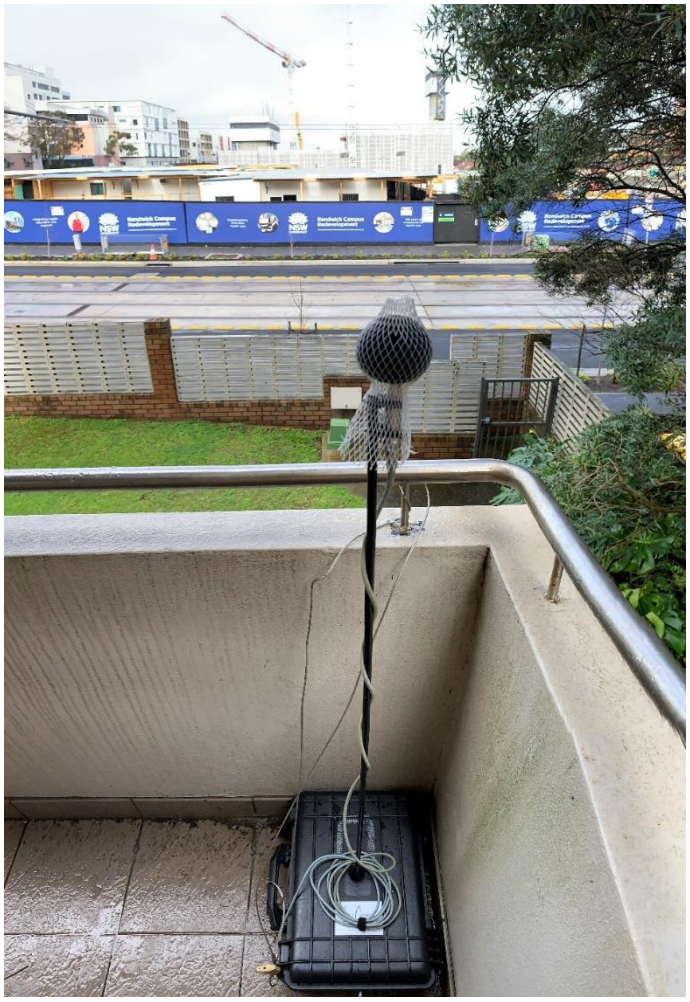
Whilst the monitoring outlined above is still believed to be valid, this must be verified with updated onsite noise surveys.

An unattended noise survey was conducted by Pulse Acoustics between Tuesday 28th July 2020 and Wednesday 12th August 2020 on the level 2 balcony of 8 Blenheim Street, Randwick building. Specifically, unit 2 which faces south along High Street directly opposite the project site, as shown in Figure 3-8 below.

Instrumentation for the survey comprised one Svan 971 noise logger (serial number 74365). Calibration of the logger was checked prior to and following the measurements. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in Appendix B. The charts present each 24-hour period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels for the corresponding 15-minute periods. This data has been filtered to remove periods affected by adverse weather conditions based on weather information.

Figure 3-8 Unattended Noise Monitor Location – High Street – Rear of 8 Blenheim Street Randwick – Level 2



Based on the unattended noise measurements outlined above, the results of each survey are presented below.

Upon review the monitoring data presented in Appendix B and the site observations made during our attended noise surveys the following has been concluded:

- Daytime noise levels between 7:00am and 5:00pm will be slightly affected by construction activities associated with the IASB building currently under construction.
- Due to the nature of the area in which the project site is located the measured levels during a Sunday when construction activities do not occur will be a good indication of RBL's. As the light rail movements are similar, the hospital is still in operation and traffic levels along Botany Street are relatively similar.
- An unusual localised activity is occurring during the early morning period on most of the monitored days. As can be clearly identified in Tuesday 8th August 2020 and Wednesday 9th August 2020.
- In addition to the localised noise identified above; a noise event for a short to medium duration is occurring during the early morning periods on a few of the monitoring days. As can be clearly identified on Friday 7th August 2020 and Wednesday 12th August 2020.

3.1.2 Results in accordance with the NSW *EPA Noise Policy for Industry (NPI) 2017* (RBL's)

In order to assess the acoustical implications of the development at nearby noise sensitive receivers, the measured background noise data of the logger was processed in accordance with the NSW EPA's *Noise Policy for Industry* (NPI, 2017).

The Rating Background Noise Level (RBL) is the background noise level used for assessment purposes at the nearest potentially affected receiver. It is the 90th percentile of the daily background noise levels during each assessment period, being day, evening and night. RBL $L_{A90\ (15minute)}$ and L_{Aeq} noise levels are presented in Table 3-1.

Data affected by adverse meteorological conditions and by spurious and uncharacteristic events have been excluded from the results, and also excluded from the data used to determine the noise emission criteria. Meteorological information has been obtained from the Observatory Hill Station (ID 067105).

Table 3-1 Measured Ambient Noise Levels corresponding to the NPI's Assessment Time Periods

Measurement Location	Daytime[1] 7:00 am to 6:00 pm		Evening[1] 6:00 pm to 10:00 pm		Night-time[1] 10:00 pm to 7:00 am	
	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)
Location 1, High Street. See Figure 3-8	51	61	48	57	46	60

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3.1.3 Results in accordance with the NSW Department of Planning "Development near Rail Corridors and Busy Roads – Interim Guideline"

In determining the required façade construction for the proposed building in accordance with the internal noise level requirements of NSW Department of Planning "Development near Rail Corridors and Busy Roads – Interim Guideline" measured noise levels are shown based on the time periods defined by the SEPP below.

Data affected by adverse meteorological conditions and by spurious and uncharacteristic events have been excluded from the results, and also excluded from the data used to determine the noise emission criteria.

Table 3-2 Measured Ambient Noise Levels corresponding to the "Development near Rail Corridors and Busy Roads – Interim Guideline" Assessment Time Periods

Measurement Location	Daytime [1] 7:00 am to 10:00 pm	Night-time [1] 10:00 pm to 7:00 am
	$L_{Aeq\ (whole\ period)}$ [2] (dBA)	$L_{Aeq\ (whole\ period)}$ [2] (dBA)
Location 1, High Street. Figure 3-8	60	60

Note 1: For Monday to Sunday, Daytime 7:00 am – 10:00 pm; Night-time 10:00 pm – 7:00 am.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3.1.4 Attended Noise Measurements

In addition to the unattended noise survey previously and currently being undertaken, an attended noise survey was carried out to establish levels at key locations within and surrounding the site. These are summarised below.

The attended noise measurements were conducted using a Brüel & Kjær Type 2250 sound level meter (serial number 3006332). Calibration of the sound level meter was checked prior to and following the measurements using a Brüel & Kjær Type 4231 sound calibrator (serial number 3009148). The calibrator emitted a calibration tone of 94 dB at 1 kHz. The drift in calibration did not exceed ±0.5 dB. All equipment carries appropriate and current NATA (or manufacturer) calibration certificates.

Attended noise measurements were undertaken on Tuesday 16th June 2020 at 3:30pm to 5:30pm and Wednesday 17th June 2020 at 12:30am and 2:30am.

Results of the attended noise measurements are outlined in Table 3-3 below.

Table 3-3 Measured Results of the Attended Noise Survey

Measurement Location	Date and Time	Measured Noise Level (dBA)		Comments
		$L_{A90\ (15\text{-}min)}$[1]	$L_{Aeq\ (15\text{-}min)}$[2]	
Location 1: Hospital Road, Outside Southern Wing of Existing SCH. (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	55	61	Construction noise affected, IASB works.
	Wednesday 17th June 2020 at 12:30am and 2:30am	51	53	Mechanical noise from existing SCH building, occasional Light Rail Vehicle along High Street.
Location 2: Corner of Hospital Road and High Street, Existing SCH Side (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	53	63	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal and distant traffic noise.
	Wednesday 17th June 2020 at 12:30am and 2:30am	52	53	Occasional Light Rail Vehicle, distant traffic movements from Botany, distant mechanical noise from existing SCH building and pedestrian signal.
Location 3: High Street, Southern Boundary of 10 Blenheim Street, Randwick (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	52	61	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal, tyre noise over concrete expansion gaps and distant traffic noise from Botany Street.
	Wednesday 17th June 2020 at 12:30am and 2:30am	46	60	Occasional Light Rail Vehicle, distant traffic noise from Botany Street, distant mechanical noise from UNSW Wallace Wurth and existing SCH buildings.
Location 4: Corner of High Street and Botany Street, new Hospital precinct side (See Figure 2-2**)**	Wednesday 17th June 2020 at 12:30am and 2:30am	45	57	Occasional vehicle movement along Botany Street, distant mechanical noise from existing SCH building.
Location 5: Botany Street, outside Entrance to Wallace Wurth Building (C27,UNSW) (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	61	68	Frequent traffic movements along Botany Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	48	58	Occasional vehicle movement along Botany Street, distant Light Rail Vehicle, distant mechanical noise from existing SCH building.

Note 1: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Table 3-3 Measured Results of the Attended Noise Survey (Cont.)

Measurement Location	Date and Time	Measured Noise Level (dBA)		Comments
		$L_{A90\ (15\text{-}min)}$[1]	$L_{Aeq\ (15\text{-}min)}$[2]	
Location 6: Corner of Magill Street and Botany Street, outside 103 Botany Street, Randwick (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	54	65	Frequent traffic noise, both along Botany Street and Magill Street.
	Wednesday 17th June 2020 at 12:30am and 2:30am	45	46	Distant mechanical noise from both UNSW Wallace Wurth and existing SCH buildings.
Location 7: Magill Street, northern boundary of 5 Magill Street, Randwick (See Figure 2-2**)**	Tuesday 16th June 2020 at 3:30pm to 5:30pm	47	56	Moderate traffic movements along Magill Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	44	45	Distant mechanical noise from existing SCH buildings.

Note 1: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3.2 Onsite Vibration Measurements

3.2.1 Methodology

Vibration measurements were conducted at the existing site on 16th June 2020 from 1:30 pm to 2:30 pm. Vibration and noise levels were recorded with a Sinus SoundBook Mark II at the location identified in Figure 2-2 above.

The accelerometer was attached to the ground using bees' wax. Light Rail Vehicle pass-bys were isolated and Lmax, slow one-third octave velocity spectra were calculated for each train pass-by. A low frequency bandwidth of 3.15 Hz to 315 Hz was used.

An additional vibration survey was conducted on Friday 26th February 2021 from 5:00am to 7:00am along the proposed High Street façade and 60m south of the High Street kerb. Vibration measurements were recorded with a Svan 958a at the location identified in Figure 2-2 above.

3.2.2 Measurement Results

The survey conducted on 16th June gathered vibration data during Light Rail Vehicle pass bys in both directions of the corridors. For the survey, it is seen that the measured vibration spectra are generally consistent with typical light rail vibration. The vibration results exhibit dominant energy in the 50 Hz to 80 Hz bands.

Outlined in Table 3-4 below is the measured acceleration vibration levels presented in VDV.

Table 3-4 Measured vibration impacts, presented in Vibration Dose Value (VDV) - mm/s

Measurement Number	Light Rail Vehicle Direction	Measured Vibration Dose Value (VDV) mm/s
Light Rail Vehicle 1	Towards City	0.006
Light Rail Vehicle 2	Towards City	0.005
Light Rail Vehicle 3	Towards Randwick	0.003
Light Rail Vehicle 4	Towards City	0.007
Light Rail Vehicle 5	Towards Randwick	0.003
Light Rail Vehicle 6	Towards City	0.006
Light Rail Vehicle 7	Towards City	0.007
Light Rail Vehicle 8	Towards Randwick	0.003
Light Rail Vehicle 9	Towards Randwick	0.003
Light Rail Vehicle 10	Towards City	0.005
Light Rail Vehicle 11	Towards Randwick	0.003

Outlined in Table 3-5 below is the measured peak velocity vibration levels presented in millimetre / second (mm/s).

Table 3-5 Measured vibration impacts, presented in Peak Velocity in millimetre / second (mm/s)

Measurement Number	Light Rail Vehicle Direction	Measured Peak Velocity mm/s		
		x-axis	y-axis	z-axis
Light Rail Vehicle 1	Towards City	0.3	0.2	0.3
Light Rail Vehicle 2	Towards City	0.3	0.1	0.3
Light Rail Vehicle 3	Towards Randwick	0.1	0.1	0.1
Light Rail Vehicle 4	Towards City	0.2	0.2	0.3
Light Rail Vehicle 5	Towards Randwick	0.1	0.1	0.2
Light Rail Vehicle 6	Towards City	0.2	0.2	0.3
Light Rail Vehicle 7	Towards City	0.2	0.2	0.3
Light Rail Vehicle 8	Towards Randwick	0.1	0.1	0.1
Light Rail Vehicle 9	Towards Randwick	0.4	0.1	0.1
Light Rail Vehicle 10	Towards City	0.4	0.1	0.3
Light Rail Vehicle 11	Towards Randwick	0.1	0.1	0.2

Outlined in Table 3-6 below is the measured peak velocity vibration levels presented in metre / second (m/s).

Table 3-6 Measured vibration impacts, presented in Peak Velocity metre / second (m/s)

Measurement Number	Light Rail Vehicle Direction	Measured Peak Velocity m/s		
		x-axis	y-axis	z-axis
Light Rail Vehicle 1	Towards City	0.0003	0.0002	0.0003
Light Rail Vehicle 2	Towards City	0.0003	0.0001	0.0003
Light Rail Vehicle 3	Towards Randwick	0.0001	0.0001	0.0001
Light Rail Vehicle 4	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 5	Towards Randwick	0.0001	0.0001	0.0002
Light Rail Vehicle 6	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 7	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 8	Towards Randwick	0.0001	0.0001	0.0001
Light Rail Vehicle 9	Towards Randwick	0.0004	0.0001	0.0001
Light Rail Vehicle 10	Towards City	0.0004	0.0001	0.0003
Light Rail Vehicle 11	Towards Randwick	0.0001	0.0001	0.0002

Measurement results of the survey conducted on Friday 26th February 2021 are presented below. These levels are the resultant VC curves on a representative building foundation in-line with the proposed SCH1/CCCC façade.

Table 3-7 Measured vibration impacts, presented in VC-curves

Location	Measurement Number	Light Rail Vehicle Direction	Measured Vibration Curve (VC) Refer to ASHRAE Chapter 43, 2007 Velocity RMS levels (mm/s)
In-line with proposed High Street Facade	Light Rail Vehicle 12	Towards City	VC-B
	Light Rail Vehicle 13	Towards Randwick	VC-B
	Light Rail Vehicle 14	Towards City	VC-B
	Light Rail Vehicle 15	Towards Randwick	VC-B
	Light Rail Vehicle 16	Towards City	VC-B
	Light Rail Vehicle 17	Towards Randwick	VC-B
	Light Rail Vehicle 18	Towards City	VC-B
60m south of the High Street kerb	Light Rail Vehicle 19	Towards City	VC-C
	Light Rail Vehicle 20	Towards Randwick	VC-C
	Light Rail Vehicle 21	Towards City	VC-B

Note 1: Measurements presented above are Velocity Root Means Square (RMS) levels unadjusted measured on a representative building footing.

4 NOISE & VIBRATION PROJECT CRITERIA

All relevant noise and vibration criteria for the project is presented below. It has been separated into four main components: external noise emission criteria, building envelope criteria (façade), vibration criteria and construction noise/ vibration criteria. Each are discussed in detail below.

4.1 External Noise Emission Criteria

4.1.1 Randwick City Council Local Environmental Plan (LEP) 2013 & Development Control Plan (DCP) 2013

Acoustic requirements relevant to noise emitted from the building are not provided in the Randwick Council LEP or DCP documents. Therefore, requirements of the NSW Health Infrastructure ESG and NSW EPA NPI 2017 will be adopted. Each is discussed in detail below.

4.1.2 NSW Health Infrastructure Engineering Services Guidelines (ESG) August 2006

Section 13.5.1 of the ESGs states the following:

> ***13.5.1 Noise Emissions from Use***
>
> *All new or redeveloped facilities will be designed so that operational noise emissions and impacts on neighbouring noise sensitive receivers comply with project specific criteria established in accordance with the requirements of the NSW planning and development assessment process.*
>
> *The design team will also consider the amenity of open external areas within the proposed development such as patient or staff courtyards and other existing healthcare buildings surrounding the development.*
>
> *All operational noise sources associated with the healthcare building must be assessed against the project specific criteria established for the development in accordance with the relevant guidelines and standards.*
>
> *Noise generating sources and activities that should be assessed include (but are not limited to):*
>
> - *All external mechanical plant (including emergency / standby plant)*
> - *Workshop areas*
> - *Loading dock areas*
> - *Car park noise*
> - *Noise from road traffic generated by the facility and*
> - *Noise from emergency helicopter flights associated with the facility.*
>
> *The assessment will also consider characteristics that influence the impact of a particular noise source (such as intermittency, tonality, low frequency noise etc.).*
>
> *General design considerations that may be incorporated in the design include:*
>
> - *Strategic location of noise generating areas (i.e. plant areas, car park areas, helipad location etc.)*

- *Consideration of proximity to neighbouring noise sensitive receivers and the cumulative impact from noise generating sources and / or activities*
- *Strategic selection of plant (i.e. quiet plant options) and*
- *Noise control measures to minimise impacts on the proposed building and surrounding environment (this may include enclosures, barriers / screening, sound absorptive panels, acoustic louvers etc.).*

In addition to the above general use noise emissions, the relevant NSW planning and assessment processes applicable to each health care project may also require specific assessment and consideration of sleep arousal and disturbance. Noise emissions that occur between 10.00pm and 7.00am (intermittent or impulsive noise in particular) may also require assessment for sleep arousal during the design process in accordance with relevant standards and guidelines applicable to a healthcare development and the particular development location.

4.1.3 NSW EPA Noise Policy for Industry (NPI) 2017 (Building Services)

In NSW, the control of noise emissions is the responsibility of Local Governments and the NSW Environment Protection Authority (NSW EPA).

The NSW EPA has recently released a document titled *Noise Policy for Industry* (NSW NPI) which provides a framework and process for determining external noise criteria for the assessment of noise emission from industrial developments. The NSW NPI criteria for industrial noise sources have two components:

- Controlling the intrusive noise impacts for residents and other sensitive receivers in the short term; and
- Maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses.

4.1.3.1 Intrusive Noise Impacts (Residential Receivers)

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). This is often termed the Intrusiveness Criterion.

The 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the NSW NPI. Using the rating background noise level approach results in the intrusiveness criterion being met for 90% of the time. Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point where the noise source contains annoying characteristics such as tonality or impulsiveness.

4.1.3.2 Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW NPI. That is, the ambient L_{Aeq} noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the 'Background Creep' or Amenity Criterion.

The amenity assessment is based on noise criteria specified for a particular land use and corresponding sensitivity to noise. The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. These criteria relate only to other continuous industrial-type noise and do not include road, rail or community noise. If the existing (measured) industrial-type noise level approaches the criterion value, then the NSW NPI sets maximum noise emission levels from new sources with the objective of ensuring that the cumulative levels do not significantly exceed the criterion.

Project amenity noise level for industrial developments is specified as the recommended amenity noise level (Table 2.2 of the NPI) minus 5 dB(A). To standardise the time periods for the intrusiveness and amenity noise levels, this policy assumes that the $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq,period}$ + 3 decibels (dB).

Where the resultant project amenity noise level is 10 dB or more lower than the existing traffic noise level, the project amenity noise levels can be set at 15 dB below existing traffic noise levels (i.e. *LAeq,period(traffic) minus 15 dBA*).

4.1.3.2.1 Commercial, Education, Hospital, Worship & Passive Recreation Areas

Amenity levels for non-residential areas around the site are shown below.

Table 4-1 NSW NPI – Recommended L_{Aeq} Noise Levels from Noise Sources

Type of Receiver	Time of Day[1]	Recommended Amenity Noise Level ($L_{Aeq, period}$)[2] (dBA)
Commercial (i.e. Office areas)	When in use	65
School classroom – Internal (i.e. Lecture Spaces)	Noisiest 1-hour period when in use	35
Hospital Wards		
Internal	Noisiest 1-hour	35
External	Noisiest 1-hour	50
Place of worship - Internal	When in use	40
Passive recreation (i.e. parks)	When in use	50

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound

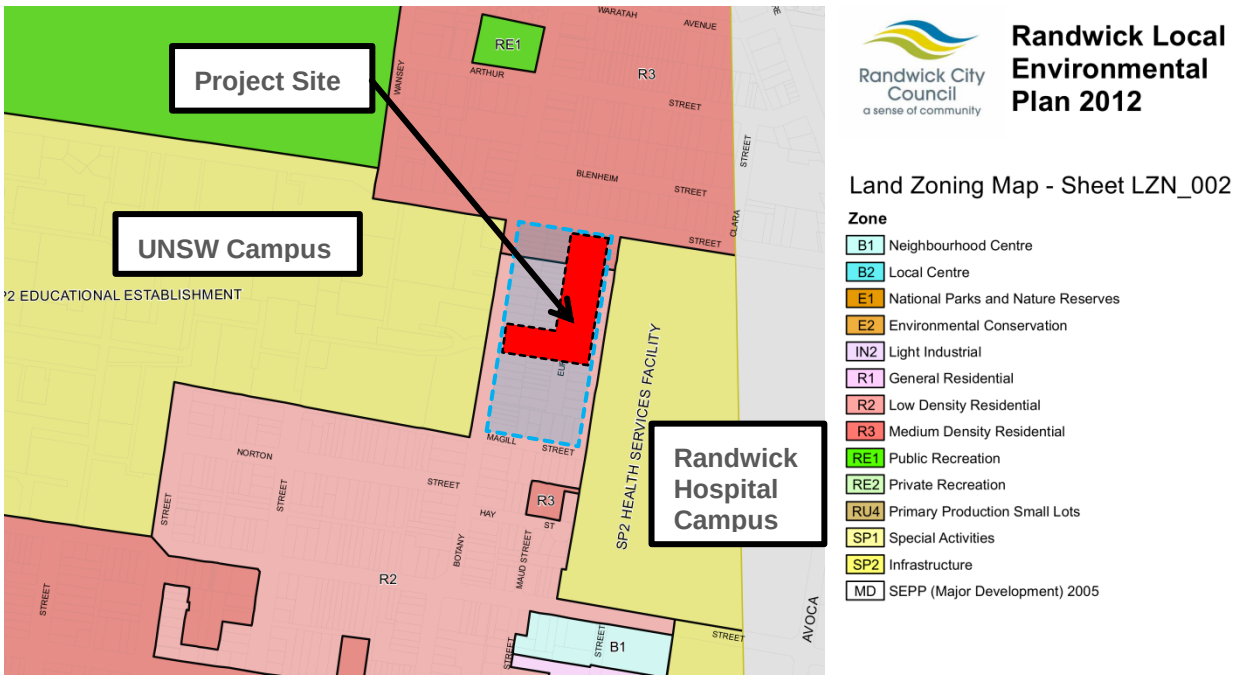
4.1.3.2.2 Residential Receivers – Area Classification

The NSW NPI characterises the "Urban Residential" noise environment as an area that has the following characteristics:

- An acoustical environment that:
  - is dominated by 'urban hum' or industrial source noise, where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources
  - has through-traffic with characteristically heavy and continuous flows during peak periods
  - is near commercial districts or industrial districts
  - has any combination of the above.

Figure 4-1 is obtained from the Randwick City Council Land Environment Plan (LEP) and shows the land zoning map of the proposed development and the nearest sensitive receivers.

Figure 4-1 Randwick City Council LEP Land Zoning Map (LZN) 2 – LZN-002



As shown above, the site and its surrounding receivers are within an area made up of SP2 (Infrastructure), R2 (Low Density Residential) and R3 (Medium Density Residential). As such, the surrounding residential receivers are defined as Urban Residential.

Resultant amenity levels for urban receivers are shown below.

Table 4-2 NSW NPI – Recommended L_{Aeq} Noise Levels from Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day[1]	Recommended Amenity Noise Level ($L_{Aeq, period}$)[2] (dBA)
Residence	Urban	Day	60
		Evening	50
		Night	45

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound

4.1.3.3 Sleeping Disturbance Criteria

Section 2.5 of the NPI states the following:

> *The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. Sleep disturbance is considered to be both awakenings and disturbance to sleep stages.*
>
> *Where the subject development/premises night-time noise levels at a residential location exceed:*
>
> - *$L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or*
> - *L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,*
>
> *a detailed maximum noise level event assessment should be undertaken.*

As outlined in section 3.1 above, the measured rating background noise level during the proposed night operating hours (10:00pm to 7:00am) is 46dBAL_{A90}. Therefore, the resultant sleeping disturbance L_{AFmax} noise criteria is 61dBA L_{AFmax}.

4.1.4 Project Specific External Noise Emission Criteria

The intrusive and amenity criteria for industrial noise emissions, derived from the measured data, are presented in Table 4-3. These criteria are nominated for the purpose of determining the operational noise limits for mechanical plant associated with the development which can potentially affect noise sensitive receivers.

For each assessment period, the lower (i.e., the more stringent) of the amenity or intrusive criteria are adopted. These are shown in bold text in Table 4-3.

Table 4-3 External noise level criteria in accordance with the NSW NPI

Location	Time of Day [1]	Project Amenity Noise Level, $L_{Aeq, period}$ [2] (dBA)	Measured $L_{A90, 15\ min}$ (RBL) [3] (dBA)	Measured $L_{Aeq, period}$ Noise Level (dBA)	Intrusive $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA)	Amenity $L_{Aeq, 15\ min}$ Criterion for New Sources (dBA) [5]
Surrounding Residences	Day	50	54	75	**59**	60 [5]
	Evening	45	46	70	**51**	55 [5]
	Night	40	33	65	**38**	50 [5]
Commercial	When in use	60	N/A	N/A	N/A	**63**

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 1:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 1:00 am.

Note 2: Project Amenity Noise Levels corresponding to "Urban" areas, equivalent to the Recommended Amenity Noise Levels minus 5 dBA.

Note 3: L_{A90} Background Noise or Rating Background Level.

Note 4: Project Noise Trigger Levels are shown in bold.

Note 5: Where the resultant project amenity noise level is 10 dB or more lower than the existing traffic noise level or traffic levels are the dominant source, the project amenity noise levels can be set at 15 dB below existing industrial noise levels.

Note 6: According to Section 2.2 of the NSW NPI, the $L_{Aeq, 15\ minutes}$ is equal to the $L_{Aeq, period}$ + 3 dB.

In addition, a maximum noise level criterion of 61dBA L_{AFmax} for a sleeping disturbance assessment applies.

4.1.5 NSW EPA (Formerly DECCW) NSW Road Noise Policy (RNP) 2011

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW Road Noise Policy states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

4.2 Building Envelope Criteria (Façade Criteria)

4.2.1 Randwick City Council Local Environmental Plan (LEP) 2013 & Development Control Plan (DCP) 2013

Acoustic requirements relevant to the building envelope are not provided in the Randwick Council LEP or DCP documents. Therefore, requirements of the NSW Health Infrastructure Engineering Services Guidelines (ESG), Australian / New Zealand Standard AS/NZS 2107:2016 and Australian Standard AS 2021:2015 will be adopted. Each of these is discussed in detail below.

4.2.2 NSW Health Infrastructure Engineering Services Guidelines (ESG) August 2006

4.2.2.1 Internal Noise Levels - Generally

Acoustic requirements for the building envelope have been developed in accordance with the requirements listed in section 13 (*Acoustics)* from the New South Wales Health *Engineering Services Guidelines (ESG)* document. The requirements listed below have been developed in accordance with other Australian Standards listed in subsequent sections, and as such, are similar in their recommendations.

Table 12 of the guideline presents all relevant acoustic requirements (internal noise levels, separation, reverberation times, etc.) for the different spaces within a health facility.

Additionally, a summary of each column presented in the guideline is provided below. This has been extracted from the ESG directly.

> ***Environmental Noise Intrusion***
>
> *All elements of the building façade will need to be constructed to control external noise entering the building. Sound insulation performance requirements for each element should be nominated based on external noise levels from all noise sources that surround the building.*
>
> *External elements including, glazing, doors and ventilation openings are generally the weakest elements in an external façade and therefore careful consideration is required in the design and specification to ensure that sufficient sound insulation is provided by the combined performance of a façade.*
>
> *Environmental noise intrusion should be considered in aggregate with the noise from mechanical services to satisfy the maximum noise levels in Column A of Table 12.*
>
> ***Steady State / Continuous Noise***
>
> *When assessing environmental noise intrusion from relatively continuous noise sources, such as free flowing road traffic, the facade should be designed to achieve the maximum allowable internal noise levels as given in Column A of Table 12:*
>
> *The environmental noise intrusion should be considered in aggregate with the noise from mechanical services to satisfy the maximum noise levels in Column A of Table 12.*

Intermittent Noise

Infrequent and short duration noise sources such as aircraft; trains and emergency vehicles will have varying impacts on the amenity of internal spaces relative to steady state / continuous noise and therefore should not be assessed using the same criteria.

The design should limit intermittent noise to achieve the maximum internal noise levels outlined in Column B of Table 12.

Helicopters Associated with Hospital Operations

Helicopter operations can exhibit similar noise characteristics to fixed wing aircraft pass-bys and also generate high levels of short period steady noise levels hovering or idling.

However, emergency medical helicopter operations differ from fixed wing aircraft as follows:

- *They can occur at any time of day or night*
- *They are generally much less frequent than fixed wing aircraft operations near a typical airport and*
- *They are directly associated with the hospital facility.*

Criteria for managing noise from emergency medical helicopter operations therefore differ from standards that apply to noise from fixed wind aircraft. Column C of Table 12 provides recommended design noise levels applicable to frequent operations (1 or more missions per day, on average). These criteria may be adjusted, in consultation with the client, to account for the frequency of emergency operations, using a risk-based approach as follows:

- *Up to 10dBA less stringent if helicopter operations are less than 1 mission per day, but more than 2 missions per week, on average*
- *Up to 20dBA less stringent if helicopter operations are very infrequent (less than 2 missions per week, on average) and subject to:*
- *an absolute limit of 80dBL Amax for any occupied room and*
- *Consideration being given to "future-proofing" the building so that, if helicopter operations were to significantly increase in the future, it would be practical to retrofit suitable acoustic treatment to manage noise impacts to an acceptable standard. For example, this may necessitate additional layers of plasterboard in the façade construction so that, if secondary glazing were to be added in the future, the rest of the façade would provide sufficient sound insulation so as not to compromise the glazing performance.*

Note: Pulse Acoustics has received advice regarding the average weekly patient transfers via helicopters in 2019 and this equated to approximately 4.3 patients per week. Therefore, including an additional tolerance of 20% for future increases, the weekly average is still less than 1 mission per day however greater than 2 missions per week.

A summary of the project's internal noise requirements based on the NSW Health ESG document is provided below.

Table 4-4 Summary of Internal Noise Levels (ESG – Table 12)

Area Designation	Column A		Column B	Column C
	Continuous Internal Noise Levels (L_{Aeq} dB)		Intermittent Internal Noise Level (L_{AMax} dB)	Internal Noise Levels Helicopter (L_{AMax} dB)
	Satisfactory	Maximum		
CLINICAL SPACES				
Operating Theatre	40	45	50	55
Birthing Room or Delivery	45	50	65	65
Intensive Care	40	45	50	55
Patient Room / Single Bed Ward	35	40	50	55
Multi Bed Ward	35	40	50	55
Toilet / En-suite	50	55	75	70
Patient Corridor	40	50	65	70
Counselling / Bereavement / Interview Room	40	45	50	55
Consultation Room	40	45	50	55
Speech and Language	35	40	50	55
Treatment / Medication / Examination	40	45	50	55
PUBLIC SPACES				
Corridors and Lobby Spaces	40	50	65	70
Cafeterias / Dining	45	50	70	70
Toilets	45	55	75	70
Waiting Rooms, Reception Areas	40	50	65	70
Multi Faith / Chapel	30	35	50	55
STAFF / BACK-OF-HOUSE AREAS				
Meeting Room	35	40	55	60
Board / Conference Room (Large)	30	35	55	60
Open Plan Offices	40	45	65	70
Private Offices	35	40	55	60
Multi Person Offices	40	45	65	70
Locker Room	50	55	75	-
Rest Room	40	45	65	70
Classrooms, Training Rooms	35	40	55	60
Lecture theatre	30	35	55	60
Library	40	45	50	60
Workshops	45	50	70	-
Plant Rooms	N/A	50	75	-
Laboratories	45	50	65	65

Note 1: All sound pressure levels referenced to 20micro-Pascals (dB re 20 µPa).

4.2.2.2 Rain Noise Intrusion

NSW Health ESG recommends that internal noise levels during rain events should be designed to be no more than 10dB based on the maximum levels presented in Column A of Table 4-4 above.

4.2.3 Australian / New Zealand Standard AS/NZS 2107:2016 Acoustics - Recommended design sound levels and reverberation times for building interiors - (AS/NZS 2107:2016)

Recommended ambient noise levels and reverberation times for internal spaces are given in a number of publications including Table 1 of Australian / New Zealand Standard 2107:2016 "*Acoustics - Recommended design sound levels and reverberation times for building interiors"*. Unlike the previous version of this Standard, this latest edition recommends a range with lower and upper levels (rather than "satisfactory" and "maximum" internal noise levels) for building interiors based on room designation and location of the development relative to external noise sources. This change has occurred due to the fact that sound levels below 'satisfactory' could be interpreted as desirable, but the opposite may in fact be the case. Levels below those which were listed as 'satisfactory' can lead to inadequate acoustic masking resulting in loss of acoustic isolation and speech privacy.

Internal noise levels due to the combined contributions of external noise intrusion and mechanical ventilation plant should not exceed the maximum levels recommended in this Standard. The levels for areas relevant to this development are given in Table 4-5 below. The mid to maximum points of the internal noise level ranges are generally adopted as the internal design noise criteria for the combined effect of mechanical services and external noise intrusion. In this report we will confine our recommendations to dBA levels, however, where the background noise appears to be unbalanced, AS/NZS 2107:2016 provides direction in terms of suitable diagnostic tools that can be used to assess the spectrum distribution of the background noise.

Table 4-5 Recommended Design Sound Levels

Type of Occupancy/Activity	Design sound level range dBA ($L_{Aeq,t}$)	Project Design Noise Level [1] dBA ($L_{Aeq,t}$)
HEALTH BUILDINGS		
Audiological test rooms	See AS/NZS 1269.4 and AS ISO 8253	
Emergency areas	40 to 45	**43**
Control areas	40 to 50	**45**
Corridors and lobby spaces	< 50	**< 50**
Consulting rooms	40 to 45	**43**
Delivery suites	45 to 50	**47**
Dental clinics	40 to 45	**43**
Dining areas	40 to 45	**43**
Geriatric rehabilitation	40 to 45	**43**
Intensive care wards	40 to 45	**43**
Kitchens, sterilizing and service areas	< 55	**< 55**
Laboratories	40 to 50	**45**

Table 4-5 Recommended Design Sound Levels (Cont.)

Type of Occupancy/Activity	Design sound level range dBA ($L_{Aeq,t}$)	Project Design Noise Level [1] dBA ($L_{Aeq,t}$)
Maintenance workshops	< 60	**< 60**
MRI, CT scan, X-Ray areas, Ultra sound	45 to 50	**47**
Nurseries	35 to 45	**40**
Nurses' stations	40 to 45	**43**
Office areas	35 to 45	**40**
Operating theatres	40 to 50	**45**
Patient lounge	40 to 45	**43**
Post-Op, Pre-Op, recovery rooms	40 to 45	**43**
Pharmacies	45 to 50	**47**
Staff rooms	40 to 45	**43**
Sterilizing, treatment, procedure rooms	40 to 45	**43**
Surgeries, treatment, procedure rooms	40 to 45	**43**
Utility rooms	50 to 60	**60**
Ward Bedrooms-		
Single bed	35 to 40	**37**
Multiple beds	35 to 40	**37**
Waiting rooms, reception areas	40 to 50	**45**

Note 1: Overall recommended level for mechanical services noise and intrusive noise, combined.

Section 6.18 of AS/NZS 2107:2016 notes that the presence of discrete frequencies or narrow band signals may cause the sound level to vary spatially within a particular area and be a source of distraction for occupants. Where this occurs, the sound level shall be determined as the highest level measured in the occupied location(s).

If tonal components are significant characteristics of the sound within a measurement time interval, an adjustment shall be applied for that time interval to the measured A-weighted sound pressure level to allow for the additional annoyance. If the background sounds include spectral imbalance, then the RC (Mark II) levels indicated in the Standard should be referenced (see also Appendix D of AS/NZS 2107:2016 for additional guidance).

Generally, where the final noise levels are within +/- 2 dB of the specified level given above, the design criteria will be considered met. Both the upper and lower limits will need to be satisfied especially where privacy is important or where noise intrusion to be avoided.

4.2.4 Australian Standard AS 2021:2015 Acoustics–Aircraft noise intrusion–Building siting and construction (non-emergency helicopter movements only)

Australian Standard AS 2021:2015 recommends that the architectural acoustic treatment should be designed in order to achieve the indoor design noise levels listed in Table 3.3 of the Standard. These levels are shown in Table 4-6 below.

It is noted that AS 2021 should only be applied in the assessment of non-hospital related aircraft movements (i.e., not medical helicopter movements).

Table 4-6 Indoor design noise levels in order to determine acoustic treatment for aircraft noise intrusion

Building type and activity	Indoor Design Noise Level[1], dBA
Hospitals, nursing homes	
Wards, theatres, treatment and consulting rooms	50
Laboratories	65
Service Areas	75
Commercial buildings, offices and shops	
Shops, supermarkets, showrooms	75

Notes:
1. *These indoor design sound levels are not intended to be used for measurement of adequacy of construction. For measurement of the adequacy of construction against aircraft noise intrusion see Appendix D of AS2021:2015.*

Please note the indoor design noise levels should not be used to confirm, with on-site measurements, the adequacy of the implemented construction, as part of the compliance process. Instead, these measurements should be based on the aircraft noise reduction (ANR) of the completed building space. The ANR is determined as the arithmetic average of the aircraft noise reduction calculated for each flyover (ANR_n). Hence the ANR_n is defined by the following equation:

$$ANR = L_{Aout} - L_{Ain}$$

Where, L_{Aout} is the maximum sound pressure level obtained outside the relevant space, and L_{Ain} is the maximum sound pressure level obtained inside the relevant space. Both sound pressure levels should be measured simultaneously for each flyover using "A" frequency weighting and slow (S) time weighting.

4.3 Vibration Criteria

4.3.1 NSW EPA (formerly, Department of Environment and Climate Change) *Assessing Vibration: a technical guideline 2006* – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AV-TG). This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table 4-7 and Table 4-9).
- Impulsive vibration – up to three instances of sudden impact e.g., dropping heavy items, per monitoring period (refer to Table 4-8 and Table 4-9).
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 4-11).

Table 4-7 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Critical areas (Assumed operating theatres, surgical areas or similar)	Day- or night-time	0.0050	0.0036	0.010	0.0072
Residences (Assumed ward areas)	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, education institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058

Table 4-8 Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Critical areas (Assumed operating theatres, surgical areas or similar)	Day- or night-time	0.0050	0.0036	0.010	0.0072
Residences (Assumed ward areas)	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, education institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Table 4-9 Continuous vibration velocity criteria (mm/s and dB re 10^{-9} m/s) 1 Hz-80 Hz, Z axis

Location	Assessment period	Z axis	
		Preferred Values	Maximum Values
Critical Spaces (Assumed operating theatres, surgical areas or similar)	Day or night-time	0.10 mm/s 100 dB	0.20 mm/s 106 dB
Residences (Assumed ward areas)	Daytime	0.20 mm/s 106 dB	0.40 mm/s 112 dB
	Night-time	0.14 mm/s 103 dB	0.28 mm/s 109 dB
Offices	Day or night-time	0.40 mm/s 112 dB	0.80 mm/s 118 dB
Workshops	Day- or night-time	0.80 mm/s 118 dB	1.6 mm/s 124 dB

Table 4-10 Impulsive vibration velocity criteria (mm/s and dB re 10^{-9} m/s) 1 Hz-80 Hz, Z axis

Location	Assessment period	Z axis	
		Preferred Values	Maximum Values
Critical Spaces (Assumed operating theatres, surgical areas or similar)	Day or night-time	0.10 mm/s 100 dB	0.20 mm/s 106 dB
Residences (Assumed ward areas)	Daytime	6 mm/s 136 dB	12 mm/s 142 dB
	Night-time	2 mm/s 126 dB	4 mm/s 132 dB
Offices	Day or night-time	13 mm/s 142 dB	26 mm/s 148 dB
Workshops	Day- or night-time	13 mm/s 142 dB	26 mm/s 148 dB

Table 4-11 Intermittent vibration impacts criteria (m/s$^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Critical Spaces (Assumed operating theatres, surgical areas or similar)	0.10	0.20	0.10	0.20
Residences (Assumed ward areas)	0.20	0.40	0.13	0.26
Offices	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

4.3.2 British Standard BS 7385: Part 2-1993 AND German DIN 4150: Part 3 – 1999 – Building Damage

It is expected that the human comfort criteria discussed in Section 4.3.1 will be more stringent than that corresponding to building damage.

Therefore, it is our opinion that a vibration assessment for building damage from light rail activity is not relevant to our investigations, since compliance with the human comfort criteria will also achieve compliance with building damage criteria.

Table 4-12 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

4.3.3 Sensitive Science and Medical Equipment

Some scientific equipment (e.g., electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

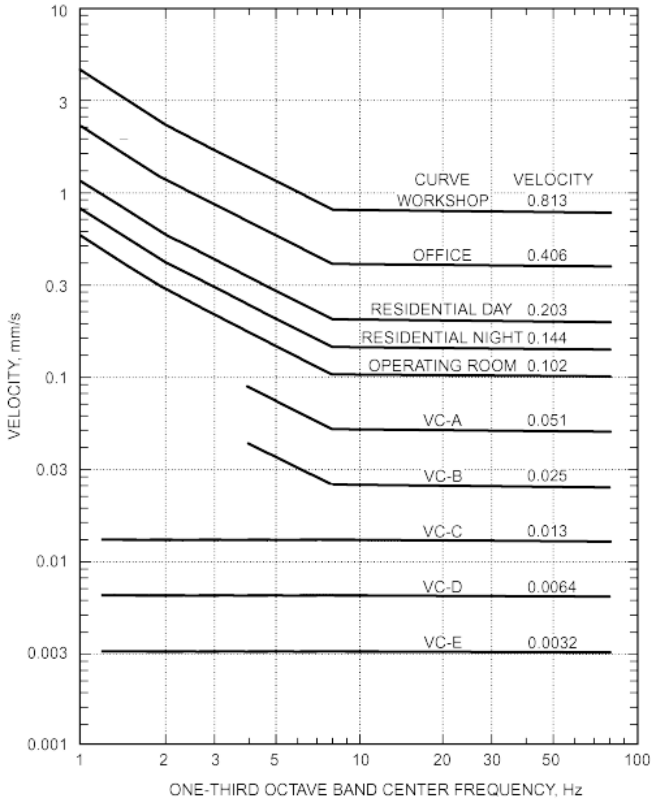
Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use at the nearest existing hospital buildings, objectives for the satisfactory operation of the instrument should be sourced from manufacturer's data.

Where manufacturer's data is not available, generic vibration criterion (VC) curves may be adopted as vibration goals. These generic VC curves are presented below in Table 4-13 and Figure 4-2.

Table 4-13 Criteria for vibration sensitive equipment

Equipment	Curve
Bench microscopes up to 100× magnification; laboratory robots	0.102 mm/s
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 mm/s VC-A
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths	0.025 mm/s VC-B
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size	0.013 mm/s VC-C
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems	0.0054 mm/s VC-D
Non-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems	0.0032 mm/s VC-E

Figure 4-2 Criteria for vibration sensitive equipment (ASHRAE 2007, HVAC Applications, Chapter 47 *"Sound and Vibration Control"*)



4.3.4 Ground-Borne Noise Criteria

According to the NSW *Developments near Rail Corridors and Busy Roads (interim Guideline)*, the criterion for ground-borne noise within hospitals is defined as follows:

- Ward areas: 35 dB $L_{Max\ (slow)}$ for 95% of rail pass-by events.
- Other noise sensitive areas: 45 dB $L_{Max\ (slow)}$ for 95% of rail pass-by events.

4.4 Construction Noise & Vibration Criteria

4.4.1 Construction Noise Criteria

Relevant construction noise criteria applicable to this project are outlined below.

4.4.1.1 NSW Health Engineering Services Guidelines (ESG) August 2016

NSW Health ESG 2016 does not contain any applicable construction noise criteria. As such, the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

4.4.1.2 Randwick Council Land Environment Plan (LEP) 2012

Randwick Council LEP 2012 does not contain any applicable construction noise criteria. As such, the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

4.4.1.3 Randwick Council Development Control Plan (DCP) 2013

Randwick Council DCP 2013 does not contain any applicable construction noise criteria. As such, the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

4.4.1.4 NSW EPA (Former DECC) Interim Construction Noise Guideline (ICNG) 2009

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all “feasible” and “reasonable” work practices to minimise construction noise impacts;
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage; and
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for residential receivers have been reproduced from the guideline and are listed in the table below.

Table 4-14 NMLs for quantitative assessment at residences

Time of Day	Noise Management Level $L_{Aeq(15minute)}$[1,2]	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work 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: 1. 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. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside the recommended standard hours above	Noise affected RBL + 5 dB	• 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 above the noise affected level, the proponent should notify 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 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Note 2 The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).

Construction noise levels at other noise receivers are outlined below:

- Construction noise levels within hospital wards and operating theatres is not to exceed 45dB LAeq,15minute, when measured internally.
- Construction noise levels within classrooms at schools and other educational institutions is not to exceed 45dB LAeq,15minute, when measured internally.
- Construction noise levels within places of worship is not to exceed 45dB LAeq,15minute, when measured internally.
- Construction noise levels at offices and retail outlets are not to exceed 70dB LAeq,15minute, when measured externally.

Based on the measured background noise levels summarised in section 3.1, and the NMLs outlined above, the construction noise criteria to be used in this assessment are listed in Table 4-15.

Table 4-15 NMLs as basis for the acoustic assessment

Receiver Types	NML, dB $L_{Aeq(15minute)}$	
	Standard Hours **Monday to Friday: 7:00am to 6:00pm** **Saturday: 8:00am to 1:00pm**	**Outside Standard Hours** **All hours not listed in the adjacent column.**
Residences (Measured externally)	**61** (RBL (51) + 10dB)	Saturday 7:00am to 8:00am 1:00pm to 6:00pm: **56** (RBL (51) + 5dB) Sunday 8:00am to 6:00pm: **56** (RBL (51) + 5dB) Monday to Sunday 6:00pm to 10:00pm: **53** (RBL (48) + 5dB) Monday to Sunday 10:00pm to 7:00am: **51** (RBL (46) + 5dB)
Hospital wards and operating theatres (Measured internally)	**45**	
Education institutions (Measured internally)	**45**	
Places of Worship (Measured internally)	**45**	
Offices & retail outlets (Measured externally)	**70**	

4.4.2 Construction Traffic Noise Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW *Road Noise Policy (RNP)* states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

4.4.3 Vibration Criteria

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed. Refer to further discussion in Section 4.4.3.1.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects. Refer to further discussion in Section 4.4.3.2.

- Effects on building structures – where vibration can compromise the integrity of the building or structure itself. Refer to further discussion in Section 4.4.3.2.

4.4.3.1 Vibration Criteria – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from AV-TG. This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table 4-16).
- Impulsive vibration – up to three instances of sudden impact e.g., dropping heavy items, per monitoring period (refer to Table 4-17).
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 4-17).

Table 4-16 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or night-time	0.0050	0.010	0.10	0.20
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 4-17 Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or night-time	0.0050	0.010	0.10	0.20
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Table 4-18 Intermittent vibration impacts criteria (m/s$^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Critical working areas (e.g. hospital operating theatres, precision laboratories)	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

4.4.3.2 Vibration Criteria – Building Contents and Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999).

4.4.3.2.1 Standard BS 7385 Part 2 - 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 4-19 and illustrated in Figure 4-3.

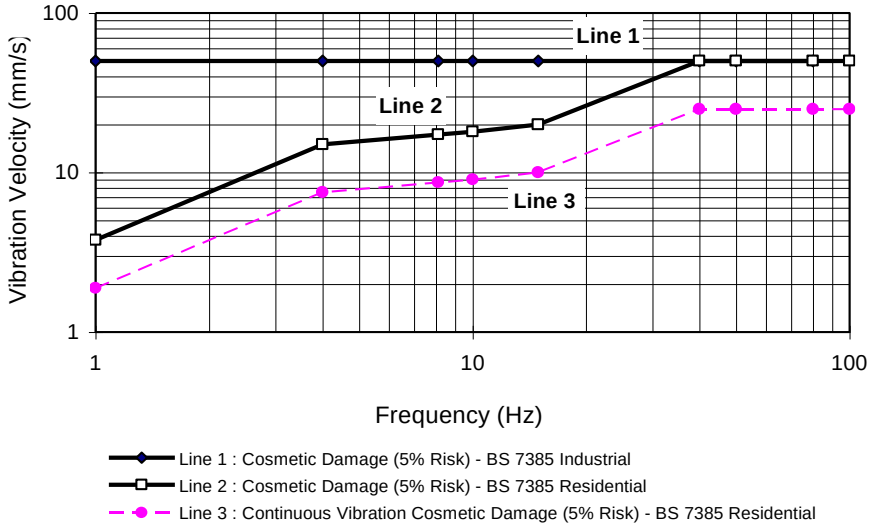
Table 4-19 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in Figure 4-3	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 4-19 relate to transient vibration which does not cause resonant responses in buildings.

Where the dynamic loading caused by continuous vibration events is such that it results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 4-19 may need to be reduced by up to 50% (refer to Line 3 in Figure 4-3).

Figure 4-3 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 4-19, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless the calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 4-19 should not be reduced for fatigue considerations.

4.4.3.2.2 Standard DIN 4150 Part 3 - 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 4-20. The criteria are frequency dependent and specific to particular categories of structures.

Table 4-20 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s Vibration at the foundation at a frequency of			
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	Vibration of horizontal plane of highest floor at all frequencies
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

4.4.4 Ground-Borne Noise Criteria

According to the ICNG, the criterion for ground-borne noise at residences is defined as follows:

- Maximum internal noise levels of 40 dB $L_{Aeq(15mins)}$ between 6:00pm and 10:00pm.

5 EXTERNAL NOISE EMISSION ASSESSMENT

Assessment of the potential noise emissions from the operation of the SCH1/CCCC building and impacting on the adjacent land users are outlined below. Noise emissions expected from the operation of the building are mainly from any base building services (mechanical, electrical, hydraulic) and vehicle movements around and within the site. Each major component is discussed in detail below.

5.1 Mechanical Services

A detailed review of the proposed mechanical services has been undertaken; from this review we recommend the following acoustic treatments be incorporated into the mechanical design to ensure compliance with the project criteria outlined in Section 4.1.

A detailed acoustic review should be undertaken prior to the installation of any mechanical services to allow for future adjustments in the mechanical design.

5.1.1 Plant Rooms – Generally

- Isolation of all plant is required.
- Acoustic Louvres for louder plant rooms may be required.

5.1.2 Ground Level Supply Air Plant Room

- Isolation of all plant is required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Installation of Acoustic Louvres/Attenuators will be required.

5.1.3 Ground Level Exhaust Air Plant Room

- Isolation of all plant is required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Installation of Acoustic Louvres/Attenuators will be required.

5.1.4 Level 2 North & South AHU Plant Room

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

- Plant room should be acoustically sealed, and the installation of Acoustic Louvres/Attenuators will be required for Outside Air Intake, Relief and Exhaust Air.
- All openings not required for airflow should be blanked off with a minimum 2 x 6mm Fibre Cement Sheeting.

5.1.5 On Floor Supply and Return Air Ductwork

- Acoustic treatment to include 50mm thick internally lined ductwork.

5.1.6 Level 9 AHU Southern Plant Room

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Plant room should be acoustically sealed, and the installation of Acoustic Louvres/Attenuators will be required for Outside Air Intake, Relief and Exhaust Air.
- All openings not required for airflow should be blanked off with a minimum 2 x 6mm Fibre Cement Sheeting.

5.1.7 Level 9 Southern External Exhaust Fan Rooms

- Isolation of all plant is required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Installation of Acoustic Louvres/Attenuators will be required.

5.1.8 Level 9 South Fume Cupboard Exhaust Room

- Isolation of all plant is required.
- Acoustic Barriers around the discharge will be required.

5.1.9 Level 9 Northern External Exhaust Fan Rooms

- Isolation of all plant is required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Installation of Acoustic Louvres/Attenuators will be required.

5.1.10 Level 9 Chiller Plant Room

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Plant room should be acoustically sealed, and the installation of Acoustic Louvres/Attenuators will be required for Outside Air Intake, Relief and Exhaust Air.
- All openings not required for airflow should be blanked off with a minimum 2 x 6mm Fibre Cement Sheeting.

5.1.11 Level 9 AHU Northern Plant Room

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.
- Plant room should be acoustically sealed, and the installation of Acoustic Louvres/Attenuators will be required for Outside Air Intake, Relief and Exhaust Air.
- All openings not required for airflow should be blanked off with a minimum 2 x 6mm Fibre Cement Sheeting.

5.1.12 Kitchen Exhaust Fans (KEF)

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

5.1.13 Toilet Exhaust Fans (TEF)

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

5.1.14 Garbage Exhaust Fans (GEF)

- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.

- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

5.1.15 Outside Air Fans (OAF)

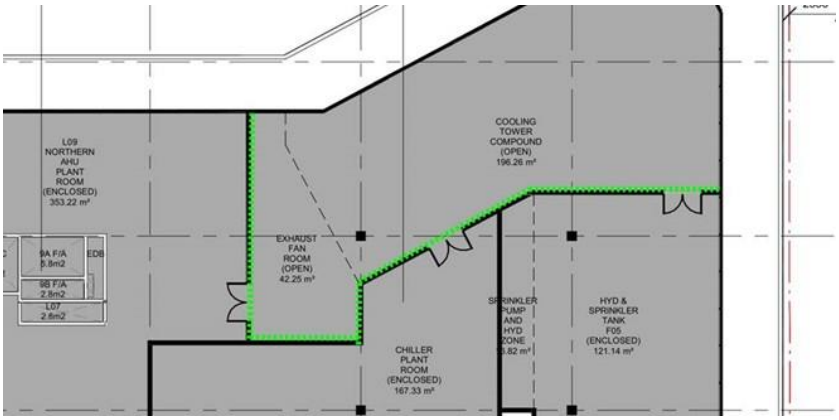
- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

5.1.16 Exhaust Air Fans (EAF)

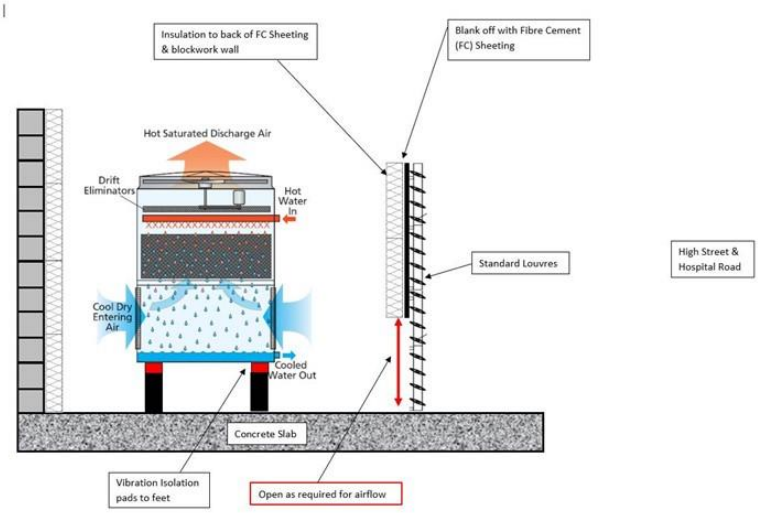
- Isolation of all plant/pumps are required.
- VSD controllers for all plant items are required.
- Inline acoustic treatment will be required for both the supply and discharge side of the fan, this could include either internally lined ductwork or attenuators.

5.1.17 Cooling Towers

- Isolation of all plant/pumps are required.
- Line the rear blockwork walls of cooling tower/exhaust fan plant rooms with externally rated insulation as shown by the green hashed line below.



- Behind the ornamental louvres, it is recommended a part acoustic barrier is installed. The screening should be constructed from Fibre Cement sheeting and absorptive acoustic insulation. The bottoms of the ornamental louvres are to be left open for airflow as required.



5.1.18 Pneumatic Tube System

- Isolation of all plant/pumps are required.

5.2 Vehicle Movements

Noise emissions from the movement of onsite vehicles are outlined below.

5.2.1 Vehicle Noise Data

To quantify the noise level likely to take place with regards to onsite vehicle movements, the noise levels of the relevant vehicles are obtained from previous project experience. Therefore, the sound power levels used in the noise impact assessment are listed in Table 5-1.

Table 5-1 Sound power levels for vehicular events

Parameter	Octave Band Centre Frequency, Hz							Overall dBA
	63	125	250	500	1000	2000	4000	
Noise Events								
Car movement at 40km/hr	81	79	76	75	76	75	68	**81**
Car movement at 5 km/hr	50	53	59	63	65	64	61	**70**[1]

Note 1: Noise event sound power level represented as a $L_{Aeq,15\ minutes}$ level without for one vehicular activity

Additionally, noise information for short term loud events that are likely to cause sleep disturbance is summarised in Table 5-2. This information is used in our assessment of sleep arousal at the nearest affected residences.

Table 5-2 L_{max} sound power levels for short term events

Parameter	Octave Band Centre Frequency, Hz							Overall dBA
	63	125	250	500	1000	2000	4000	
L_{Amax}[1]								
Car door slam	54	57	59	60	61	57	54	**65**
Ambulance Engine Start	71	70	62	63	69	69	67	**75**

Note 1: Noise information used for the prediction of short-term noise events and sleep arousal assessment.

Pulse Acoustics has been provided with the following vehicle movement data from the project traffic consultant, ARUP.

Table 5-3 Assumed vehicular movements

Vehicle Type	Vehicular Movements (number of vehicular movements within a 15 minute period)		
	AM Peak Hour (8:00am to 9:00am)	PM Peak Hour (5:00pm to 6:00pm)	All Day (Averaged 24-hour period)
Emergency Department	3.5	5.5	3.75
Visitor Parking	15.75	15.75	6.72
TOTAL (15-minute)	**19.25**	**21.25**	**10.47**

5.2.2 Surrounding Roadways

Noise impacts from the increase in vehicle movements along Botany Street are to be assessed in accordance with the NSW EPA Road Noise Policy (RNP) 2011.

A peak hour increase of 85 vehicles will not exceed a 2dBA increase as summarised in the NSW EPA RNP to be barely perceptible to the average person and therefore considered acoustically acceptable.

5.2.3 Basement Carpark

As the visitor parking is located within an enclosed basement beneath the proposed building with the only opening beneath the descending driveway. The resultant L_{Max} noise levels for a sleeping disturbance assessment from a door slam or engine starting are compliant with the requirements.

5.2.4 Loading Dock

Located on the northern portion of the basement 2 level is the buildings future loading dock. As the loading dock is located in an enclosed basement level, noise from the operation of the loading dock will be attenuated by the building above.

6 BUILDING ENVELOPE ASSESSMENT (FAÇADE)

6.1 Future Façade Levels

6.1.1 Future Façade Noise Levels – Generally

In determining the required construction for the future building envelope, contributing L_{Aeq} noise levels from surrounding road/corridor to each future façade need to be determined. Utilising the 15-minute interval difference between the attended measurement and the unattended monitor as well as the difference between 15-minute interval and overall period result the calculated noise levels at each façade are determined below. Where applicable, angle of view and distance corrections have also been provided.

Table 6-1 Predicted Noise Level at Future Facades

Prediction Location	Predicted Façade Noise Level LAeq (Period) [2] (dBA)	
	Day time (7:00am-10:00pm) $L_{Aeq\ (Whole\ Period)}$	Night time (10:00pm-7:00am) $L_{Aeq\ (Whole\ Period)}$
Future Northern Façade (Along High Street)	62	60
Future Eastern Façade (Along Hospital Road)	58 (assumed without construction noise)	53
Future Southern Façade (Towards IASB Building)	50	45
Future Western Façade (Towards HTH building/Botany Street)	58	53

Note 1: For Monday to Sunday, Daytime 7:00 am – 10:00 pm; Night-time 10:00 pm – 7:00 am.

Note 2: The LAeq is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

6.1.2 Future Façade Noise Levels – Aircraft Noise Intrusion

Commercial aircraft operations from flight movements associated with Sydney Kingsford Airport have a potential for future noise intrusion, as such external noise levels at the site are determined in accordance with the procedures given in standard AS 2021:2015, the project site is located at the distances listed in Table 6-2 from the airport's runways.

Table 6-2 Distances from project site relative to airport's runways

Runway	Distance (m)		
	DS	DL	DT
Main North – South runway	6280	-240 (before runway end)	4050
Parallel North – South runway	800	7250	9180
East – West runway	970	4850	7520

Notes:

1. *The sideline projection is a line which is perpendicular to the extended runway centre-line and which passes over the project site*
2. *DS: Distance from project site to the extended runway centre-line measured along the sideline projection*
3. *DL: Distance from closer end of runway to the intersection of the extended runway centre-line and the sideline projection*
4. *DT: Distance from further end of runway to the intersection of the extended runway centre-line and the sideline projection.*

Based on these distances and the procedures discussed in standard AS 2021:2015 (including typical maximum noise levels for jet and non-jet aircrafts), the project site will be exposed to the following maximum noise levels:

- Departure: 73 dBA
- Arrival: 67 dBA

Please note the following in regards to these maximum noise levels:

- These maximum noise levels are mostly related to flyovers which use the Parallel North – South runway.
- Noise levels indicated above are from a Boeing 777-300-ER aircraft.

Table 6-3 below summarises the ANRs required in order to achieve the internal design noise listed in section 4.2.4. These ANRs will be used to determine the sound insulation performance of architectural components which form part of the building envelope.

Table 6-3 Recommended aircraft noise reductions (ANRs)

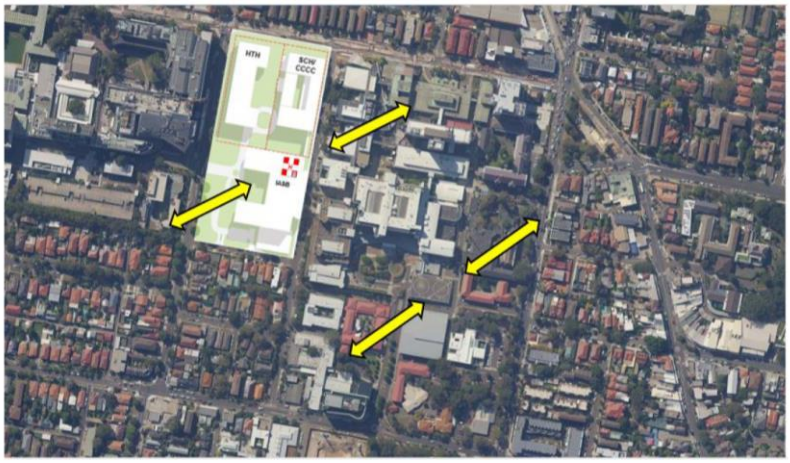
Building Type and Spaces	Recommended ANRs, dB
Hospitals, nursing homes	
Wards, theatres, treatment and consulting rooms	23
Laboratories	8
Service Areas	N/A

6.1.3 Future Façade Noise Levels – Emergency Helicopter Flights

The existing RHC currently operates a helipad above the emergency department parking station in the south east corner of the campus as indicated in Figure 2-1 above. Additionally, as part of the construction of the IASB building located to the south of the SCH1/CCCC building a new helipad will be constructed. IASB's new helicopter landing site (HLS) will be in the north-eastern corner of the new building. It is understood once the IASB helipad is operational the existing helipad of the POW Hospital will be decommissioned. Therefore, an assessment of the future helipad location on the IASB will only need to be undertaken to ensure the façade of the future SCH1/CCCC building will achieve the internal noise objectives as shown in 4.2.

Outlined in section 4.2 and figure 11 of the AviPro *Aviation Due Diligence Report*, dated 14th May 2020 for the SCH1/CCCC building shows the two planned approach and departure paths. An extract of the report is shown below.

Figure 6-1 Figure 11 of AviPro Due Diligence Report – Current and Planned HLS Locations and Approach/Departure Paths



In our experience, NSW Health suggests for planning of a new HLS an Agusta Westland (Leonardo) AW139 should be considered. An Agusta Westland AW139 helicopter has a noise level of approximately 127dBAL$_{Max}$.

Information provided by HI and PWC indicate the existing helipad located at the Prince of Wales Hospital (POW) in 2019 had 225 admissions via helicopter missions for a 12-month period.

As this number is equal to less than 1 mission per day but more than 2 missions per week, a 10dBA tolerance is permitted to the levels outlined in Column C. Refer to section 4.2.2 for the relevant procedure.

This assumption (i.e., 10dBA tolerance on Column C) will be sufficient for no more than a 40% increase in missions per year.

6.2 Façade Acoustic Treatments

Preliminary façade acoustic treatments based on the external levels discussed above are provided below.

6.2.1 Glazing Recommendations

The recommended sound transmission loss requirement required to satisfy the specified internal noise level criteria outlined above are summarised in Table 6-4 below.

Please note these recommendations are also based on the floor details shown in the architectural drawings included in Appendix C.

Table 6-4 In-principle Glazing Recommendations

Location	Occupancy Area [1]	Minimum Glazing System Rating Requirements [1]	Indicative Construction [1]
Future Northern Façade (Along High Street)	Ward Areas	Rw (C;Ctr): 41 (-2;-6)	6mm Float + 12mm Airgap + 8.76mm laminated
	Laboratory Areas	Rw (C;Ctr): 39 (-2;-5)	6mm Float + 12mm Airgap + 6.76mm laminated
Future Eastern Façade (Along Hospital Road)	Ward Areas	**Option 1 – Helicopter Flight Path ≥ 20m from Facade**	
		Rw (C;Ctr): 45 (-2,-4)	12mm Float + 16mm Airgap + 8.76mm Laminate
		Option 2 – Helicopter Flight Path ≥ 40m from Facade	
		Rw (C;Ctr): 39 (-2;-5)	6mm Float + 12mm Airgap + 6.76mm laminated
	Laboratory Areas	Rw (C;Ctr): 39 (-2;-5)	6mm Float + 12mm Airgap + 6.76mm laminated
Future Southern Façade (Towards IASB Building)	Ward Areas	**Option 1 – Helicopter Flight Path ≥ 20m from Facade**	
		Rw (C;Ctr): 45 (-2,-4)	12mm Float + 16mm Airgap + 8.76mm Laminate
		Option 2 – Helicopter Flight Path ≥ 40m from Facade	
		Rw (C;Ctr): 43 (-2,-5)	12mm Float + 12mm Airgap + 6.76mm Laminate
	Laboratory Areas	Rw (C;Ctr): 39 (-2;-5)	6mm Float + 12mm Airgap + 6.76mm laminated
Future Western Façade (Towards HTH building/Botany Street)	Ward Areas	Rw (C;Ctr): 37 (-2;-3)	12.38mm Laminate
	Laboratory Areas	Rw (C;Ctr): 33 (-2;-3)	10mm float

Note 1: These are preliminary selections will be confirmed in the detailed design stage once the layouts and façade orientations are finalised.

Please note for windows, this performance is not only subject to the glazing selection but also to the construction of the window frame and the frame seal selection. Therefore, it is recommended that the window manufacturer should confirm that the required sound insulation can be achieved. It is anticipated that the window system should comprise Q-Lon (or equivalent) or fin seals with deep C channels as part of the window track **(i.e., Performance levels outlined above need to be achieved with glazed panels + frame + seals).**

6.2.2 External Wall Construction

External wall constructions which are constructed from a concrete or masonry construction will be acoustically sufficient and no further acoustic upgrading is required. However, for wall systems constructed from a lightweight cladding system, the following construction is recommended.

Table 6-5 Recommended Light Weight External Wall Construction

Façade	Occupancy Area [1]	External Lining	Studwork System	Internal Lining
Future Northern Façade (Along High Street)	Ward Areas	Aluminium Composite Panel (similar to Alucobond®) + 1x9mm Fibre Cement Sheeting	150mm Steel Studwork with 100mm thick 14kg/m^3 glasswool insulation in the cavity	1 x 13mm Fyrcheck Plasterboard
	Laboratory Areas			1 x 13mm Standard Plasterboard
Future Eastern Façade (Along Hospital Road)	Ward Areas	Aluminium Composite Panel (similar to Alucobond®) + 1x9mm Fibre Cement Sheeting		**Option 1 – Helicopter Flight Path ≥ 20m from Facade:** 2 x 13mm Fyrcheck Plasterboard
				Option 2 – Helicopter Flight Path ≥ 40m from Facade: 1 x 13mm Fyrcheck Plasterboard
	Laboratory Areas			1 x 13mm Standard Plasterboard
Future Southern Façade (Towards IASB Building)	Ward Areas	Aluminium Composite Panel (similar to Alucobond®) + 1x9mm Fibre Cement Sheeting		**Option 1 – Helicopter Flight Path ≥ 20m from Facade:** 2 x 13mm Fyrcheck Plasterboard
				Option 2 – Helicopter Flight Path ≥ 40m from Facade: 1 x 13mm Fyrcheck Plasterboard
	Laboratory Areas			1 x 13mm Standard Plasterboard
Future Western Façade (Towards HTH building/Botany Street)	Ward Areas	Aluminium Composite Panel (similar to Alucobond®)		1 x 13mm Fyrcheck Plasterboard
	Laboratory Areas			1 x 13mm Standard Plasterboard

Note 1: Recommended constructions are identical for each level.

Note 2: These are preliminary selections will be confirmed in the detailed design stage once the layouts and façade orientations are finalised.

If penetrations through any external skin are required, all gaps remaining in the penetration are to be filled with an acoustic grade sealant which provides an equal or better performance to the system being penetrated.

6.2.3 External Roof Construction

External roofs will be constructed from a concrete construction, as such no further acoustic upgrading is required. If penetrations through any external skin are required, all gaps remaining in the penetration are to be filled with an acoustic grade sealant which provides an equal or better performance to the system being penetrated.

6.2.4 Link Bridges

The following indicative acoustic treatments are recommended for the Link Bridges

- Glazed components should achieve a minimum sound insulation performance of Rw 32. Material example: 6.38mm thick laminated glass
- Roof construction should comprise the following:
    - Metal deck roof with 4-5 kg/m^2 minimum mass density
    - Set plasterboard ceiling (with 9 kg/m^2 minimum mass density)
    - Roof cavity with 150 mm min. cavity depth separating metal deck roof and plasterboard ceiling. Cavity to include 75 mm thick insulation (with 10 kg/m^3 minimum density)

7 VIBRATION INTRUSION ASSESSMENT

Located along the northern boundary of the site in the middle of High Street is the L2 Light Rail corridor. Due to the distance between the existing corridor and the proposed building footprint to the corridor a ground-borne noise and vibration assessment has been carried out, see below.

7.1 Ground-Borne Noise Prediction Methodology

Utilising the attended vibration measurements presented in Section 3.2, ground-borne noise levels into the hospital building are predicted in this section.

7.1.1 Propagation of Vibration within Buildings

Losses occur with the transfer of vibration from floor-to-floor within buildings. Calculations in this report incorporate the losses listed in Table 7-1, which are obtained from data presented by Nelson (1987), extrapolated to include frequency bands below 16 Hz. The ground-borne noise and vibration levels attenuate by approximately 2 dB per floor.

Table 7-1 Floor-to-floor loss values

Applicable Floor Levels	Floor-to-Floor Loss (dB) in 1/3 Octave Band Frequencies (Hz)					
	5 Hz to 10 Hz	12 Hz to 20 Hz	25 Hz to 40 Hz	50 Hz to 80 Hz	100 Hz to 160 Hz	200 Hz to 315 Hz
Basement One - Emergency Department						
From basement two (grade) to basement one level + Coupling Loss	3	5	5	6	5	5
Total (Basement 1 – Emergency Department	**3**	**5**	**5**	**6**	**5**	**5**
Level 5 – Ward Areas						
From basement two (grade) to basement one level + Coupling Loss	3	5	5	6	5	5
From basement one to ground level	1	2	2	2	2	3
From ground level to level one	1	2	2	2	2	3
From level one to level two	1	2	2	2	2	3
From level two to level three	1	2	2	2	2	3
From level three to level four	1	2	2	2	2	3
From level four to level five	1	2	2	2	2	3
Total (Level 5 – Ward Area	**9**	**17**	**17**	**18**	**17**	**23**

Low frequency vibration can be amplified within buildings by resonances in floors and walls. Based on information discussed by Nelson (1987), the amplification spectra presented in Table 7-2 has been adopted. Nelson (1987) indicates that amplification values found in practice are typically within ±3 dB of these values. Slightly lower values are assumed for the ground-borne noise calculations as the use of the full floor amplification values can result in over estimation of the resultant noise levels.

Table 7-2 Amplification values within building

Parameter	Floor to Floor Amplification (dB) in 1/3 Octave Band Frequencies (Hz)											
	5 Hz to 16 Hz	20 Hz	25 Hz to 40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz
Floor Vibration	10	10	11	10	9	9	-	-	-	-	-	-
Ground-borne Noise	-	6	7	6	6	5	5	4	3	2	1	1

7.1.2 Conversion between Velocity Levels and Ground-Borne Noise Levels

According to the book titled *"Measurement & Assessment of Groundborne Noise & Vibration"*, authored by the Association of Noise Consultants (ANC 2001), the relationship between ground borne noise levels and vibration velocity levels is established as follows:

$L_p = L_v - 27$, where:

L_p is the L_{Amax} sound pressure level

L_v is the A weighted, L_{max} velocity level, in dB re 1 x 10^{-9} m/s

Note: In Section 4.1.2 of the latest version of the ANC Guideline (second edition 2012), the authors suggest that:

> *"… the conversion from the rms vibration velocity to the sound pressure level may overstate the sound pressure level by 5 dB and that the measured data supported a correction of -32 rather than -27 dB."*

7.2 Prediction of Vibration Levels & Ground-Borne Noise Levels

Based on the information and methodology discussed in the sections above, ground-borne noise levels have been predicted for the nearest residential areas located immediately above the survey location at the existing Ground Level. In the proposed new development, these residential areas are situated on Level 1 (refer to drawings in Appendix C). The predicted levels are summarised in Table 7-3. The predicted ground-borne noise levels utilise the measured L_{AMax} vibration levels from the suburban train with the highest levels of vibration.

Table 7-3 Summary of predicted vibration velocity and ground-borne noise levels on Level 1

Floor Level in the New Development	Predicted L_{ASmax} Velocity Level (dB re 1x10^{-9} m/s) A Weighted Level (including floor amplification)	Predicted L_{ASmax} Ground Borne Noise Level (dB re 1x10^{-6} Pa) A Weighted Level
Basement 1 (Emergency Department)	**67**	**40 (Criteria 45dBA)**
Level 5 (Ward Areas)	**44**	**17 (Criteria 35dBA)**

Red: 10-15dB attenuation required
Orange: 5-10 dB attenuation required
Blue: 0-5 dB attenuation required
Green: no attenuation required

7.2.1 Assessment of Ground-Borne Noise Levels

Based on the information presented in Table 7-3, predicted ground-borne noise levels are below the criteria for both ward and other sensitive spaces. **Vibration isolation treatment of the structure is therefore not required**.

7.3 Vibration Assessment

The number of trains passing by the proposed development is predicted/assumed below in Table 7-4. The number of light rail movements is taken from the current Sydney Light Rail timetable.

Table 7-4 Assumed Number of Movements Per Day

Line	Day (7:00am to 10:00pm)	Night (10:00pm to 7:00am)
L2 Light Rail	180 [1]	72 [1]
Total	**180 [1]**	**72 [1]**
Note 1: Estimated number of train pass-bys per day		

The maximum individual VDV dose value measured in Table 3-4 was 0.007. Utilising the maximum individual VDV and the assumed number of trains per period, the predicted VDV can be calculated using the formula below

$VDV = (\sum_{i=1-N} VDV_i^4)^{0.25}$ where VDV_i is the individual dose value

The predicted VDV for the day and night period from the light rail is therefore shown in Table 7-5. Compliance with the intermittent vibration criteria for a hospital building is predicted.

Table 7-5 Predicted VDV and Criteria (Intermittent) $m/s^{1.75}$

Trains	Criteria (Ward Areas) $m/s^{1.75}$	Predicted $m/s^{1.75}$
Day	0.2	<0.2
Night	0.13	<0.13

7.4 Assessment of Sensitive Science and Medical Equipment

Based on the proposed end users of the SCH1/CCCC it is anticipated that several sensitive science or medical equipment will be located within the building. As such vibration from the operation of the CSELR has been reviewed and assessed.

Results of the assessment indicate the following:

- Measured vibration levels (see section 3.2) in-line with the proposed High Street façade were compliant with the VC-B criteria. This result does not include any attenuation throughout the building or any isolation from manufacturers machines (i.e., isolated benches or footings).

- Measured vibration levels (see section 3.2) 60m south of the High Street kerb were compliant with the VC-B and in some cases VC-C criteria. This result does not include any attenuation throughout the building or any isolation from manufacturers machines (i.e., isolated benches or footings).

8 CONSTRUCTION NOISE & VIBRATION ASSESSMENT

8.1 Construction Noise Assessment

Sound power levels have been predicted for the construction tasks identified in the project program. The equipment anticipated for use in each task is based on previous project experience. The sound power levels for the equipment likely to be used for each of the listed tasks are provided in Table 8-1 below.

Table 8-1 Summary of predicted sound power levels

Tasks	Equipment	Sound Power Levels (dBA re 1pW)	Aggregate Sound Power Level per Task (dBA re 1pW)
Site Establishment Works	Mobile crane	110	113
	Power hand tools	109	
	Semi Rigid Vehicle [1]	105	
Ground Works and Demolition	Excavator	112	119
	Hand held jack hammer [1]	111	
	Dump truck [1]	104	
	Concrete saw [1]	114	
	Skid steer	110	
	Power hand tools	109	
Structure	Hand held jack hammer [1]	106	117
	Concrete saw [1]	114	
	Power hand tools	109	
	Welder	101	
	Concrete pump truck	110	
	Concrete agitator truck	108	
Internal Works	Power hand tools	109	109
Common and External Works	Concrete agitator truck	108	117
	Saw cutter [1]	104	
	Dump truck [1]	104	
	Concrete saw [1]	114	
	Power hand tools	109	

Note 1: An assumed time correction has been applied, this being 5 minutes of operation in any 15-minute interval.

Table 8-2 Receiver 1 - Summary of preliminary predicted construction noise levels – Blenheim Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	58 to 72	61 to 76	**Monday to Friday** 07.00-18.00 51 + 10 = **61** **Saturday** 08.00-13.00 51 + 10 = **61** 13.00-17.00 51 + 5 = **56** **Highly Noise Affected Level** Standard Construction Hours **75**	**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Power hand tools		57 to 71			
	Semi Rigid Vehicle		53 to 68			
Ground Works and Demolition	Excavator	119	60 to 74	66 to 81		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Handheld jack hammer		54 to 69			
	Dump truck		52 to 67			
	Concrete saw		62 to 77			
	Skid steer		58 to 72			
	Power hand tools		57 to 71			
Structure	Handheld jack hammer	117	54 to 69	65 to 80		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Concrete saw		62 to 77			
	Power hand tools		57 to 71			
	Welder		49 to 63			
	Concrete pump truck		58 to 72			
	Concrete agitator truck		56 to 70			
Internal Works	Power hand tools	109	57 to 71	57 to 71		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	56 to 70	65 to 79		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Saw cutter		52 to 67			
	Dump truck		52 to 67			
	Concrete saw		62 to 77			
	Power hand tools		57 to 71			

Table 8-3 Receiver 2 - Summary of predicted construction noise levels – Botany North Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	56 to 63	59 to 66	**Monday to Friday** 07.00-18.00 51 + 10 = **61** **Saturday** 08.00-13.00 51 + 10 = **61** 13.00-17.00 51 + 5 = **56** **Highly Noise Affected Level** Standard Construction Hours **75**	Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Power hand tools		55 to 62			
	Semi Rigid Vehicle		51 to 58			
Ground Works and Demolition	Excavator	119	58 to 65	64 to 71		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Handheld jack hammer		52 to 59			
	Dump truck		50 to 57			
	Concrete saw		60 to 67			
	Skid steer		56 to 63			
	Power hand tools		55 to 62			
Structure	Handheld jack hammer	117	52 to 59	63 to 70		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Concrete saw		60 to 67			
	Power hand tools		55 to 62			
	Welder		47 to 54			
	Concrete pump truck		56 to 63			
	Concrete agitator truck		54 to 61			
Internal Works	Power hand tools	109	55 to 62	55 to 62		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
Common and External Works	Concrete agitator truck	117	54 to 61	63 to 70		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Saw cutter		50 to 57			
	Dump truck		50 to 57			
	Concrete saw		60 to 67			
	Power hand tools		55 to 62			

Table 8-4 Receiver 3 - Summary of predicted construction noise levels – Magill Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	43 to 48	46 to 52	**Monday to Friday** 07.00-18.00 51 + 10 = **61** **Saturday** 08.00-13.00 51 + 10 = **61** 13.00-17.00 51 + 5 = **56** **Highly Noise Affected Level** Standard Construction Hours **75**	Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Power hand tools		42 to 47			
	Semi Rigid Vehicle		38 to 44			
Ground Works and Demolition	Excavator	119	45 to 50	51 to 57		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Handheld jack hammer		39 to 45			
	Dump truck		37 to 43			
	Concrete saw		47 to 53			
	Skid steer		43 to 48			
	Power hand tools		42 to 47			
Structure	Handheld jack hammer	117	39 to 45	51 to 56		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Concrete saw		47 to 53			
	Power hand tools		42 to 47			
	Welder		34 to 39			
	Concrete pump truck		43 to 48			
	Concrete agitator truck		41 to 46			
Internal Works	Power hand tools	109	42 to 47	42 to 47		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
Common and External Works	Concrete agitator truck	117	41 to 46	50 to 55		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Saw cutter		37 to 43			
	Dump truck		37 to 43			
	Concrete saw		47 to 53			
	Power hand tools		42 to 47			

Table 8-5 Receiver 4 - Summary of predicted construction noise levels – Norton Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	52 to 58	56 to 62	**Monday to Friday** 07.00-18.00 51 + 10 = **61** **Saturday** 08.00-13.00 51 + 10 = **61** 13.00-17.00 51 + 5 = **56** **Highly Noise Affected Level** Standard Construction Hours **75**	Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Power hand tools		51 to 57			
	Semi Rigid Vehicle		48 to 54			
Ground Works and Demolition	Excavator	119	54 to 60	61 to 67		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Handheld jack hammer		49 to 55			
	Dump truck		47 to 53			
	Concrete saw		57 to 63			
	Skid steer		52 to 58			
	Power hand tools		51 to 57			
Structure	Handheld jack hammer	117	49 to 55	60 to 66		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Concrete saw		57 to 63			
	Power hand tools		51 to 57			
	Welder		43 to 49			
	Concrete pump truck		52 to 58			
	Concrete agitator truck		50 to 56			
Internal Works	Power hand tools	109	51 to 57	51 to 57		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
Common and External Works	Concrete agitator truck	117	50 to 56	59 to 65		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Saw cutter		47 to 53			
	Dump truck		47 to 53			
	Concrete saw		57 to 63			
	Power hand tools		51 to 57			

Table 8-6 Receiver 5 - Summary of predicted construction noise levels – Randwick Hospital Campus

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	43 to 58	46 to 62	**Monday to Friday** 07.00-18.00 **Saturday** 08.00-17.00 **45dBA (applies when properties are being used)**	Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Power hand tools		42 to 57			
	Semi Rigid Vehicle		38 to 54			
Ground Works and Demolition	Excavator	119	45 to 60	51 to 67		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Handheld jack hammer		39 to 55			
	Dump truck		37 to 53			
	Concrete saw		47 to 63			
	Skid steer		43 to 58			
	Power hand tools		42 to 57			
Structure	Handheld jack hammer	117	39 to 55	50 to 66		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Concrete saw		47 to 63			
	Power hand tools		42 to 57			
	Welder		34 to 49			
	Concrete pump truck		43 to 58			
	Concrete agitator truck		41 to 56			
Internal Works	Power hand tools	109	42 to 57	42 to 57		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
Common and External Works	Concrete agitator truck	117	41 to 56	50 to 65		Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.
	Saw cutter		37 to 53			
	Dump truck		37 to 53			
	Concrete saw		47 to 63			
	Power hand tools		42 to 57			

Table 8-7 Receiver 6 - Summary of predicted construction noise levels - UNSW

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	38 to 43	42 to 47	**Monday to Friday** 07.00-18.00 **Saturday** 08.00-17.00 **45dBA (applies when properties are being used)**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		37 to 42			
	Semi Rigid Vehicle		34 to 39			
Ground Works and Demolition	Excavator	119	40 to 45	47 to 52		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		35 to 40			
	Dump truck		33 to 38			
	Concrete saw		43 to 48			
	Skid steer		38 to 43			
	Power hand tools		37 to 42			
Structure	Handheld jack hammer	117	35 to 40	46 to 51		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		43 to 48			
	Power hand tools		37 to 42			
	Welder		29 to 34			
	Concrete pump truck		38 to 43			
	Concrete agitator truck		36 to 41			
Internal Works	Power hand tools	109	37 to 42	37 to 42		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	36 to 41	45 to 50		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		33 to 38			
	Dump truck		33 to 38			
	Concrete saw		43 to 48			
	Power hand tools		37 to 42			

8.2 Construction Traffic Noise Assessment

It is proposed that the construction traffic would access the site via Botany Street.

From the criteria discussed in Section 4.3.4, it is noted that vehicle numbers on surrounding roads would need to increase by around 60% from existing traffic flows, for a 2 dB increase in road traffic noise to occur. As noted previously, a 2 dB increase in road traffic noise is not considered to be noticeable.

Based on the number of vehicles projected over each of the phases, it is concluded that noise impacts from construction traffic is unlikely to have an impact at the nearest affected properties. As a result, no further assessment is required.

8.3 Vibration Assessment

In order to maintain compliance with the human comfort vibration criteria discussed in Section 4.3.4, it is recommended that the indicative safe distances listed in Table 8-8 should be maintained. These indicative safe distances should be validated prior to the start of construction works by undertaking measurements of vibration levels generated by construction and demolition equipment to be used on site.

Since the criteria for scientific or medical equipment (should any of these exist close to the site) can be more stringent than those required for human comfort, vibration validating measurements should be conducted at each site to determine the vibration level and potential impact onto this sensitive equipment.

Additionally, any vibration levels should be assessed in accordance with the criteria discussed in Section 4.3.4. This information should also be included as part of a *Construction Noise Vibration Management Plan* (CNVMP).

Table 8-8 Recommended indicative safe working distances for vibration intensive plant

Plant	Rating / Description	Safe Working Distances (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
Vibratory roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 – 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Jackhammer	Hand held	1	Avoid contact with structure and steel reinforcements

8.4 Acoustic Management Procedures

8.4.1 Summary of Management Procedures

Table 8-9 below summarises the management procedures recommended for airborne noise and vibration impact. These procedures are also further discussed in the report.

Table 8-9 Summary of mitigation procedures

Procedure	Abbreviation	Description
General Management Measures	GMM	Introduce best-practice general mitigation measures in the workplace which are aimed at reducing the acoustic impact onto the nearest affected receivers.
Project Notification	PN	Issue project updates to stakeholders, discussing overviews of current and upcoming works. Advanced warning of potential disruptions can be included. Content and length to be determined on a project-by-project basis.
Verification Monitoring	V	Monitoring to comprise attended or unattended acoustic surveys. The purpose of the monitoring is to confirm measured levels are consistent with the predictions in the acoustic assessment, and to verify that the mitigation procedures are appropriate for the affected receivers. If the measured levels are higher than those predicted, then the measures will need to be reviewed and the management plan will need to be amended.
Complaints Management System	CMS	Implement a management system which includes procedures for receiving and addressing complaints from affected stakeholders
Specific Notification	SN	Individual letters or phone calls to notify stakeholders that noise levels are likely to exceed noise objectives. Alternatively, contractor could visit stakeholders individually in order to brief them in regards to the noise impact and the mitigation measures that will be implemented.
Respite Offer	RO	Offer provided to stakeholders subjected to an ongoing impact. The offer could include movie tickets, meal vouchers, gift cards or equivalent measures.
Alternative Construction Methodology	AC	Contractor to consider alternative construction options that achieve compliance with relevant criteria. Alternative option to be determined on a case-by-case basis. It is recommended that the selection of the alternative option should also be determined by considering the assessment of on-site measurements (refer to Verification Monitoring above).

The application of these procedures is in relation to the exceedances over the relevant criteria. For airborne noise, the criteria are based on NMLs. The allocation of these procedures is discussed in Section 8.4.2

For vibration, the criteria either correspond to human comfort, building damage or scientific and medical equipment. The application of these procedures is discussed in Section 8.4.3.

8.4.2 Allocation of Noise Management Procedures

For residences, the management procedures have been allocated based on noise level exceedances at the affected properties, which occur over the designated NMLs (refer to Section 4.3.4 for list of NMLs used in the acoustic assessment). The allocation of these procedures is summarised in Table 8-10 below.

Table 8-10 Allocation of noise management procedures – residential receivers

Construction Hours	Exceedance over NML (dB)	Management Procedures (see definition above)
Standard Hours Mon – Fri: 7:00 am to 6:00 pm Sat: 8:00 am – 1:00 pm	0 - 3	GMM
	4 - 10	GMM, PN, V [1], CMS, AC
	> 10	GMM, PN, V, CMS, SN, AC
Outside Standard Hours Sat: 1:00 pm – 5:00 pm	0 - 10	GMM, AC
	11 - 20	GMM, PN, V [1], CMS, AC
	> 20	GMM, PN, V, CMS, SN, RO, AC

Notes
1. Verification monitoring to be undertaken upon complaints received from affected receivers

Please note the following regarding the allocation of these procedures:

- The exceedances have been estimated as part of the acoustic assessment, and these are summarised in Section 8.1.
- The allocation of procedures is based on the assumptions used for noise level predictions (refer to Section 8.1). Consequently, these allocations are to be further refined once additional details of the project and construction program become available.

For non-residential receivers (such as commercial), management measures are provided in Section 8.5.4.

8.4.3 Allocation of Vibration Management Procedures

Table 8-11 below summarises the vibration management procedures to be adopted based on exceedance scenarios (i.e., whether the exceedance occurs over human comfort criteria, building damage criteria, or criteria for scientific and medical equipment). Please note these management procedures apply for any type of affected receiver (i.e., for residences as well as non-residential receivers).

Table 8-11 Allocation of vibration management procedures

Construction Hours	Exceedance Scenario	Management Procedures
Standard Hours Mon – Fri: 7:00 am to 6:00 pm Sat: 8:00 am – 1:00 pm	Over human comfort criteria (refer to Section 4.3.4)	GMM, PN, V, RO
	Over building damage criteria (refer to Section 4.3.4)	GMM, V, AC
Outside Standard Hours Sat: 1:00 pm – 5:00 pm	Over human comfort criteria (refer to Section 4.3.4)	GMM, SN, V, RO, CMS
	Over building damage criteria (refer to Section 4.3.4)	GMM, V, AC

8.5 Site Specific Noise Mitigation Measures

8.5.1 Respite Periods

Predicted noise levels outlined in section 8.1 indicate exceedances above the Noise Management Levels (NMLs) as indicated in section 4.3.4. To militate against any exceedances, the site will need to incorporate respite periods for noisy works. This is to be further refined once additional details of the project and construction program become available.

8.5.2 General Comments

The contractor will, where reasonable and feasible, apply best practice noise mitigation measures. These measures shall include the following:

- Maximising the offset distance between plant items and nearby noise sensitive receivers.
- Preventing noisy plant working simultaneously and adjacent to sensitive receivers.
- Minimising consecutive works in the same site area.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.

In order to minimise noise impacts during the works, the contractor will take all reasonable and feasible measures to mitigate noise effects.

The contractor will also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

The contractor should apply all feasible and reasonable work practices to meet the NMLs and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the proposal.

8.5.3 Noise Monitoring

Noise monitoring, if required, will be performed by an acoustical consultant directly engaged by the contractor.

Noise monitoring for the excavation, compaction and construction works should be undertaken using statistical noise loggers. The statistical parameters to be measured should include the following noise descriptors: L_{Amin}, L_{A90}, L_{A10}, L_{A1}, L_{Amax} and L_{Aeq}. Unattended noise measurements should be conducted over consecutive 15 minute periods.

This monitoring should also be complemented by undertaking attended noise measurements in order to:

- Differentiate between construction noise sources and other extraneous noise events (such as road traffic and aircraft noise)
- Note and identify any excessive noise emitting machinery or operation.

In the event of any complaints, the noise impact at the affected location should be confirmed by conducting attended noise measurements.

The survey methodology and any equipment should comply with the requirements discussed in Standard AS 1055.1-1997.

8.5.4 Noise Mitigation Measures for Non-Residential Receivers

Where exceedances have been identified in Section 8.1, the following mitigation measures are recommended:

- Undertake general mitigation measures as discussed in Section 8.10
- Issue project updates to tenants in affected premises. The updates can include overview of current and upcoming works, as well as advanced warning of potential disruptions. These updates can also be issued through an email distribution list or via social media. Refer to Section 8.7 for further details.
- Signage to be posted in order to provide stakeholders information regarding project details, emergency contacts and enquiry contact information.

8.5.5 Alternate Equipment or Process

Exceedance of the site's NMLs should result in an investigation as to whether alternate equipment could be used, or a difference process could be undertaken.

In some cases, the investigation may conclude that no possible other equipment can be used, however, a different process could be undertaken.

8.5.6 Acoustic Enclosures/Screening

Typically, on a construction site there are three different types of plant that will be used: mobile plant (i.e., excavators, skid steers, etc.), semi mobile plant (i.e., hand tools generally) or static plant i.e. (diesel generators).

For plant items which are static it is recommended that, in the event exceedances are being measured due to operation of the plant item, an acoustic enclosure/screen is constructed to reduce impacts. These systems can be constructed from Fibre Cement (FC) sheeting or, if airflow is required, acoustic attenuators or louvres.

For semi mobile plant, relocation of plant should be investigated to either be operated in an enclosed space or at locations away from a receiver.

With mobile plant it is generally not possible to treat these sources. However, investigations into the machine itself may result in a reduction of noise (i.e., mufflers/attenuators etc).

8.6 Vibration Mitigation Measures

8.6.1 General Comments

As part of the CNVMP, the following vibration mitigation measures should be implemented:

- Any vibration generating plant and equipment is to be in areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of construction plant and equipment; that is, smaller capacity plant.
- Minimise conducting vibration generating works consecutively in the same area (if applicable).

- Schedule a minimum respite period of at least 30 minutes before activities commence which are to be undertaken for a continuous 4-hour period.

- Use only dampened rock breakers and/or “city” rock breakers to minimise the impacts associated with rock breaking works.

- Conduct attended measurements of vibration generating plant at commencement of works in order to validate the indicative safe working distances advised in Table 8-8 and, consequently, to establish safe working distances suitable to the project. Measurements should be conducted at the nearest affected property boundary. These safe working distances should be defined by considering the vibration criteria discussed in Section 4.3.4 (i.e., criteria for structural damage, human comfort and impact to scientific or medical equipment).

8.6.2 Vibration Monitoring

Vibration monitoring, if required, should be undertaken continuously at the nearest most affected structures.

The monitoring location would be on a stiff part of the structure (at the foundation) on the side of the structure adjacent to the subject demolition and construction works.

The vibration monitoring system will be configured to record the peak vibration levels and to trigger an audible/visual alarm when predetermined vibration thresholds are exceeded. The thresholds correspond to an “Operator Warning Level” and an “Operator Halt Level”, where the Warning Level is 75% of the Halt Level. The Halt Level should be determined based on the vibration criteria for building contents and structure (refer to Section 4.3.4).

Exceedance of the “Operator Warning Level” would not require excavation or demolition work to cease, but rather, alerts the site manager to proceed with caution at a reduced force or load.

An exceedance of the “Operator Halt Level” would require the contractor to implement an alternative excavation technique pending further analysis of the vibration frequency content in order to determine any potential exceedance of the criteria.

The vibration monitoring equipment would be downloaded and analysed by the acoustical consultant.

Reports of the measured vibration levels and their likely impacts would be prepared by the acoustical consultant and issued to the contractor.

8.7 Community Consultation

8.7.1 Stakeholder Engagement

The overarching Communications and Stakeholder Engagement Strategy for the Randwick Campus Redevelopment (RCR), as well as the Communications and Engagement plans to support each stage of the redevelopment, including the Project, have been developed in line with HI’s guiding principles for capital projects, which centre on:

- Proactive stakeholder engagement

- Proactive and transparent communications

- Coordinated information

- Collaboration

Significant work has been undertaken for the Randwick Campus Redevelopment (RCR) to identify and develop collaborative and productive relationships with key stakeholders and neighbouring sensitive receivers. These relationships will continue to be leveraged throughout planning, design and delivery of the SCH1/CCCC Project.

8.7.2 Stakeholders

The Project's stakeholder environment is complex and extensive. The Project team has developed a deep understanding of stakeholders and the engagement environment which has informed the timing, method and level of engagement across all stages of the redevelopment. Key engagement methods include:

- Formal and information briefings and meetings
- Workshops
- Door Knocks
- Letterbox Drops
- Email Notifications

These methods have proven successful to date and will continue to be utilised for stakeholder engagement on the SCH1/CCCC Project.

8.8 Complaints Management System

The Contractor is to establish a communication register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

All complaints should be investigated by the Contractor in accordance with the procedures outlined in Australia Standard 2436-2010. In addition, the following procedures are an example of the procedures that are to be specifically adopted for complaints relating to noise.

Upon receipt of a complaint the Contractor is to:

- Try to ascertain from the complaint which appliance is causing the problem i.e., inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.
- The Site Supervisor is to ensure that a report of any incident is provided to the Project Manager.
- The Project Manager is to provide a report on the incident to the relevant stakeholders.
- The Contractor is to provide a 24-hour telephone contact number and this number is to be prominently displayed on the site.

8.9 Contingency Plans

Contingency plans are required to address noise or vibration problems if excessive levels are measured at surrounding sensitive receivers and/or if justified complaints occur. Such plans could include:

- Stop the onsite works.
- Identify the source of the main equipment within specific areas of the site which is producing the most construction noise and vibration at the sensitive receivers; and
- Review the identified equipment and determine if an alternate piece of equipment can be used or the process can be altered.
- In the event an alternate piece of equipment or process can be used, works can re-commence.
- In the event an alternate piece of equipment or process cannot be determined implement a construction assessment to be performed by a suitably qualified acoustic consultant.

The Superintendent shall have access to view the Contractor's noise measurement records on request. The Superintendent may undertake noise monitoring if and when required.

8.10 General Mitigation Measures (Australia Standard 2436-2010)

As well as the above project specific noise mitigation controls, AS 2436-2010 "*Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*" sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the subject project are listed below, including the typical noise reduction achieved, where applicable.

8.10.1 Adoption of Universal Work Practices

- Regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration.
- Regular identification of noisy activities and adoption of improvement techniques.
- Avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby sensitive receivers.
- Where possible, avoiding the use of equipment that generates impulsive noise.
- Minimising the need for vehicle reversing for example (particularly at night), by arranging for one-way site traffic routes.
- Use of broadband audible alarms on vehicles and elevated work platforms used on site.
- Minimising the movement of materials and plant and unnecessary metal-on-metal contact.
- Minimising truck movements.

8.10.2 Plant and Equipment

- Choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks.
- Selecting plant and equipment with low vibration generation characteristics.

- Operating plant and equipment in the quietest and most efficient manner.

8.10.3 On Site Noise Mitigation

- Maximising the distance between noise activities and noise sensitive land uses.
- Installing purpose-built noise barriers, acoustic sheds and enclosures.

8.10.4 Work Scheduling

- Providing respite periods which could include restricting very noisy activities to time periods that least affect the nearby noise sensitive locations, restricting the number of nights that after-hours work is conducted near residences or by determining any specific requirements.
- Scheduling work to coincide with non-sensitive periods.
- Planning deliveries and access to the site to occur quietly and efficiently and organising parking only within designated areas located away from the sensitive receivers.
- Optimising the number of deliveries to the site by amalgamating loads where possible and scheduling arrivals within designated hours.
- Including contract conditions that include penalties for non-compliance with reasonable instructions by the principal to minimise noise or arrange suitable scheduling.

8.10.5 Source Noise Control Strategies

Some ways of controlling noise at the source are:

- Where reasonably practical, noisy plant or processes should be replaced by less noisy alternatives.
- Modify existing equipment: Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, graders, excavators, trucks, etc. In order to minimise noise emissions, residential grade mufflers should be fitted on all mobile plant utilised on site.
- Siting of equipment: locating noisy equipment behind structures that act as barriers, or at the greatest distance from the noise-sensitive area; or orienting the equipment so that noise emissions are directed away from any sensitive areas, to achieve the maximum attenuation of noise.
- Regular and effective maintenance.

8.10.6 Miscellaneous Comments

Deliveries should be undertaken, where possible, during standard construction hours.

Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles at site and monitor the profiles in use.

It is advised that mobile plant and trucks operating on site for a significant portion of the project are to have reversing alarm noise emissions minimised. This is to be implemented subject to recognising the need to maintain occupational safety standards.

No public address system should be used on site.

APPENDIX A: ACOUSTIC TERMINOLOGY

Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Background Sound Low	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the LA90 value
Ctr	A frequency adaptation term applied in accordance with the procedures described in ISO 717.

dB (A)	'A' Weighted overall sound pressure level
Noise Reduction	The difference in sound pressure level between any two areas. The term "noise reduction" does not specify any grade or performance quality unless accompanied by a specification of the units and conditions under which the units shall apply
NR Noise Rating	Single number evaluation of the background noise level. The NR level is normally around 5 to 6 dB below the "A" weighted noise level. The NR curve describes a spectrum of noise levels and is categorised by the level at 1000 Hz ie the NR 50 curve has a value of 50 dB at 1000 Hz. The NR rating is a tangential system where a noise spectrum is classified by the NR curve that just encompasses the entire noise spectrum consideration.
R_w	Weighted Sound Reduction Index - Laboratory test measurement procedure that provides a single number indication of the acoustic performance of a partition or single element. Calculation procedures for Rw are defined in ISO 140-2:1991 "Measurement of Sound Insulation in Buildings and of Building Elements Part 2: Determination, verification and application of precision data".
R'_w	Field obtained Weighted Sound Reduction Index - this figure is generally up to 3-5 lower than the laboratory test determined level data due to flanked sound transmission and imperfect site construction.
Sound Isolation	A reference to the degree of acoustical separation between any two areas. Sound isolation may refer to sound transmission loss of a partition or to noise reduction from any unwanted noise source. The term "sound isolation" does not specify any grade or performance quality and requires the units to be specified for any contractual condition
Sound Pressure Level, L_P dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, L_W dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt
Speech Privacy	A non-technical term but one of common usage. Speech privacy and speech intelligibility are opposites and a high level of speech privacy means a low level of speech intelligibility. It should be recognised that acceptable levels of speech privacy do not require that speech from an adjacent room is inaudible.
Transmission Loss	Equivalent to Sound Transmission Loss and to Sound Reduction Index in terminology used in countries other than Australia. A formal test rating of sound transmission properties of any construction, by usually a wall, floor, roof etc. The transmission loss of all materials varies with frequency and may be determined by either laboratory or field tests. Australian Standards apply to test methods for both situations.

APPENDIX B: UNATTENDED NOISE MONITORING RESULTS

Weather Station: Sydney (Observatory Hill)

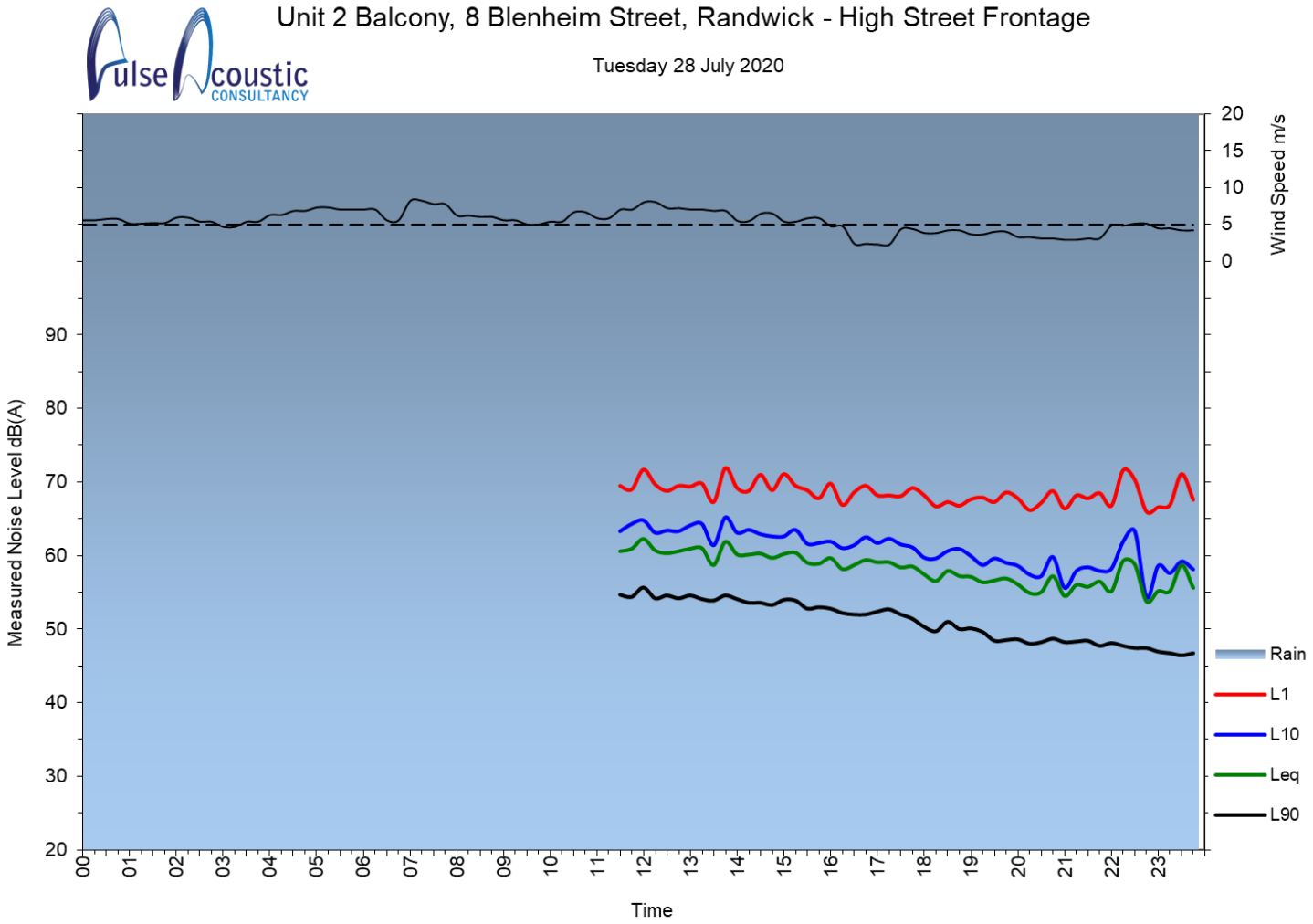
Weather Station ID: 066062

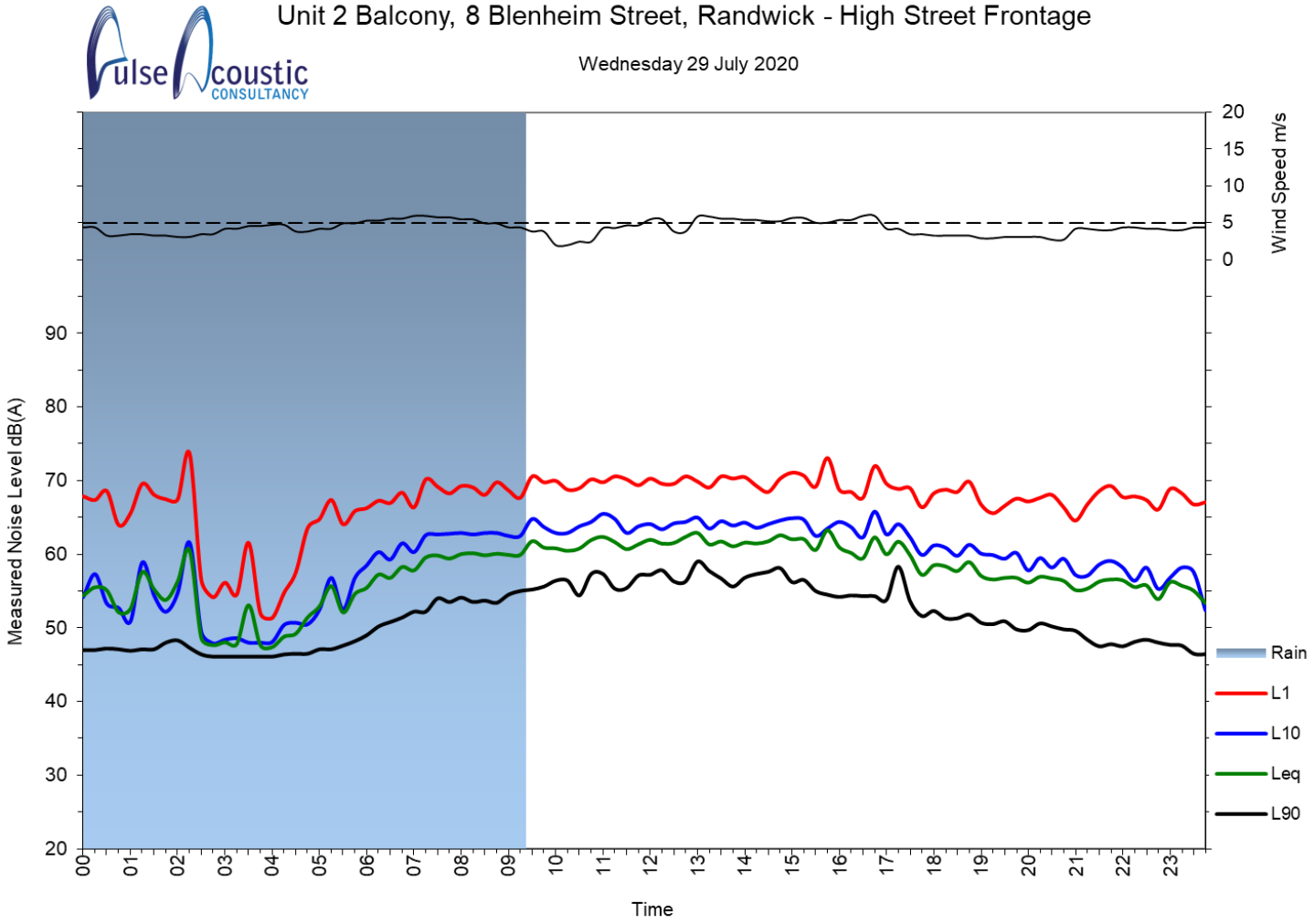
Co-ordinates: Lat: 33.8607°S, Lon: 151.2050°E, Height: 39m AMSL

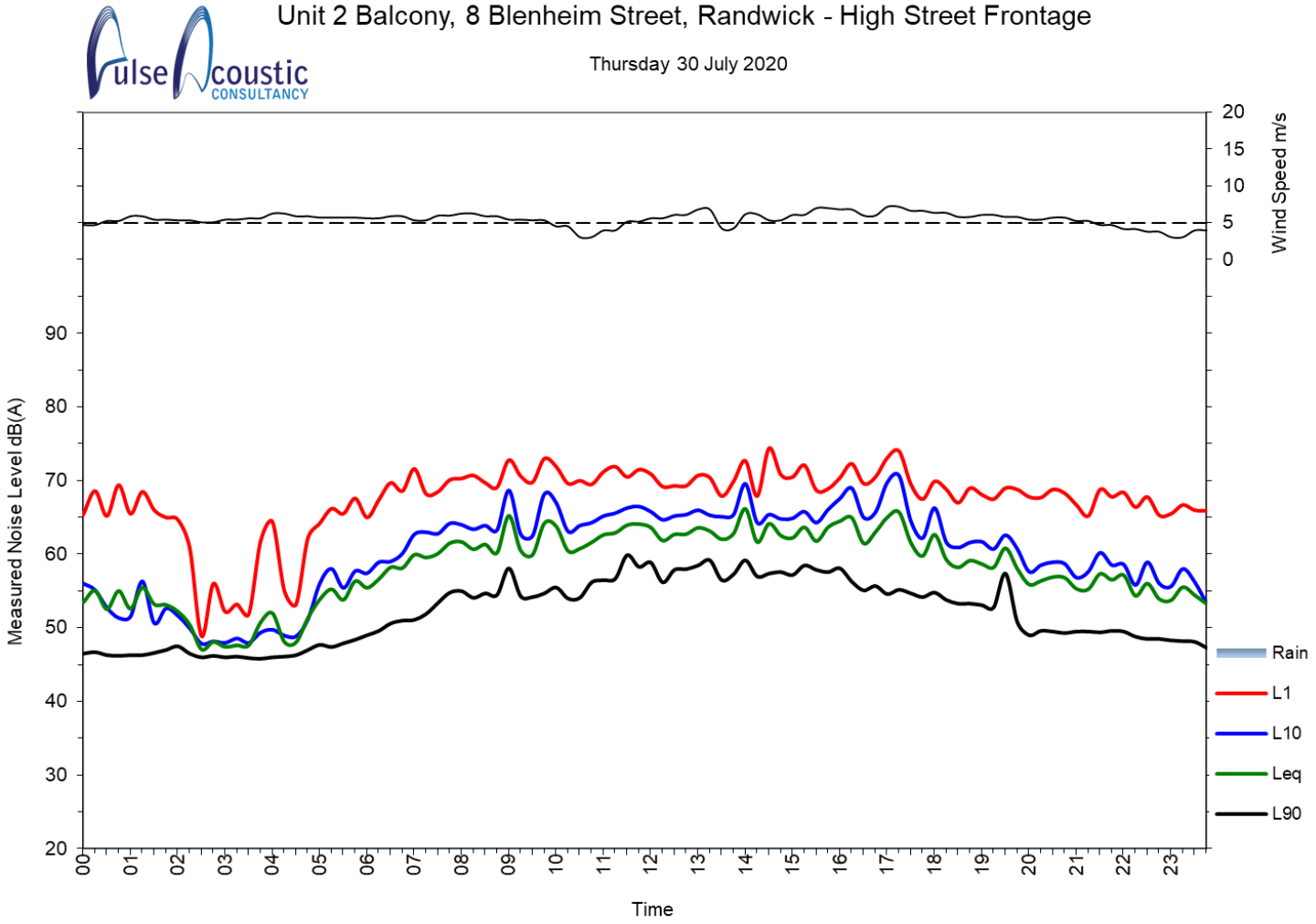
Figure B-1 Photo of Unattended Noise Monitor Location – Rear of 8 Blenheim Street, Randwick

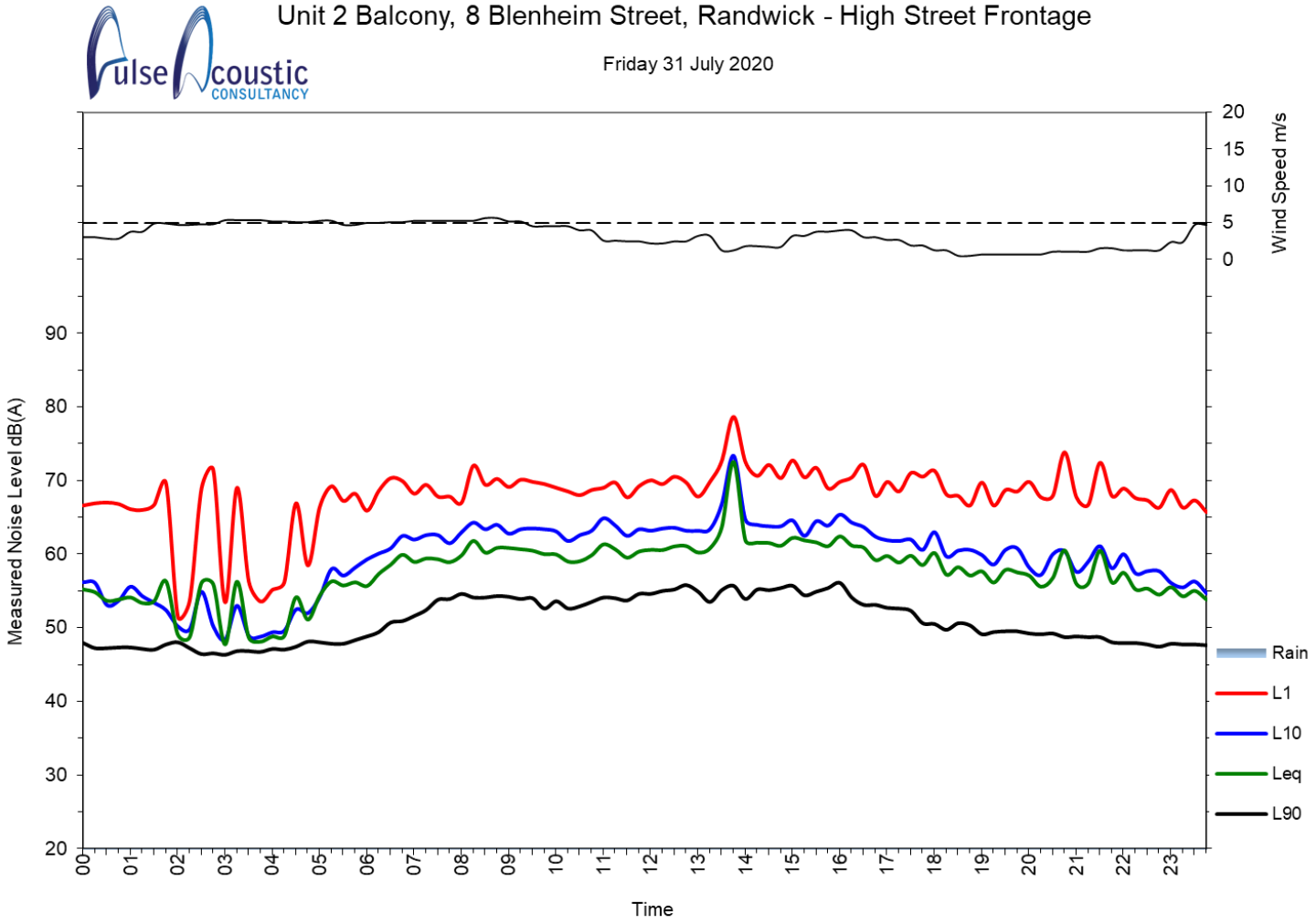
Table A--1 Tabulated Summary of Pulse Acoustics Unattended Noise Measurements

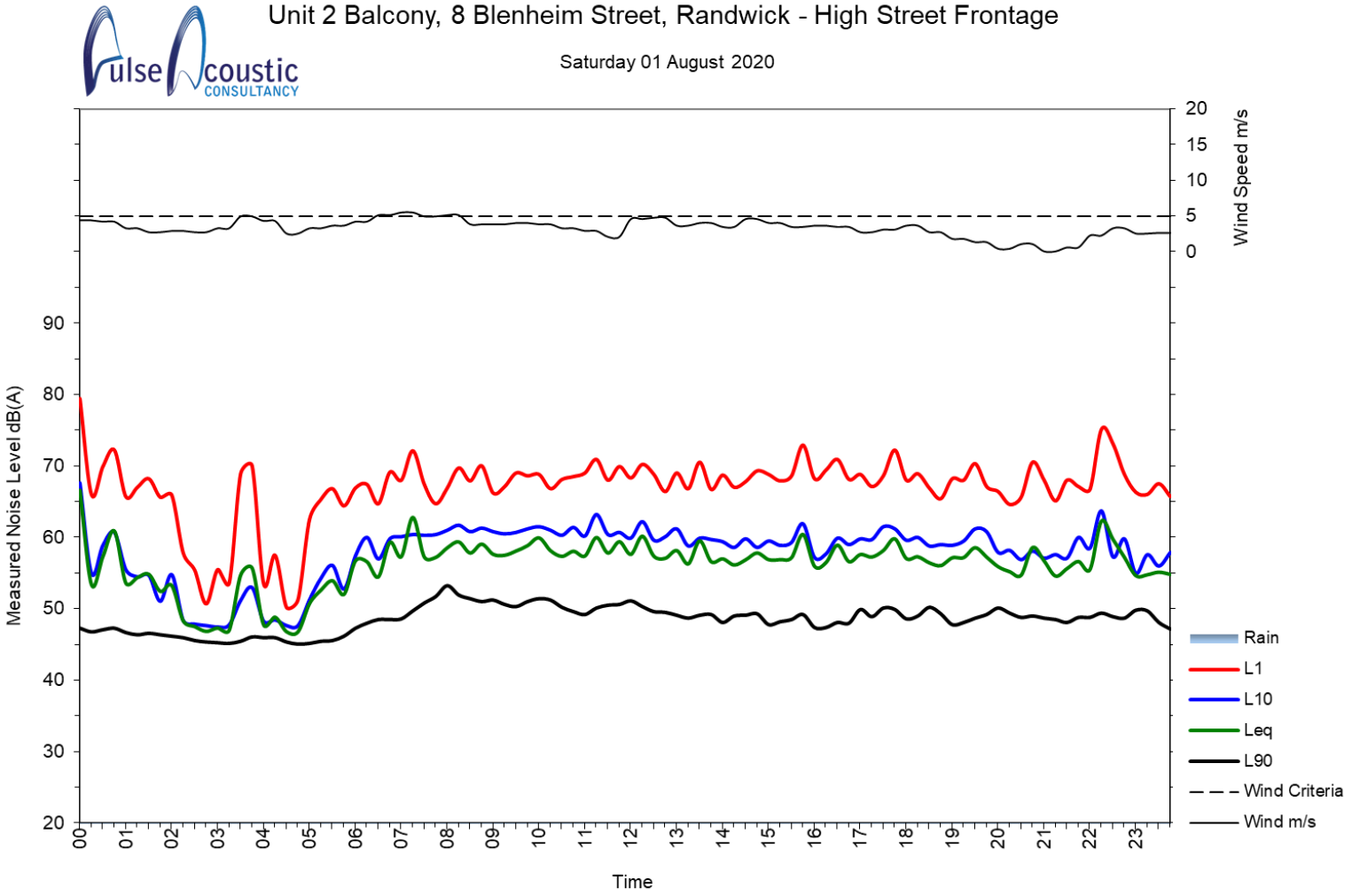
Date	Daytime dBA – 7:00am to 6:00pm		Evening dBA – 6:00pm to 10:00pm		Nightime dBA – 10:00pm to 7:00am (next day)	
	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}
Tuesday 28th July 2020	60 (Not full period)	52 (Not full period)	56	48	55	46
Wednesday 29th July 2020	61	54	57	48	54	46
Thursday 30th July 2020	63	55	58	49	55	47
Friday 31st July 2020	62	53	58	49	56	46
Saturday 1st August 2020	58	49	57	48	54	46
Sunday 2nd August 2020	59	49	56	48	55	46
Monday 3rd August 2020	61	50	57	47	56	46
Tuesday 4th August 2020	60	51	57	48	55	46
Wednesday 5th August 2020	61	51	57	48	54	46
Thursday 6th August 2020	60	53	58	49	61	46
Friday 7th August 2020	61	53	60	51	54	46
Saturday 8th August 2020	58	48	56	48	54	46
Sunday 9th August 2020	60	48	59	50	58	50
Monday 10th August 2020	63	54	57	48	55	46
Tuesday 11th August 2020	61	54	56	48	56	46
Wednesday 12th August 2020	61 (Not full period)	53 (Not full period)	-	-	-	-

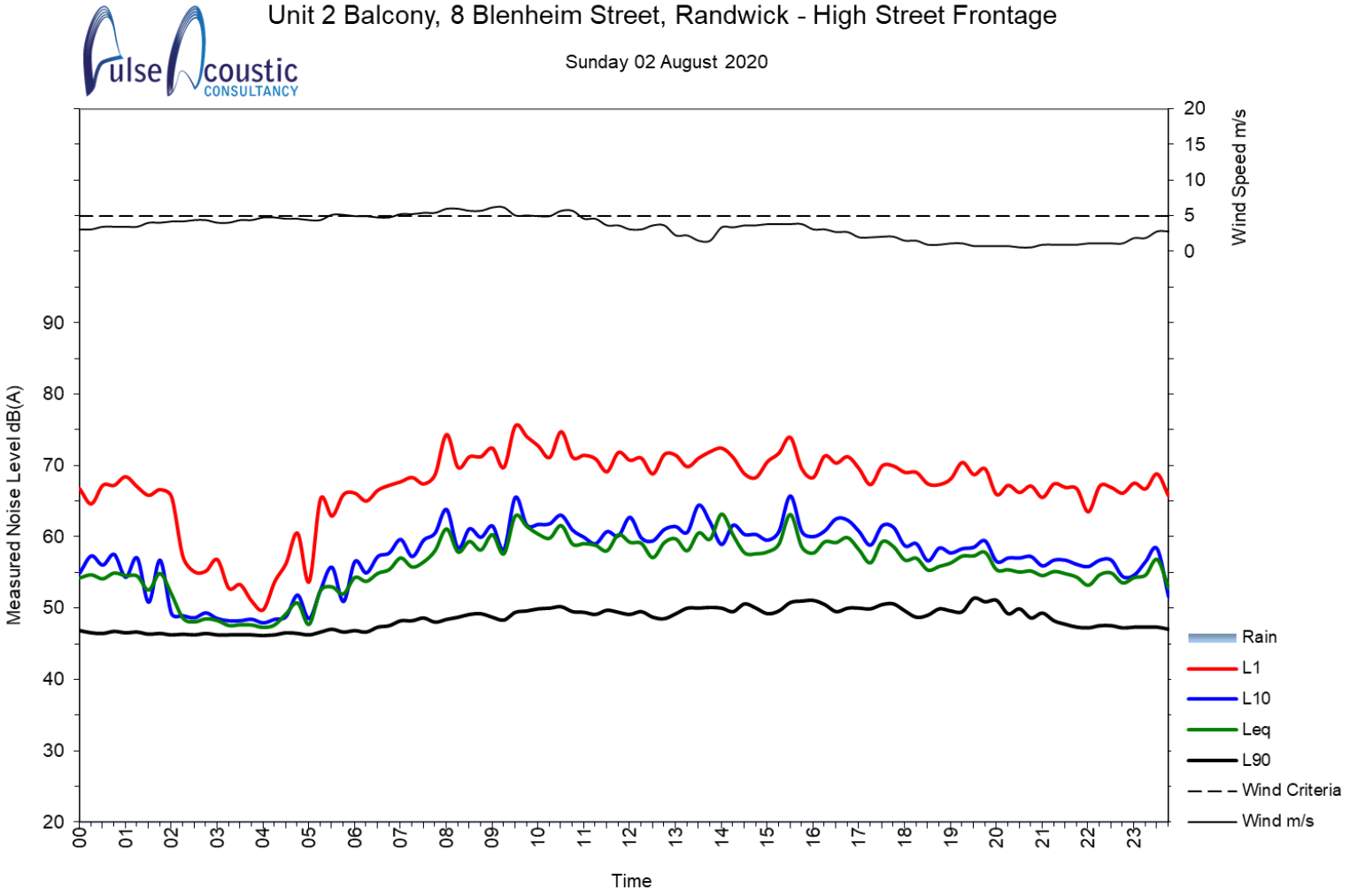

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Tuesday 28 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90

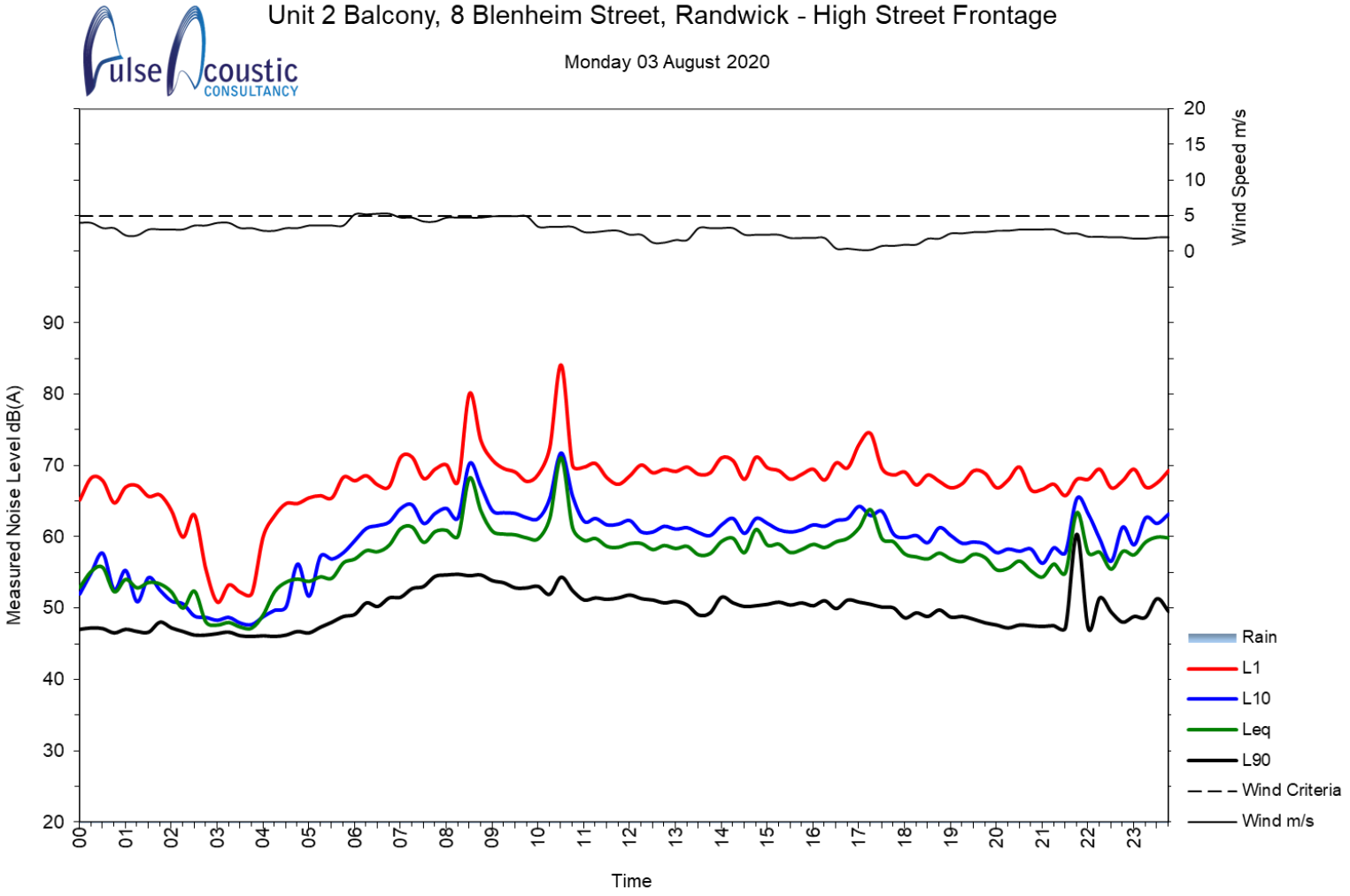

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Wednesday 29 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90

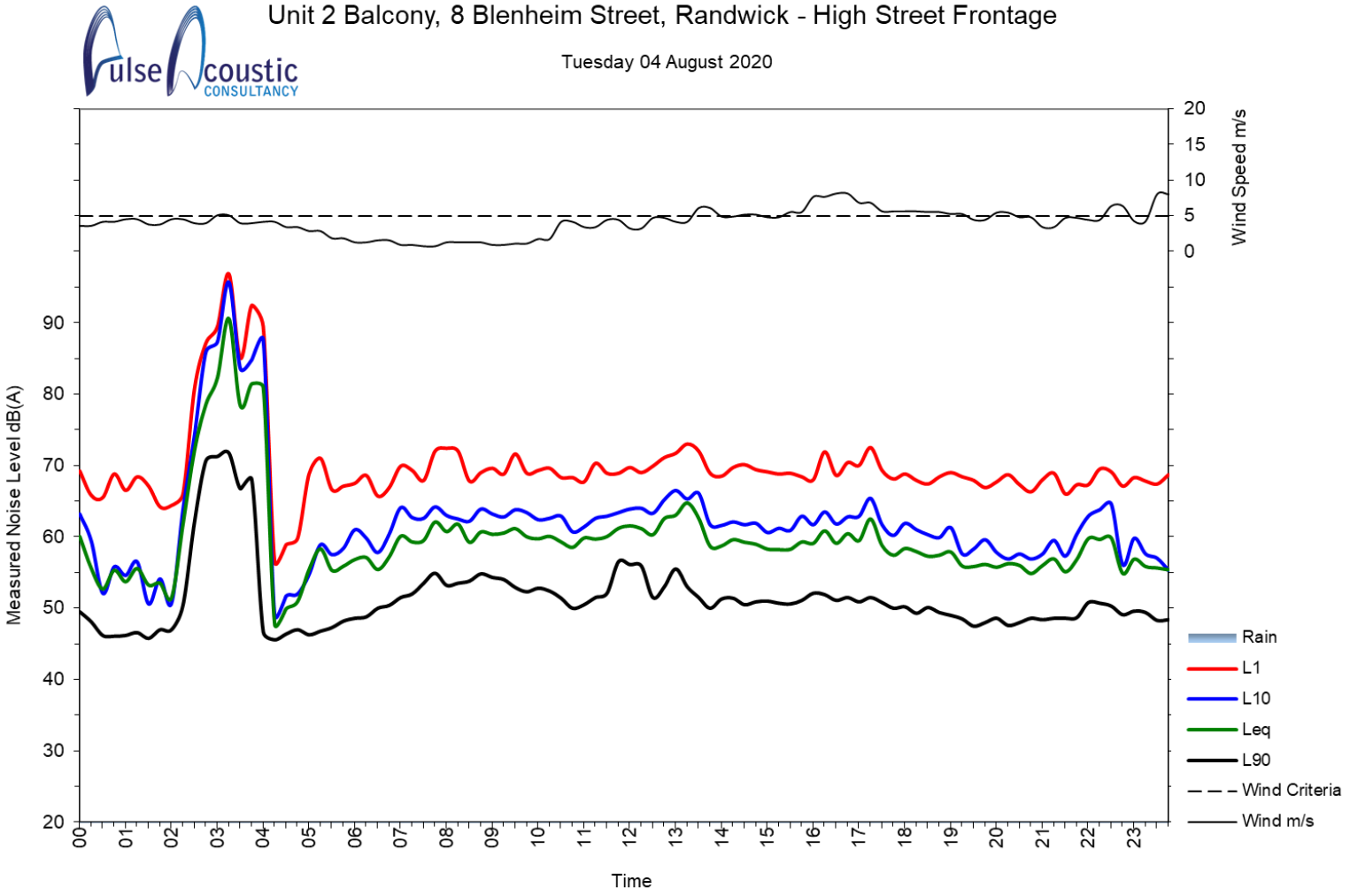

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Thursday 30 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90

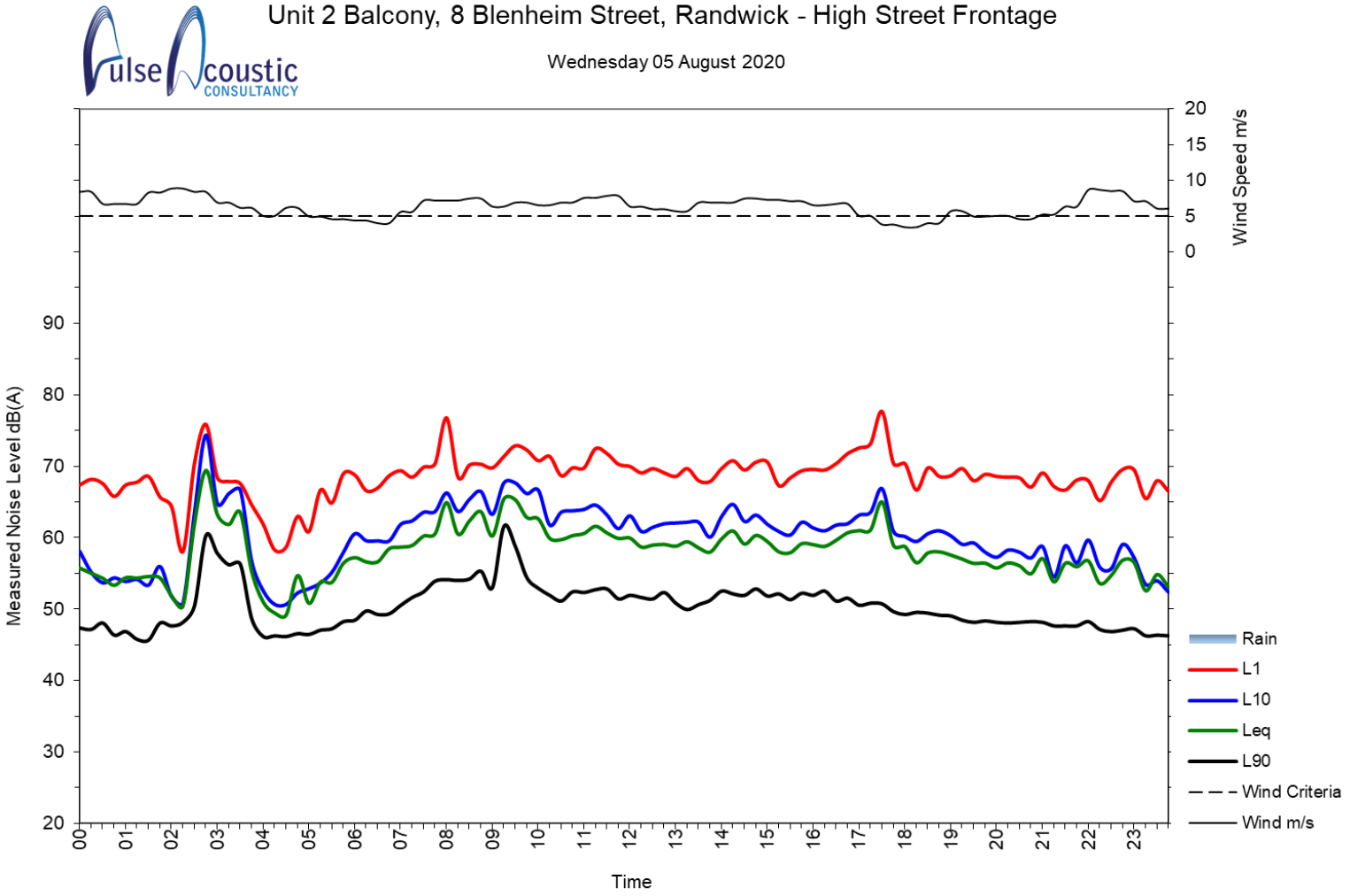

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Friday 31 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90

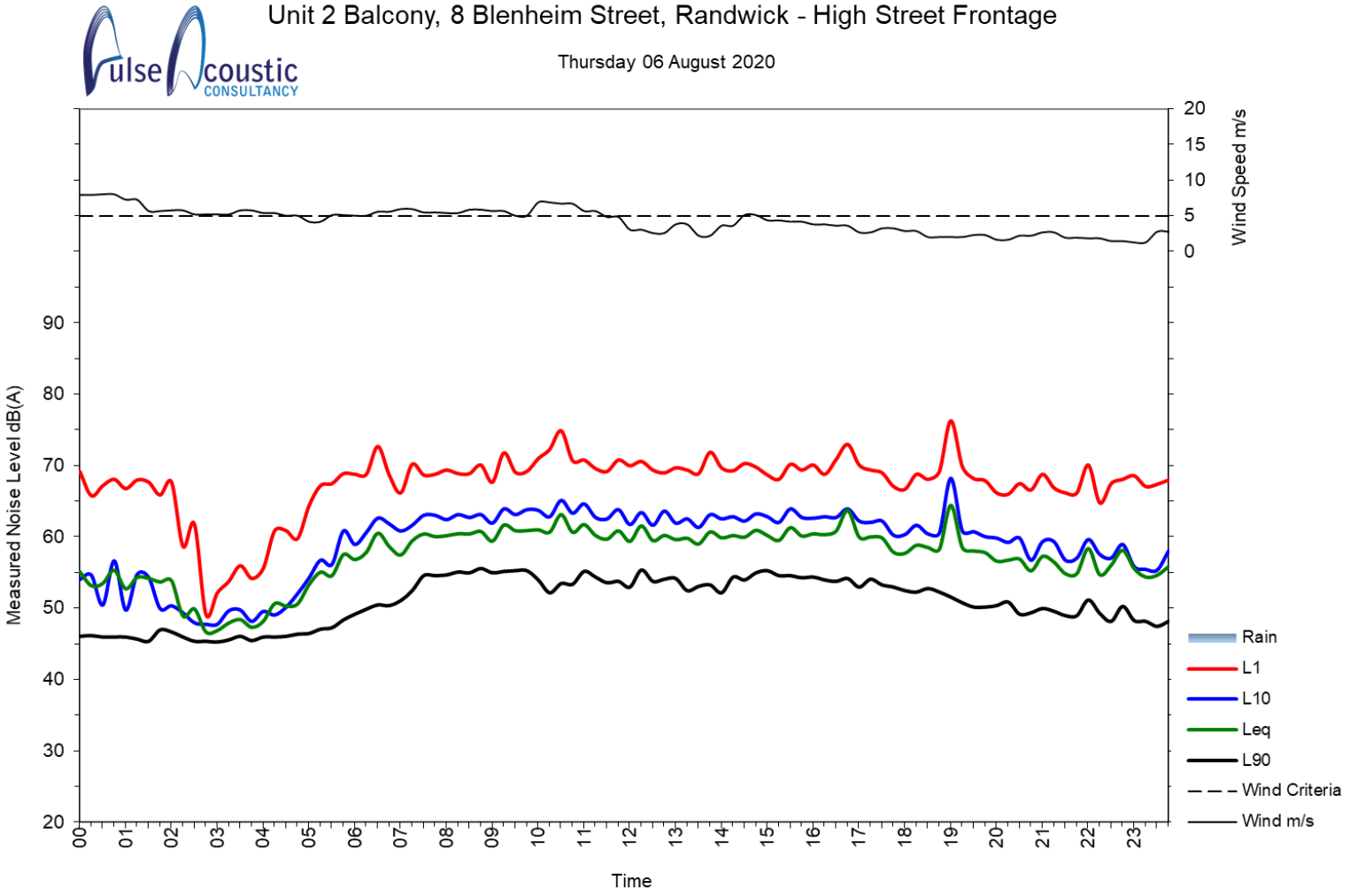

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Saturday 01 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

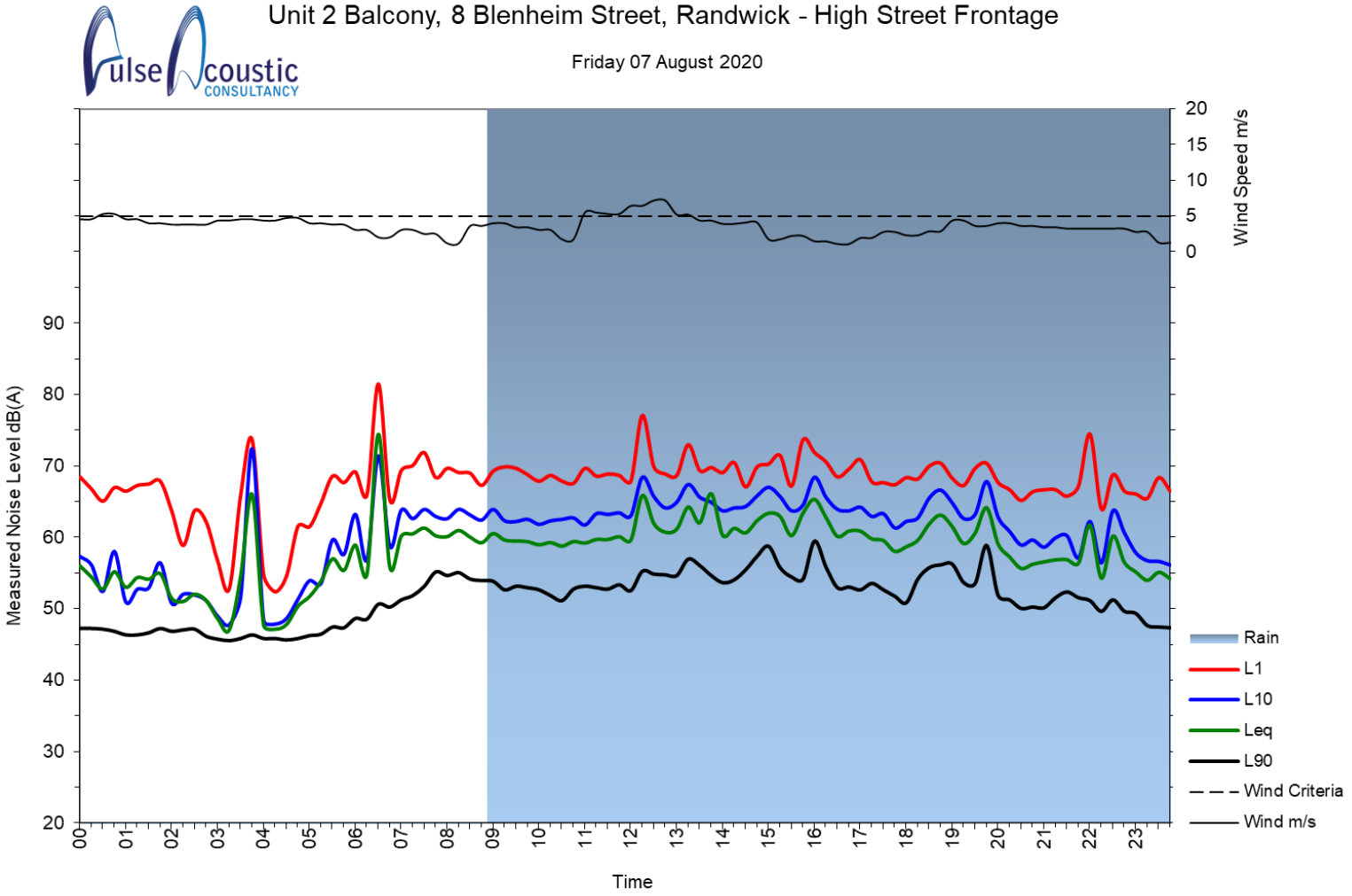

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Sunday 02 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

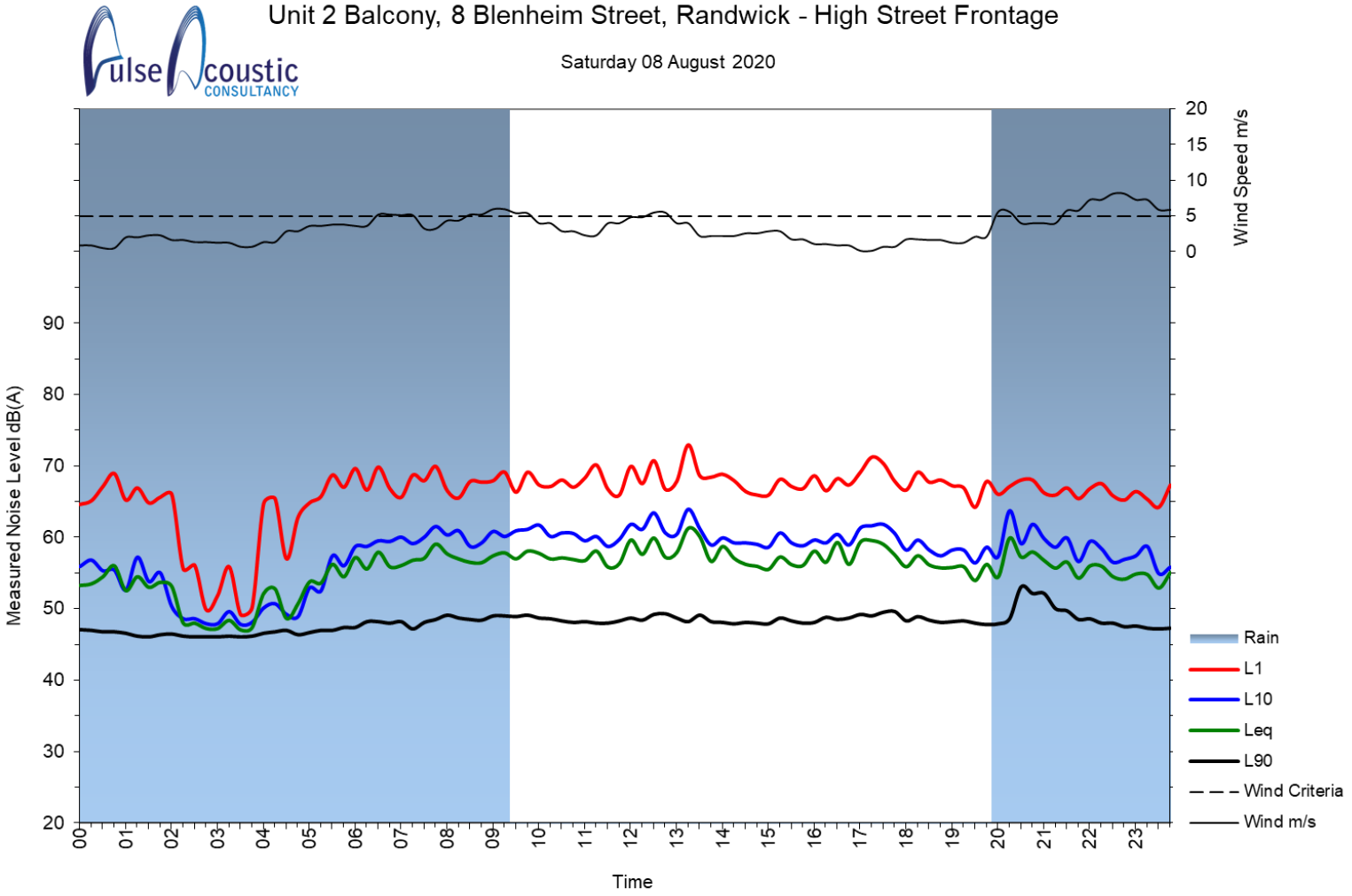

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Monday 03 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

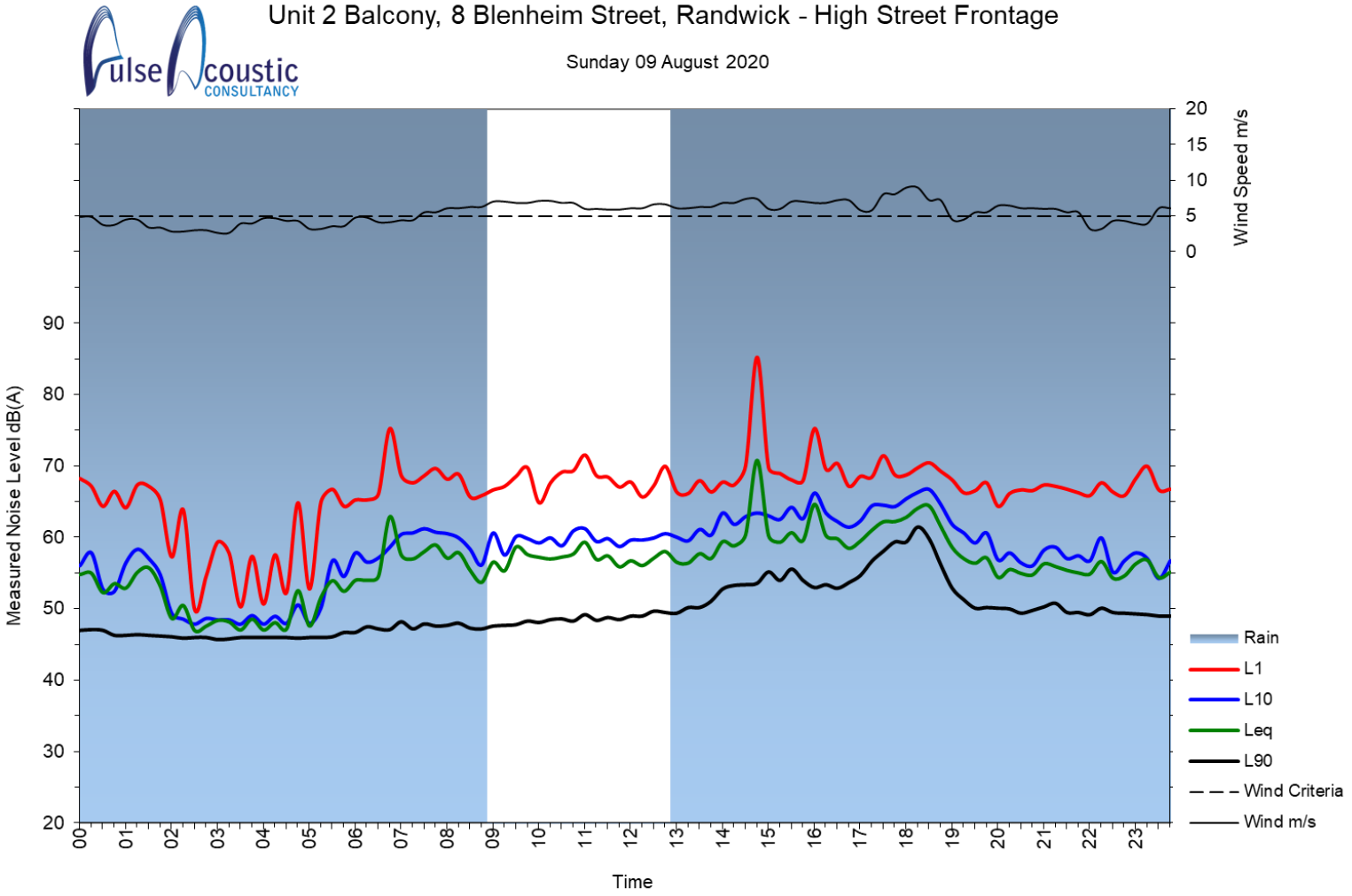

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Tuesday 04 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

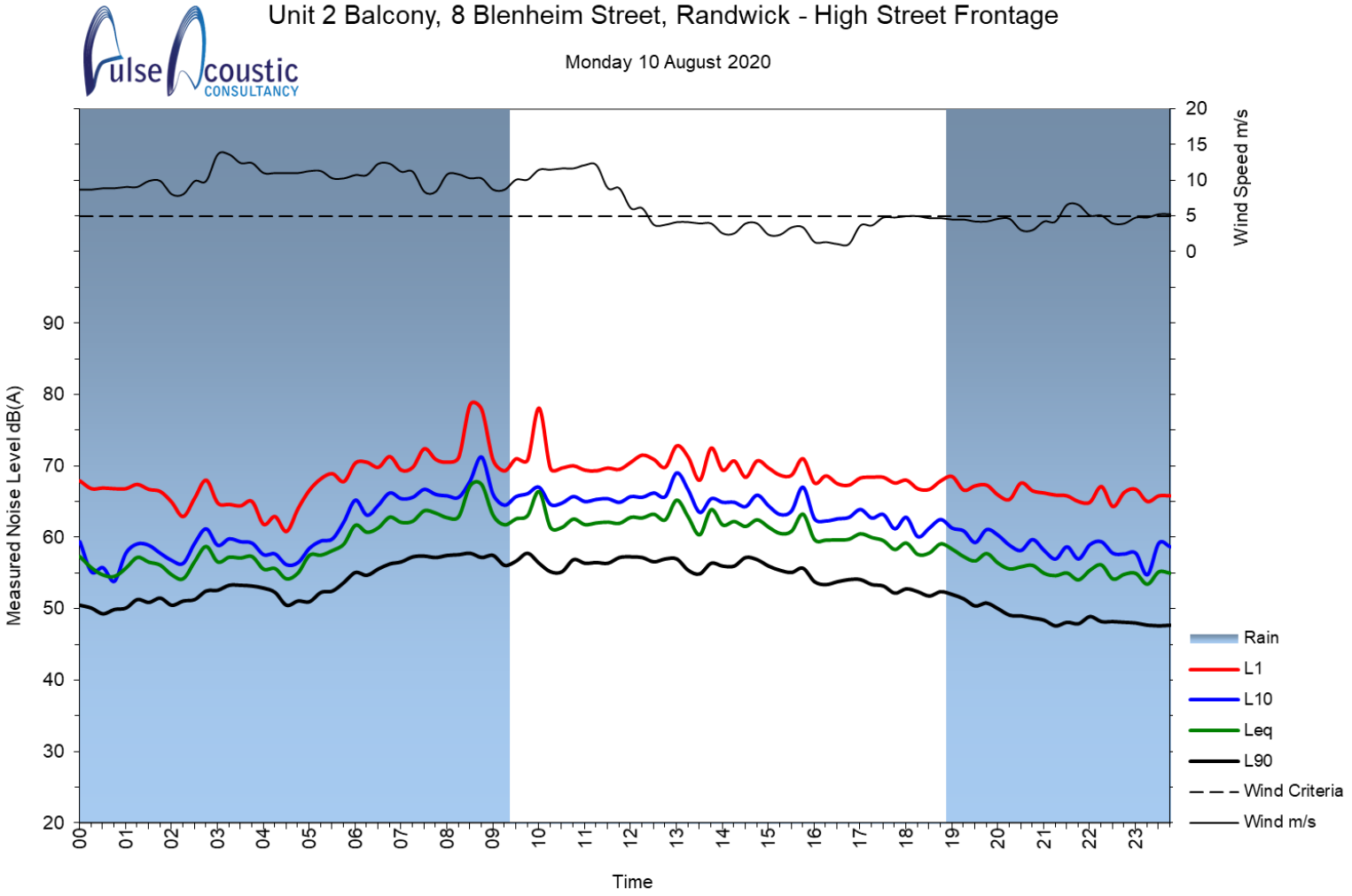

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Wednesday 05 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

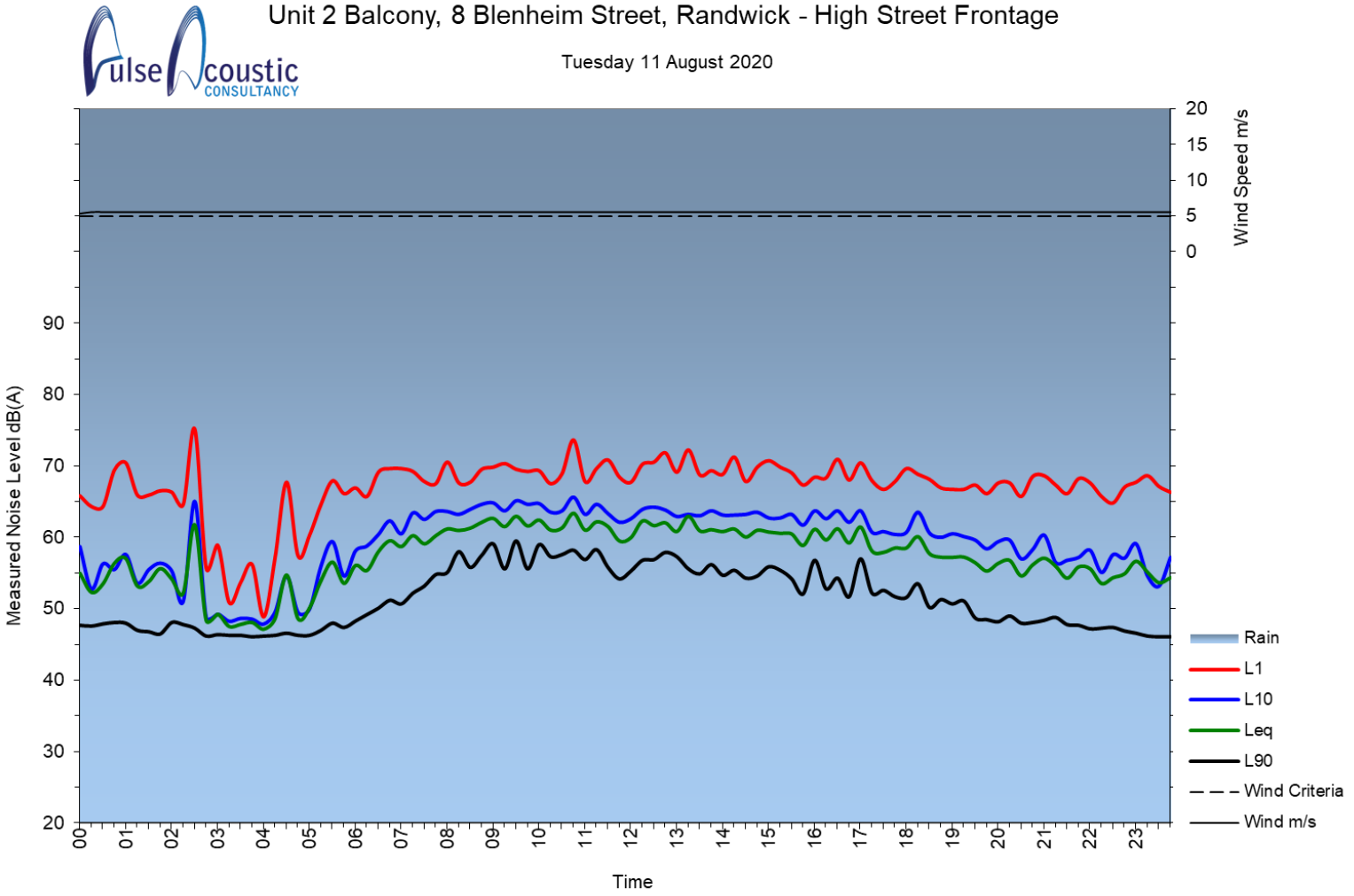

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Thursday 06 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

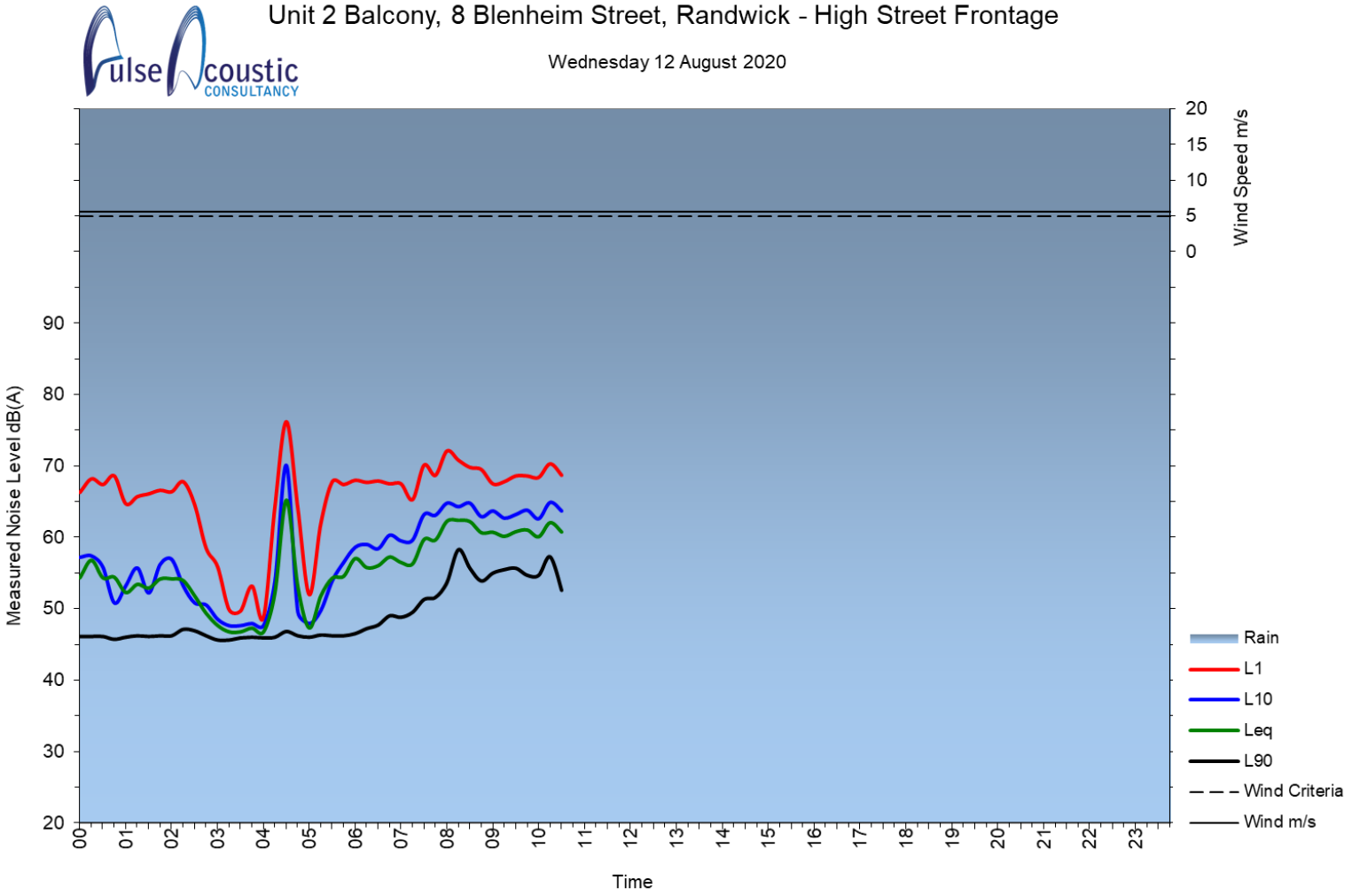

Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Friday 07 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Saturday 08 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Sunday 09 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Monday 10 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Tuesday 11 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Wednesday 12 August 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s