Acoustics
Vibration
Structural Dynamics

MACQUARIE DATA CENTRES IC3 SUPER WEST

Noise and Vibration Report for SSDA

4 November 2021

Macquarie Data Centres C/- Giddis Project Management

TM162-01F02 Acoustic Assessment (r7)

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Executive summary

This Noise and Vibration Report has been prepared by Renzo Tonin & Associates (Renzo Tonin) on behalf of Macquarie Data Centres (MDC) C/- GIDDIS Project Management.

The following Noise and Vibration Report has been produced to support the Environmental Impact Statement (EIS) prepared by Willowtree Planning PTY Ltd (Willowtree Planning).

The EIS has been submitted to the New South Wales (NSW) Department of Planning, Industry and Environment (DPIE), in support of an application for State Significant Development (SSD), for the construction and operation of a data centre, involving earth works, provision of infrastructure and expansion of an existing data centre at 17 – 23 Talavera Road, Macquarie Park (Lot 527 DP 752035).

The proposal represents an extension to the approved data centre (LDA/2018/0322) to allow for additional data storage capacity at the subject site, improving the overall operational efficiencies and provision of technology services to customers and the wider locality.

The proposal involves the construction and operation of an expansion to an existing data centre located at 17-23 Talavera Road, Macquarie Park (Lot 527 in DP 752035), comprising:

- a five-storey building
- ancillary office space and staff amenities
- a back-up power system
- associated infrastructure, car parking, loading docks and landscaping

The subject site is located within the City of Ryde Local Government Area (LGA). The proposal seeks to operate 24 hours per day, seven (7) days per week.

The particulars of this proposal are summarised below:

- Minor earthworks involving cut and fill works
- Infrastructure comprising civil works and utilities servicing
- Construction of a five (5) storey building extension, comprising up to:
    - 14 data halls
    - 18 back up generators
    - Fitout of the building for use as a data centre (on an as-needs basis)

Site description

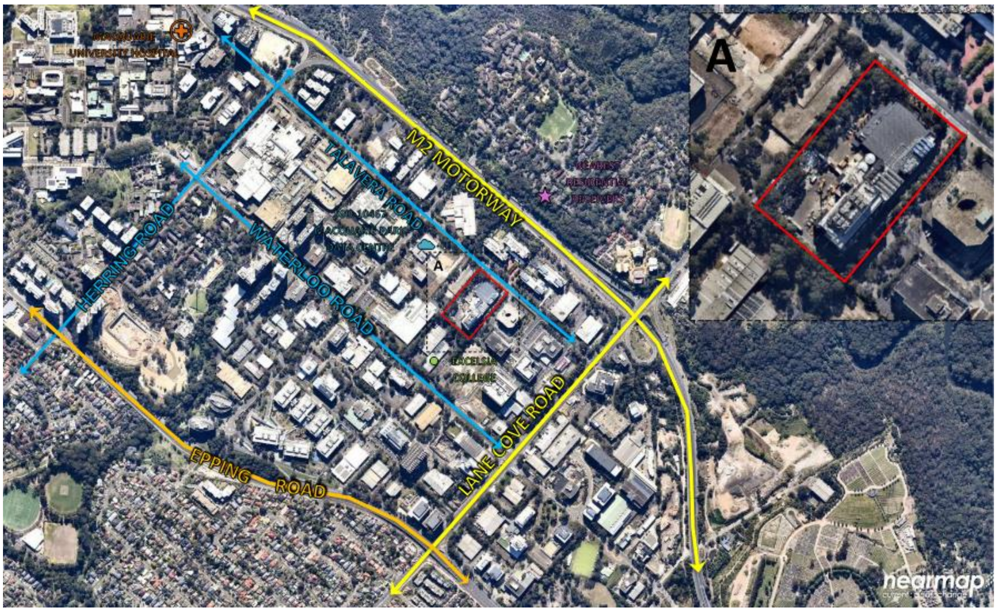
The site is described as Lot 527 DP 752035, commonly known as 17 – 23 Talavera Road, Macquarie Park. The site has a total area of approximately 20,000m^2, with access achieved via Talavera Road.

The site forms part of the Macquarie Park Corridor, which is the strategic centre of Macquarie Park, being a health and education precinct and an important economic and employment powerhouse in Sydney's North District.

The site is described through its current commercial setting as an existing Data Centre (LDA/2018/0322), adjoining surrounding commercial premises along Talavera Road, and forming part of the wider Macquarie Park Corridor.

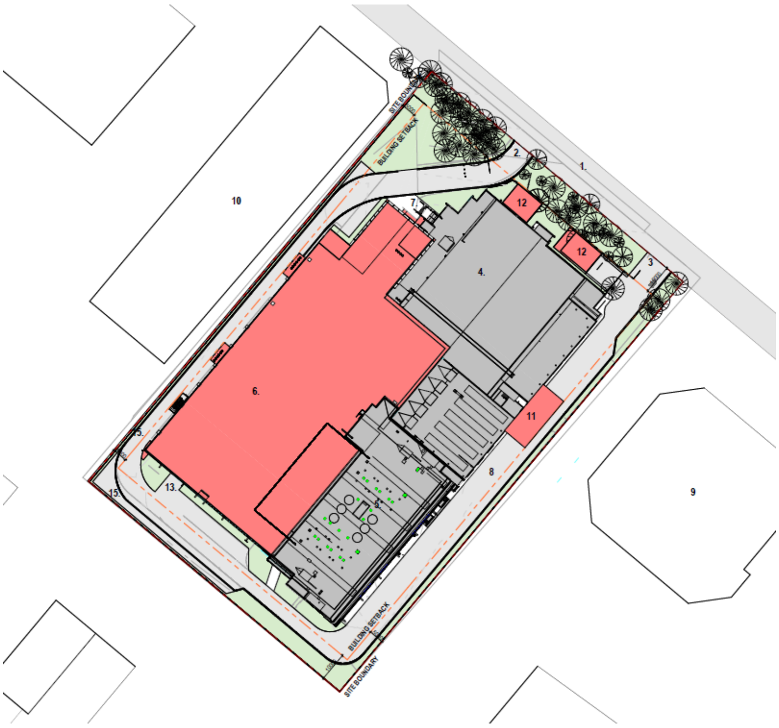
The site is situated approximately 12.5 km northwest of the Sydney CBD and 11.3 km northeast of Parramatta. It is within close proximity to transport infrastructure routes (predominantly the bus and rail networks), as well as sharing direct links with the wider regional road network, including Talavera Road, Lane Cove Road, Epping Road and the M2 Motorway.

These road networks provide enhanced connectivity to the subject site and wider locality. Additionally, the site is located within close proximity to active transport links, such as bicycle routes, providing an additional mode of accessible transport available to the subject site



Site Location

The site 17 – 23 Talavera Road, Macquarie Park, being Lot 527 DP 752035.



Secretary's Environmental Assessment Requirements

This Noise and Vibration Report is prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs). The SEARs for the proposal outline Key Issues to be addressed as part of this EIS and includes:

Renzo Tonin & Associates (Renzo Tonin) have been appointed by Macquarie Data Centres (MDC) to undertake the Noise and Vibration Report for the proposed development of the Macquarie Park Data Centre Campus IC3 Super West site.

The following Secretaries Environmental Assessment Requirements (SEARS) are addressed within Table 1 of this report.

Table 1: Secretary's environmental assessment requirements – Noise and vibration

SEARs Item	Secretary's Environmental Assessment Requirements	Response
Noise and vibration	A quantitative noise and vibration impact assessment undertaken by a suitably qualified acoustic consultant in accordance with the relevant Environment Protection Authority guidelines and Australian Standards which includes:	
	- the identification of impacts associated with construction, site emissions and traffic generation at noise affected sensitive receivers (including consideration of cumulative impacts from the existing data centre and surrounding developments), including the provision of operational noise contours and a detailed sleep disturbance assessment	Section 4 – Construction Section 5.6 – Operational road traffic Section 5.1 to 5.4 – Operational – Site emissions (including cumulative) and sleep disturbance APPENDIX C - Operational noise contours

SEARs Item	Secretary's Environmental Assessment Requirements	Response
	- details of noise monitoring survey, background noise levels, noise source inventory and 'worst case' noise emission scenarios	Section 2.1 – Monitoring Section 5.3 – Assessment scenarios Table 27 to Table 31 - Noise source inventory
	- consideration of annoying characteristics of noise and prevailing meteorological conditions in the study area	Section 5.2.2 - Meteorological conditions Section 5.4 - Annoying characteristics
	- adequate modelling of site operational noise and vibration sources such as cooling system fans and motors in proposed locations, energy back-up systems such as generator engines, and vehicle access, traverse, and manoeuvring paths	Table 27 to Table 31 - Noise source inventory Section 5.3 - Predictions
	- details and analysis of the effectiveness of proposed management and mitigation measures to adequately manage identified impacts, including a clear identification of residual noise and vibration following application of mitigation these measures and details of any proposed compliance monitoring programs.	Section 5.1.1.2.1 and 5.1.1.2.2- Mitigation measures Section 5.3 - Predictions Section 5.7 - Operational noise management

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1 Introduction

Renzo Tonin & Associates (Renzo Tonin) have been appointed by Macquarie Data Centres (MDC) to undertake the Noise and Vibration Report for the proposed development of the Macquarie Park Data Centre Campus IC3 Super West (IC3w) site at 17-23 Talavera Road, Macquarie Park.

This Noise and Vibration Report serves to support the State Significant Development Application (SSDA) relating to the proposed development.

The report has been prepared to address the requirements of the Secretary of the Department of Planning, Industry and Environment (DPIE) ('the Secretary's environmental assessment requirements') (SEARs) and EPA requirements. As part of preparing this construction noise and vibration and operational noise assessment, the following policies, guidelines and standards have been considered:

- NSW *Noise Policy for Industry* (NPfI) (EPA 2017)
- NSW *Road Noise Policy* (RNP) (DECCW 2011)
- Australian Standard AS 1055:2018 *Acoustics—Description and measurement of environmental noise.*
- NSW *Interim Construction Noise Guideline* (ICNG) (DECC 2009)
- NSW *Assessing Vibration – A Technical Guideline* (AVTG) (DEC 2006)

1.1 Assessment requirements

1.1.1 Secretary's environmental assessment requirements

The Secretary's environmental assessment requirements relating to the project are detailed in the Executive Summary above.

1.1.2 EPA assessment requirements

The NSW Environmental Protection Authority (EPA) has provided the following feedback in relation to the development, which are outlined in Table 2.

Table 2: EPA assessment requirements – Noise and vibration

EPA assessment requirements	Where addressed
Noise and vibration	
The proponents Scoping Report states that the site is to be “sufficiently separated from any noise sensitive receivers” and that the proposal will consider construction and operational acoustic impacts through the preparation of both a Construction Noise and Vibration Management Plan (CNVMP) and an operational Noise and Vibration Impact Assessment. The EPA notes that the site is close to a number of sensitive receivers including: • 100m to the north of Excelsia College; • 200m to the south-east of WiSE Specialist Emergency Clinic; • 300m to the south of high density residential zoned land; • 300m to the south-east of Meriton Suites North Ryde; and • Between 150m-300m to the south-east, west, and north-west of several childcare centres.	Section 4 – Construction noise assessment Section 5 – Operational noise assessment Section 1.5 and Figure 1 – nearest sensitive receivers
The EPA recommends that a noise and vibration assessment be prepared in accordance with the *Noise Policy for Industry* (2017) and include an assessment of all potential noise and vibration generating activities occurring at the premises, including the operation and testing of specific generators that will be used for backup electricity generation. The noise and vibration assessment must consider all sensitive receptors that will potentially be impacted during construction and operational stages of the proposal.	Section 3.3 – Operational noise and vibration objectives Section 4 – Construction noise assessment Section 5.1 to 5.4 – Operational – Site emissions (including cumulative) and sleep disturbance

1.2 Project description

The site is located at 17-23 Talavera Road, Macquarie Park. The site is currently occupied by the existing data centre buildings, including IC2 building at the northern half of the site and the existing IC3e building at the south-east corner of the site. The proposed IC3w building will be located at the south-west corner of the site.

This site is bounded by Talavera Road to the north, commercial premises to the east and west and an education premises to the south. The nearest residential receivers are located north of the M2 Motorway, approximately 300m from the site. A location map is presented in Figure 1.

The facility is proposed to operate 24 hours a day, 7 days a week.

1.3 Assessment objectives

The assessment objectives are to determine the potential levels of noise and vibration at sensitive receivers located near the Project and determine the levels of mitigation that would be required to enable compliance with the current NSW requirements.

In undertaking the assessment, unattended noise monitoring was referred to conducted to measure noise from the existing acoustic environment and potential noise sources.

Three-dimensional noise modelling software was used to create a noise model of the Project to predict noise levels and assess the need for noise mitigation.

For operational noise, cumulative impacts from the existing data centres (IC2 and IC3e) were accounted for.

1.4 Reference material

The acoustic assessment is based on the following packages:

- The HDR architectural Drawing package [ref: HDR-IC3W-AR-SSD Application – combined 211015.pdf], dated 14 October 2021
- The HDR mechanical drawing package [ref: IC3W-Combined Services.pdf], dated 19 October 2021

APPENDIX A contains a glossary of acoustic terms used in this report.

1.5 Nearest sensitive receivers

This site is surrounded by commercial premises to the north, east and west and an education premises to the south. The nearest residential receivers are located north of the M2 Motorway, approximately 310m from the site.

The extent of receiver buildings that have been included in the assessment modelling for the operational and construction noise assessment are presented in Figure 1. For the purpose of reporting a set of representative receiver locations are presented in this assessment.

Additionally, as the existing acoustic environment varies at the nearby residential receivers, these residential receivers have been grouped into Noise Catchment Areas (NCAs) based upon areas with similar acoustic environments. This has been done to logically group the receivers to assist with the assessment and allocate the appropriate project noise trigger levels or management levels to each receiver.

The locations of the representative receiver points are presented in Table 3 and shown in Figure 1.

Table 3: Representative receiver locations

Receiver number	Address / location	Receiver type	Residential noise catchment area (NCA)	Approximate distance to subject site, metres
R1	1-15 Fontenoy Road, Macquarie Park	Residential	1	350
R2	25 Fontenoy Road, Macquarie Park	Residential	1	310
R3	7 Tasman Place, Macquarie Park	Residential	1	320
R4	101 Waterloo Road, Macquarie Park	Residential	2	470
R5	80 Waterloo Road, Macquarie Park	Residential	2	490
R6	384-386 Lane Cove Road, Macquarie Park	Residential	2	500
R7	136 Epping Road, North Ryde	Residential	3	635

Receiver number	Address / location	Receiver type	Residential noise catchment area (NCA)	Approximate distance to subject site, metres
R8	34-41 Waterloo Road, Macquarie Park (Only About Children Macquarie Park Station)	Childcare	-	220
R9	Building B/11 Talavera Road, Macquarie Park (Macquarie Early Learning Centre)	Childcare	-	130
R10	24 Talavera Road, Macquarie Park (North Ryde Early Learning Centre)	Childcare	-	110
R11	40-52 Talavera Road, Macquarie Park (Guardian Childcare)	Childcare	-	160
R12	97 Waterloo Road, Macquarie Park (Greenwood North Ryde)	Childcare	-	390
R13	63-71 Waterloo Road, Macquarie Park (Excelsia College)	Education	-	Adjacent
R14	44 Waterloo Road, Macquarie Park (Macquarie University (School of Engineering)	Education	-	225
R15	17 Khartoum Road, Macquarie Park (WiSE Specialist Emergency Clinic)	Medical	-	140
R16	7/11 Talavera Road, Macquarie Park (Marriot Hotel)	Hotel/motel	-	270
R17	88 Talavera Road, North Ryde (Meriton Suites)	Hotel/motel	-	680
R18	10 Byfield St, Macquarie Park (Holiday Inn Express)	Hotel/motel	-	550
R19	15 Talavera Rd, North Ryde	Commercial	-	Adjacent
R20	11 Talavera Rd, Macquarie Park	Commercial	-	Adjacent
R21	11-17 & 39 Khartoum Road, Macquarie Park	Commercial	-	60
R22	1-5 Khartoum Road, Macquarie Park	Commercial	-	Adjacent

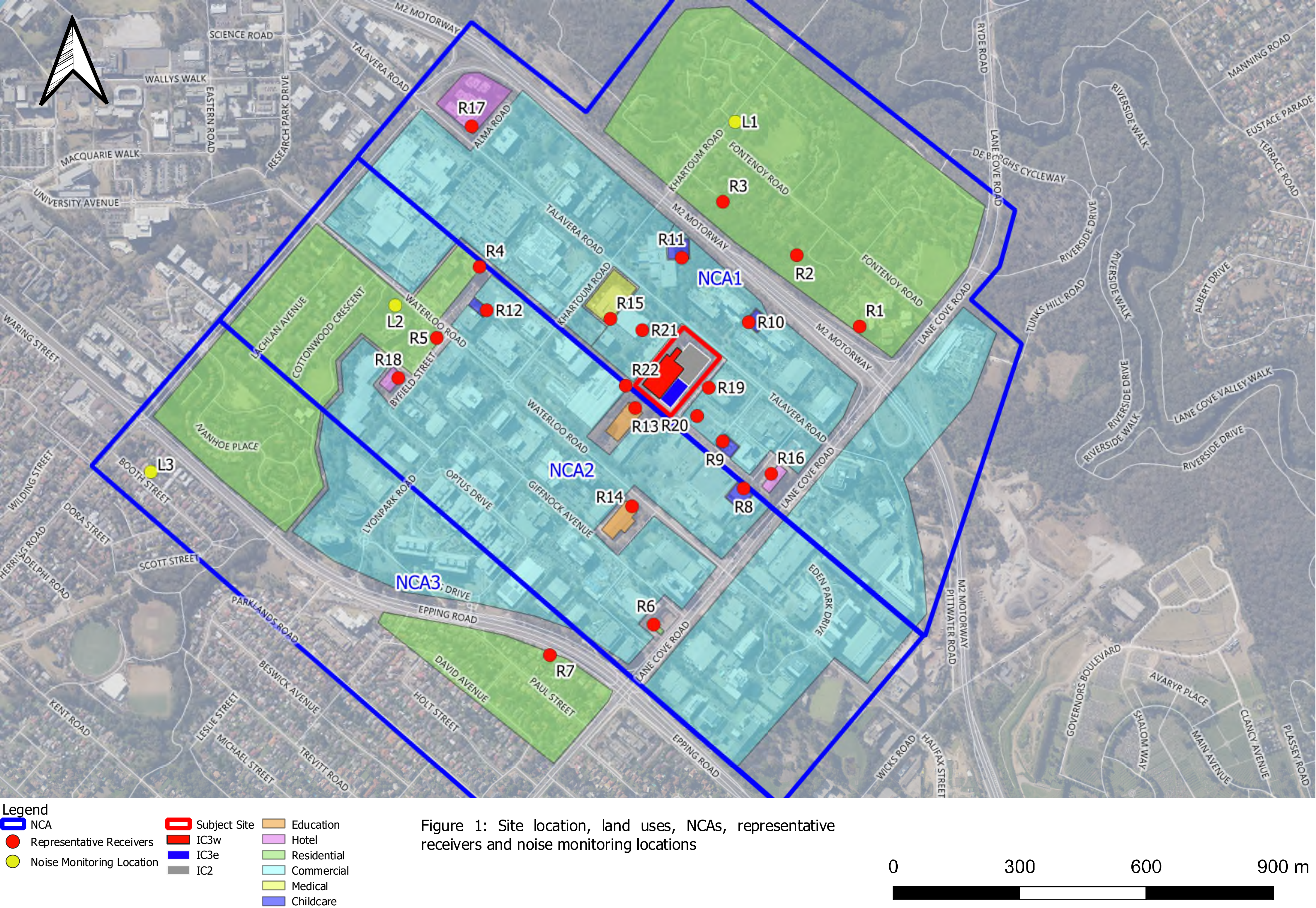


Figure 1: Site location, land uses, NCAs, representative receivers and noise monitoring locations

2 Existing noise environment

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

Fact Sheet B of the NSW EPA *Noise Policy for Industry* (NPfI) outlines two methods for determining the background noise level of an area, being 'B1 – Determining background noise using long-term noise measurements' and 'B2 – Determining background noise using short-term noise measurements'. This assessment has used long-term noise monitoring.

As the noise environment of an area almost always varies over time, background and ambient noise levels need to be determined for the operational times of the proposed development. For example, in a suburban or urban area the noise environment is typically at its minimum at 3:00am in the morning and at its maximum during the morning and afternoon traffic peak hours. The NPfI outlines the following standard time periods over which the background and ambient noise levels are to be determined:

- Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
- Evening: 18:00-22:00 Monday to Sunday & Public Holidays
- Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

2.1 Noise monitoring

2.1.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out

At the time of preparing this report, the current COVID-19 situation and the current lockdowns within Greater Sydney were both impacting the existing noise environment and were restricting the possibility of undertake noise monitoring for the purposes of establishing background noise levels. As the existing noise environment is often controlled by road traffic noise or urban activities (ie. M2 Motorway), these noise levels would not be representative of a typical situation and so not suitable for the purposes of establishing background noise levels in accordance with the NPfI.

As such, this assessment has relied on noise measurement data collected by Renzo Tonin in 2016 and noise data presented within the AECOM prepared *Macquarie Park Data Centre - Environmental Impact Statement – Appendix J Noise and Vibration Assessment' (reference: 60628128-RPNV-02, Revision B, dated 9 November 2020)* (EIS 2020). The EIS 2020 was sourced via the DPIE Planning Portal and was prepared for 11-17 Khartoum Road and 33-39 Talavera Road, Macquarie Park, which is located in proximity to the Project.

The long-term measurement locations are outlined in Table 4 and shown in Figure 1.

Table 4: Noise monitoring locations

ID	Source	Address	Monitoring Period	Description
Long-term noise monitoring				
L1	EIS 2020	Unit 6, 37 Khartoum Road, Macquarie Park	10/03/2020 - 20/03/2020	The monitor was located in the front garden of the property. The noise monitoring location is considered representative of receiver locations within NCA 1.
L2	Renzo Tonin	82 Waterloo Road, Macquarie Park	15/09/2016 - 22/09/2016	The monitor was located in the free field near the northern boundary facing Waterloo Road The noise monitoring location is considered representative of receiver locations within NCA 2.
L3	EIS 2020	7 Booth Street, Marsfield	10/03/2020 - 20/03/2020	The monitor was located in the front garden of the property. The noise monitoring location is considered representative of receiver locations within NCA 3.

2.1.2 Renzo Tonin instrumentation and methodology

The Renzo Tonin long-term noise monitoring was conducted using the instrumentation presented in Table 5.

Table 5: Unattended noise monitoring equipment

Reference location	Address	Instrument	Logger reference	Monitoring period
L2	82 Waterloo Road, Macquarie Park	NTi Audio XL2	RTA05-008	15/09/2016 - 22/09/2016

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated Type 1, and are suitable for field use.

Long-term noise monitoring was conducted in general accordance with Fact Sheet B of the NSW EPA NPfI and AS1055:2018. The equipment calibration was field checked prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator, with no significant calibration drift observed.

APPENDIX A of this report presents a description of noise terms. A summary of the unattended noise monitoring results along with a graphical recorded output from the long-term noise monitoring is included in APPENDIX B. The graphs in APPENDIX B were analysed to determine an assessment background level (ABL) for each day, evening and night period in each 24-hour period of noise monitoring. Based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NPfI.

Noise measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NPfI. This is indicated in the long-term noise monitoring graphs presented in APPENDIX B. Determination of extraneous meteorological conditions was based on data provided by the nearest Bureau of Meteorology (BOM) station, which was the Sydney Olympic Park AWS (Station 066212).

2.1.3 Long-term noise measurement results

Table 6 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period.

Table 6: Long-term noise monitoring results, dB(A)

Monitoring location	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
L1 - Unit 6, 37 Khartoum Road, Macquarie Park	45	45	38	57	59	51
L2 - 82 Waterloo Road, Macquarie Park[4]	52	48	40	61	60	54
L3 -7 Booth Street, Marsfield	42	42	33	55	56	47

Notes:
1. Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
2. Evening: 18:00-22:00 Monday to Sunday & Public Holidays
3. Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays
4. As required by the NPfI, the external ambient noise levels presented are free-field noise levels. [ie. no façade reflection]

3 Noise and vibration objectives

3.1 Construction noise objectives

3.1.1 Noise management levels (NMLs)

The NSW *Interim Construction Noise Guideline* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of LAeq as the descriptor for measuring and assessing construction noise.
- Application of reasonable and feasible noise mitigation measures.
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods described for the assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration and involves the measurement and prediction of noise levels and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification. Given the scale and duration of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

Table 7 reproduced from the ICNG, sets out the airborne noise management levels and how they are to be applied for residential receivers.

Table 7: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm 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 LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

<table>
<tr><th>Time of day</th><th>Management level $L_{Aeq\ (15\ min)}$ *</th><th>How to apply</th></tr>
<tr><td></td><td>Highly noise affected
75 dB(A)</td><td>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/ 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.</td></tr>
<tr><td>Outside recommended standard hours</td><td>Noise affected
RBL + 5 dB</td><td>• 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 5dB(A) above the noise affected level, the proponent should negotiate with the community.
• For guidance on negotiating agreements see ICNG section 7.2.2.</td></tr>
</table>

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

Table 8 sets out the ICNG noise management levels for other noise sensitive receiver locations.

Table 8: Noise management levels at other noise sensitive land uses

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 65 dB(A)
Hospital wards and operating theatres	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 65 dB(A)
Places of worship	When in use	Indoor noise level Outdoor noise level[1]	45 dB(A) 65 dB(A)
Active recreation areas	When in use	Outdoor noise level	65 dB(A)
Passive recreation areas	When in use	Outdoor noise level	60 dB(A)
Commercial premises	When in use	Outdoor noise level	70 dB(A)
Industrial premises	When in use	Outdoor noise level	75 dB(A)

Notes: 1. Outdoor noise level based on internal noise level in ICNG and assumes 20 dB loss through a closed window

3.1.2 Summary of construction noise management levels

Table 9 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 2. The assessment locations and nearby sensitive receivers for the construction assessment are identified in Section 1.5.

Table 9: Construction noise management levels

ID	Location description	Noise management level LAeq(15min)1	
		ICNG Standard Hours **Monday to Fridays** 7:00am to 6:00pm **Saturdays** 8:00am to 1:00pm	**ICNG Outside Standard Hours** **Monday to Friday** 6:00am to 7:00am and 6:00pm to 7:00pm **Saturday** 6:00am to 8:00am and 1:00pm to 5:00pm **Sunday** 7:00am to 3:00pm
NCA1	Residential premises	55	50[4]
NCA2	Residential premises	62	57[4]
NCA3	Residential premises	52	47[4]
R8 - R12	Childcare centre - classroom (external)	65[2,3]	
	Childcare centre - playground	65[2]	
R13 – R14	Education - classroom (external)	65[2,3]	
R15	Medical - operating theatres (external)	65[2,3]	
R16 – R22	Commercial	70[2]	

Notes:
1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level. If the property boundary is more than 30m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.
2. Noise management levels apply when receiver areas are in use only.
3. External noise management level. A conversion from internal to external assumes 20 dB(A) loss from outside to inside through a closed window.
4. Noise management levels based on daytime RBL. A visual review of the long-term noise monitoring data reveals L_{A90} levels from 6:00am to 7:00am and 6:00pm to 7:00pm Mondays to Friday; 6:00am to 7:00am Saturday; and 7:00am to 8:00am Sunday are typically louder than the quietest part of the day.

3.2 Construction vibration objectives

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings, and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The International System of Units (SI unit) for distance is the metre (m), although common industrial standards include mm.

- Velocity (v=Δx/Δt) is the rate of change of displacement with respect to change in time. The SI unit for velocity is metres per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration (a=Δv/Δt) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is metres per second squared (m/s2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

3.2.1 Disturbance to buildings occupants

The acceptable vibration values to assess the potential for human annoyance from vibration are set out in the NSW 'Environmental Noise Management Assessing Vibration: A Technical Guideline' (AVTG).

To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. The screening test is based on the continuous vibration velocity (i.e. vibration that continues uninterrupted for a defined period). If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (i.e. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

The initial screening test values and VDVs recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected, are presented in Table 10. The 'Low probability of adverse comment eVDV' represent the preferred and maximum value presented in the AVTG.

Table 10: Vibration management levels for disturbance to building occupants

Place and Time	Initial screening test Velocity, PEAK, mm/s (>8Hz)	Low probability of adverse comment eVDV $m/s^{1.75}$	Adverse comment possible eVDV $m/s^{1.75}$	Adverse comment probable eVDV $m/s^{1.75}$
Critical areas (day or night)[1]	0.28	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Residential buildings 16 hr day[2]	0.56	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night[2]	0.40	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices, schools, educational institutions and places of worship (day or night)	1.10	0.4 to 0.8	0.8 to 1.6	1.6 to 2.4
Workshops (day or night)	2.20	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

Notes 1. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above

2. Daytime is 7am to 10pm and night-time is 10pm to 7am

3.2.2 Building damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN 4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 times higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

Within British Standard 7385 Part 1, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

Within DIN 4150-3, damage is defined as "any permanent consequence of an action that reduces the serviceability of a structure or one of its components" (p.4). The Standard also outlines:

"For buildings as in lines 2 and 3 of Tables 1, 4 or B.1, the serviceability is considered to have been reduced if, for example

- *cracks form in plastered or rendered surfaces of walls;*
- *existing cracks in a structure are enlarged;*
- *partitions become detached from load-bearing walls or floor slabs.*

These effects are deemed 'minor damage. " (DIN 4150.3:2016, p.6)

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS 7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

3.2.2.1 British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS 7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS 7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 11 sets out the BS 7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, BS 7385 Part 2 (1993) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" (p.5).

Table 11: BS 7385 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor*	100		
		Major*	200		
2		Cosmetic	15 to 20	20 to 50	50

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
	Un-reinforced or light framed structures Residential or light commercial type buildings	Minor*	30 to 40	40 to 100	100
		Major*	60 to 80	80 to 200	200

Notes: Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

* Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

3.2.2.2 German Standard

German Standard DIN 4150 - Part 3 (2016) '*Vibration in buildings - Effects on Structures*' (DIN 4150-3:2016), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3:2016 presents the recommended maximum limits over a range of frequencies (Hz), measured at the foundations, in the plane of the uppermost floor of a building or structure or vertically on floor slabs. The vibration limits at the foundations increase as the frequency content of the vibration increases. The criteria are presented in Table 12.

Table 12: DIN 4150-3:2016 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s				
		At foundation in all directions at frequency of			Plane of floor uppermost storey in horizontal direction	Floor slabs, vertical direction
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, cannot be classified under Groups 1 and 2 and are of great intrinsic value (eg listed buildings)	3	3 to 8	8 to 10	8	20

3.3 Operational noise

This assessment aims to quantify the potential operational noise emissions from the Project in accordance with the NSW *Noise Policy for Industry* (NPfI) (EPA 2017). The assessment procedure has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the project noise trigger level which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

3.3.1 Project intrusive noise levels

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq,15min}$ descriptor) does not exceed the background noise level measured in the absence of the source by more than 5 dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

$L_{Aeq,15minute}$ Intrusiveness noise level = Rating Background Level ('RBL') plus 5 dB(A)

For the purposes of assessing operational noise impacts, background noise levels have been determined at nearby receiver locations that may be the potentially most affected, these are presented in Section 2. The intrusiveness noise levels for residential receivers are reproduced in Table 13 below.

Table 13: Intrusiveness noise levels

Receiver	Intrusiveness noise level, $L_{Aeq,15min}$		
	Day	Evening	Night
NCA1	45 + 5 = 50	45 + 5 = 50	38 + 5 = 43
NCA2	52 + 5 = 57	48 + 5 = 53	40 + 5 = 45
NCA3	42 + 5 = 47	42 + 5 = 47	33 + 5 = 38

Notes: 1. Day: 7:00 to 18:00 Monday to Saturday and 8:00 to 18:00 Sundays & Public Holidays
2. Evening: 18:00 to 22:00 Monday to Sunday & Public Holidays
3. Night: 22:00 to 7:00 Monday to Saturday and 22:00 to 8:00 Sundays & Public Holidays

3.3.2 Amenity noise levels

The project amenity noise levels for different time periods of day are determined in accordance with Section 2.4 of the NPfI. The NPfI recommends amenity noise levels ($L_{Aeq,period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for total industrial noise experienced at a receiver location. However, when assessing a single industrial development and its impact on an area then "project amenity noise levels" apply.

The recommended project amenity noise levels applicable for the subject receiver areas are reproduced from the NPfI in Table 14 below.

Table 14: Project amenity noise levels

Type of receiver	Noise amenity area	Time of day	Recommended amenity noise level, $L_{Aeq,}$ dB(A)
Residential	Urban	Day	60
		Evening	50
		Night	45
	Suburban	Day	55
		Evening	45
		Night	40
	Rural	Day	50
		Evening	45
		Night	40
Hotels / motels	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom (internal)[6]	All	Noisiest 1-hour period when in use	40
Hospital ward	All		
- Internal		Noisiest 1-hour	35
- External		Noisiest 1-hour	50
Passive recreation (e.g. national park)	All	When in use	50
Active recreation (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. 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.
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
4. The recommended amenity noise levels refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated
5. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$

To ensure that the total industrial noise level (existing plus new) remain within the recommended amenity noise levels for an area, the project amenity noise level that applies for each new industrial noise source is determined as follows:

$$L_{Aeq,period}\ \textbf{Project amenity noise level} = L_{Aeq,period}\ \textbf{Recommended amenity noise level} - \textbf{5dB(A)}$$

For the receivers that share the western, southern and eastern boundaries of the site (R13, R19, R20 and R22), given the proximity to the site and the orientation of the receiver buildings, the nearest affected facade to the Project is unlikely to be impacted by any more than 1 other industrial noise sources. For these receivers, the project amenity noise level that applies to each new industrial noise source is determined as follows:

$L_{Aeq,period}$ Project amenity noise level = $L_{Aeq,period}$ Recommended amenity noise level – 3dB(A)

Furthermore, given that the intrusiveness noise level is based on a 15 minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the $L_{Aeq,period}$ level to a representative $L_{Aeq,15minute}$ level in order to standardise the time periods.

$L_{Aeq,15minute}$ = $L_{Aeq,period}$ + 3dB(A)

3.3.2.1 Residential amenity category

Table 2.3 "*Determining which of the residential receiver categories applies*" of the NPfI provides guidance on assigning residential receiver noise categories. It presents three methods for determining which of the residential receiver noise categories apply. The three methods presented are:

- typical planning zoning (column 2 of NPfI Table 2.3);
- typical existing background noise levels (column 3 of NPfI Table 2.3); and
- description of the acoustical environment (column 4 of NPfI Table 2.3).

Given that the NPfI is unclear about which of these three methods is preferred compared to the other methods, the NSW EPA (Noise) has been consulted. It is understood that the use of typical planning zoning (column 2 of NPfI Table 2.3) is the starting point in the process for determining which receiver noise category applies, and a further review of the noise environment can be undertaken looking at background noise levels (column 3 of NPfI Table 2.3) and the acoustical environment (column 4 of NPfI Table 2.3), to support and justify a different receiver noise category. Particular reference was made during the consultation, to the note in the description column of NPfI Table 2.3 under Rural residential, which supports the consideration of a higher noise amenity area where background noise levels are higher than those presented in column 3 of NPfI Table 2.3. The advice given in relation to this is that the principle of considering higher noise amenity based on high background noise levels applies to any category (the whole NPfI Table 2.3).

Furthermore, the NSW EPA made reference to the Fact Sheet E: Worked case studies in the NPfI, which make reference to the use of existing background noise levels to justify and support the selected receiver noise category. During the consultation, particular reference was made to Case Study E4 where a change of residential amenity category based on the acoustic environment prevailing at the receiver location is illustrated. In this case study, the receiver locations to the east have a zoning of R5 which would attract a rural residential amenity category, however they have been classified as suburban residential based on higher traffic noise levels prevailing in the area.

Assigning a noise category based on planning zoning alone provides for a conservative assessment without giving any consideration to the existing acoustic environment. In accordance with Ryde City Council Local Environmental Plan 2014, the potentially impact residential receivers nearby the development are located within the following land zoning:

- NCA1 – located within R4 (High Density Residential), which falls into 'Urban' category of column 2 of NPfI Table 2.3
- NCA2 – located within B3 (Commercial Core) or B4 (Mixed Use), which falls into 'Urban' category of column 2 of NPfI Table 2.3
- NCA3 – located within R2 (Low Density Residential), which falls into 'Suburban' category of column 2 of NPfI Table 2.3.

As such, by the appropriate amenity category have been based upon the conservative approach of planning zoning alone.

The project amenity noise levels ($L_{Aeq,\ 15min}$) applied for the Project are reproduced in Table 14 below.

Table 15: Project amenity noise levels

Type of receiver	Noise amenity area	Time of day	Recommended noise level, dB(A)	
			$L_{Aeq,\ Period}$	$L_{Aeq,\ 15min}$
Residence (NCA1 and NCA2)	Urban	Day	60 – 5 = 55	55 + 3 = **58**
		Evening	50 – 5 = 45	45 + 3 = **48**
		Night	45 – 5 = 40	40 + 3 = **43**
Residence (NCA3)	Suburban	Day	55 – 5 = 50	50 + 3 = **53**
		Evening	45 – 5 = 40	40 + 3 = **43**
		Night	40 – 5 = 35	35 + 3 = **38**
Hotels / motels[4]	Urban	Day	65 – 5 = 60	60 + 3 = **63**
		Evening	55 – 5 = 50	50 + 3 = **53**
		Night	50 – 5 = 45	45 + 3 = **48**
School classroom (internal)[5]	All	Noisiest 1-hour period when in use	40 – 5 = 35	35 + 3 = **38**
School classroom (adjacent to site – R13) (internal)[5]	All	Noisiest 1-hour period when in use	40 – 3 = 37	37 + 3 = **40**
Hospital ward	All	Noisiest 1-hour	50 – 5 = 45	45 + 3 = **48**
Active recreation area (childcare play area)	All	When in use	55 – 5 = 50	50 + 3 = **53**
Commercial Premises	All	When in use	65 – 5 = 60	60 + 3 = **63**
Commercial Premises (adjacent to site - R19, R20 & R22)	All	When in use	65 – 3 = 62	62 + 3 = **65**

Type of receiver	Noise amenity area	Time of day	Recommended noise level, dB(A)	
			$L_{Aeq, Period}$	$L_{Aeq, 15min}$

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. 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
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
4. In accordance with the NPfI Table 2.2, 5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
5. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable L_{Aeq} noise level may be increased to 40 dB $L_{Aeq(1hr)}$

3.3.3 Project noise trigger levels

In accordance with the NPfI the project noise trigger levels, which are the lower (i.e. more stringent) value of the project intrusiveness noise level and project amenity noise level, have been determined as shown in Table 16 below.

Table 16 Project noise trigger levels

Receiver location		Time of Day[1,2]	Intrusiveness noise level, $L_{Aeq,15min}$ dB(A)	Project amenity noise levels $L_{Aeq, 15min}$ dB(A)	$L_{Aeq, 15min}$ Project noise trigger levels, dB(A)
Residential Receiver	NCA1	Day	50	58	50
		Evening	50	48	48
		Night	43	43	43
	NCA2	Day	57	58	57
		Evening	53	48	48
		Night	45	43	43
	NCA3	Day	47	53	47
		Evening	47	43	43
		Night	38	38	38

Receiver location	Time of Day[1,2]	Intrusiveness noise level, $L_{Aeq,15min}$ dB(A)	Project amenity noise levels $L_{Aeq, 15min}$ dB(A)	$L_{Aeq, 15min}$ Project noise trigger levels, dB(A)
Hotels / motels	Day	-	63	63
	Evening	-	53	53
	Night	-	48	48
Childcare (external)[3]	Noisiest 1-hour period when in use	-	58	58
Childcare play area		-	53	53
School classroom (external)[3]	Noisiest 1-hour period when in use	-	58	58
School classroom (adjacent to site – R13) (external)[3]	Noisiest 1-hour period when in use	-	60	60
Hospital ward	Noisiest 1-hour	-	48	48
Commercial	When in use	-	63	63
Commercial Premises (adjacent to site - R19, R20 & R22)	When in use	-	65	65

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am.
2. 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
3. Conversion of trigger levels from internal to external for childcare and school classroom assumes 20 dB(A) loss from outside to inside through a closed window.
4. For a residence, the project noise trigger level and maximum noise levels are to be assessed at the reasonably most-affected point on or within the residential property boundary.
5. For commercial or industrial premises the noise level is to be assessed at the reasonably most-affected point on or within the property boundary.

3.4 Sleep disturbance noise levels

The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. In accordance with NPfI, a detailed maximum noise level event assessment should be undertaken where the subject development 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.

Where there are noise events found to exceed the initial screening level, further analysis is undertaken to identify:

- The likely number of events that might occur during the night assessment period,
- The extent to which the maximum noise level exceeds the rating background noise level.

The sleep disturbance noise levels for the project are presented in Table 17.

Table 17: Sleep disturbance assessment levels

Receiver type	Assessment Level $L_{Aeq,15min}$	Assessment Level L_{AFmax}
NCA1	38 + 5 = 43	38 + 15 = 53
NCA2	40 + 5 = 45	40 + 15 = 55
NCA3	40	52

The night-time noise sources associated with the Project are steady-state, and therefore there is unlikely to be significant variation between $L_{Aeq,15min}$ values and L_{AFmax} values, hence compliance with the more stringent project trigger noise level presented in Table 16 will result in compliance with the project's sleep disturbance criteria set out in Table 17.

3.5 Road traffic noise

Noise impacts from the potential increases in traffic on the surrounding road network due to construction and operational activities from the Project is assessed in accordance with the NSW *Road Noise Policy* (DECCW, 2011) (RNP). The RNP sets out criteria to be applied to particular types of road and land uses. These noise criteria are to be applied when assessing noise impact and determining mitigation measures for sensitive receivers that are potentially affected by road traffic noise associated with the construction and operation of the subject site, with the aim of preserving the amenity appropriate to the land use.

The Project will be using sub-arterial / arterial roads and not local roads. Therefore, for existing residences affected by additional traffic on existing sub-arterial / arterial roads generated by land use developments, the following RNP road traffic noise criteria would apply.

Table 18: RNP Road Traffic Noise Criteria, dB(A)

Road Category	Type of Project/Land Use	Assessment Criteria, dB(A)	
		Day 7am – 10pm	Night 10pm – 7am
Freeway/arterial/sub-arterial roads	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,(15 hour)}$ 60 (external)	$L_{Aeq,(9 hour)}$ 55 (external)

Further to the above, the RNP states the following for land use developments generating additional traffic:

"For existing residences and other sensitive land uses affected by **additional traffic on existing roads generated by land use development**, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'."

The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

4 Construction noise and vibration assessment

4.1 Background

Construction activities associated with the proposed development will result in increased noise levels during construction hours. The works undertaken in the various stages consist of a mixture of both high and low noise activities. This assessment identifies potentially noisy activities, their impacts on surrounding receivers and outlines management strategies to control the impacts of noise and vibration during the construction stages of the project.

4.2 Construction hours

Construction works for the Project are proposed to take place during and outside the ICNG standard construction hours, detailed in Section 3.1.1. These hours are summarised below in Table 19 along with the proposed associated construction activity, which is further detailed in Section 4.4.1.

Table 19: Construction hours and associated proposed activity

	Defined hours	Proposed Construction Activity
Standard hours	• Monday to Friday 7:00am to 6:00pm • Saturday 8:00am to 1:00pm • No work performed on Sunday and Public Holidays	All activities: • Minor earthworks and civil works • Building construction • Building fit-out
Extended hours Period 1	• Monday to Friday 6:00am to 7:00am and 6:00pm to 7:00pm • Saturday 6:00am to 8:00am and 1:00pm to 5:00pm • Sunday 7:00am to 3:00pm	• Building construction • Building fit-out
Extended hours Period 2	Remaining hours • Monday to Friday 7:00pm to 6:00am • Saturday 5:00pm to 6:00am • Sunday 3:00pm to 7:00am	• Internal fit-out works with hand tools only – Only when building fabric has been completed • No external activities, only light vehicles accessing site

4.3 Receiver locations

The identified receiver locations were outlined in Table 3 and shown on Figure 1.

4.4 Construction noise and vibration activities and assumptions

4.4.1 Construction works and activities

An assessment of the potential level of construction noise and vibration impact has been carried out to determine whether mitigation would be required, and to determine appropriate management controls. Specific construction equipment requirements are not yet known. The type and number of plant and equipment associated with the proposed works was assumed based upon experience with similar noise assessments.

Prior to the commencement of construction, the final construction details should be reviewed against the assumptions in this report to ensure that the mitigation and management measures that will be implemented remain consistent with these assumptions, and appropriate for the project.

The approximate phases and duration of works are presented in Table 20.

Table 20: Approximate construction phases and duration of works

Stage / Description	Details	Time frame
Stage 1 - Minor earthworks and civil works	Minor earthworks and civil works, including piling	6 months
Stage 2 - Building construction	Construction of the main building structure	6 months
Stage 3 - Building fit-out	Deliveries and fitout of the datacentre, deliveries of operational plant and equipment	9 months

4.4.2 Construction traffic

The worksite will generate additional traffic movements in the form of:

- Light vehicle movements generated by construction personnel travelling to and from work
- Heavy vehicle movements generated by:
  - Delivery vehicles bringing raw materials, plant, and equipment to the site
  - Concrete trucks

Construction traffic on the site is included as part of the construction noise assessment of the work activities identified in Section 4.4.1. When construction-related traffic moves on the public road network, a different noise assessment methodology is appropriate as vehicle movements would be regarded as additional road traffic on public roads rather than as part of the construction site's activities.

Access to the site will be from Talavera Road. The estimated daily number of heavy vehicles accessing the site will be up to 50 trucks per day during peak periods or an average of 5 per hour, over a standard 10 hour work day. This volume of truck traffic is not expected to significantly alter existing traffic noise and for the majority of the construction works will be significantly lower. Furthermore, there are no residential receivers located along Talavera Road.

Construction traffic from the site on public roads is predicted not to be a significant noise impact and is not further addressed in this report.

4.4.3 Construction noise sources

The schedule of items of plant and equipment likely to be used during the construction phases of the Proposal is presented in Table 21 below.

Table 21: Typical construction equipment & sound power levels, dB(A) re 1pW

Plant item	Plant description	Estimated number of items	Sound power levels $L_{Aeq(15min)}$
Stage 1 - Minor earthworks and civil works			
1	Vibratory Roller	1	113[1]
2	Grader	1	109
3	Pilling Rig – Bored	1-2	108
4	Dump Trucks	1-2	108
5	Watercart	1	104
6	Excavator (35T)	1	103
7	Franna Crane	1-2	99
Stage 2 - Building construction			
8	Concrete trucks	2	108
9	Delivery trucks	2	108
10	Hand tools	Various	107
11	Mobile crane	1	105
12	Concrete pump	2	102
13	Concrete vibrator	4	99
14	Non-powered hand tools	Various	98
Stage 3 - Building fit-out			
15	Delivery trucks	2	108
16	Hand tools	Various	107
17	Bobcat	1	102
18	Scissor lift	2	99
19	Non-powered hand tools	Various	98

Notes 1. A 5 dB(A) penalty has been factored into the sound power level to allow for particularly annoying activities

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the Interim Construction Noise Guideline (ICNG), information from past projects and/or information held in our library files.

4.5 Construction noise and vibration assessment

4.5.1 Predicted noise levels

Noise levels at any receiver location resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Noise emissions were determined by modelling the noise sources, receiver locations, and operating activities, based on the information presented in Section 4.4.1.

Table 22 presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site. The noise level range presented represents the plant item operating at a location furthest from the receiver and a location closest to the receiver. Noise levels were calculated taking into consideration attenuation due to distance between the construction works and the receiver locations and any intervening structures. The noise predictions are conservative and do not incorporate acoustic shielding provided by hoarding. For the internal Building Fit-out works, the predictions include a modest 20 dB(A) loss from outside to inside through the completed building fabric.

The worst affected receivers for are typically in the first row of houses/apartments back from the Project site, with direct line-of-sight to the construction work area. Receivers in the next row of houses/apartments back from the Project, or receivers without direct line-of-sight to the construction area would typically be exposed to construction noise levels 5 to 10 dB(A) lower than the levels predicted for the worst affected receivers.

Table 22: Predicted $L_{Aeq(15min)}$ noise levels for typical construction plant, dB(A)

Plant Item	Plant description	Predicted $L_{Aeq(15min)}$ construction noise levels																	
		NCA1	NCA2	NCA3	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22
NML (external) – Standard hours Mon-Fri – 7:00am to 6:00pm Sat – 8:00am to 1:00pm		55	62	52	65- classroom 65- playground					65		65	70						
NML (external) – Outside Standard hours Mon-Fri – 6:00am to 7:00am & 6:00pm to 7:00pm Sat – 6:00am to 8:00am & 1:00pm to 5:00pm Sun – 7:00am to 3:00pm		50	57	47															
Stage 1 - Minor earthworks and civil works																			
1	Vibratory Roller (6T)	29-50	46-50	32-43	27-47	31-38	31-56	39-58	42-45	55-69	25-45	52-56	27-35	37-41	38-42	38-56	36-53	62-67	59-71
2	Grader	25-46	42-46	28-39	23-43	27-34	27-52	35-54	38-41	51-65	21-41	48-52	23-31	33-37	34-38	34-52	32-49	58-63	55-67
3	Pilling Rig – Bored	24-45	41-45	27-38	22-42	26-33	26-51	34-53	37-40	50-64	20-40	47-51	22-30	32-36	33-37	33-51	31-48	57-62	54-66
4	Dump Trucks	24-45	41-45	27-38	22-42	26-33	26-51	34-53	37-40	50-64	20-40	47-51	22-30	32-36	33-37	33-51	31-48	57-62	54-66
5	Watercart	20-41	37-41	23-34	18-38	22-29	22-47	30-49	33-36	46-60	16-36	43-47	18-26	28-32	29-33	29-47	27-44	53-58	50-62
6	Excavator (35T)	19-40	36-40	22-33	17-37	21-28	21-46	29-48	32-35	45-59	15-35	42-46	17-25	27-31	28-32	28-46	26-43	52-57	49-61
7	Franna Crane	15-36	32-36	18-29	13-33	17-24	17-42	25-44	28-31	41-55	11-31	38-42	13-21	23-27	24-28	24-42	22-39	48-53	45-57
Three noisiest plant operating concurrently		**31-53**	**49-53**	**35-45**	**29-49**	**34-40**	**33-59**	**41-60**	**44-48**	**57-71**	**27-47**	**54-59**	**29-38**	**40-43**	**41-45**	**41-58**	**38-56**	**65-70**	**61-73**
Stage 2 -Building construction																			
8	Concrete trucks	24-45	41-45	27-38	22-42	26-33	26-51	34-53	37-40	50-64	20-40	47-51	22-30	32-36	33-37	33-51	31-48	57-62	54-66
9	Delivery trucks	24-45	41-45	27-38	22-42	26-33	26-51	34-53	37-40	50-64	20-40	47-51	22-30	32-36	33-37	33-51	31-48	57-62	54-66
10	Hand tools	23-44	40-44	26-37	21-41	25-32	25-50	33-52	36-39	49-63	19-39	46-50	21-29	31-35	32-36	32-50	30-47	56-61	53-65
11	Mobile crane	21-42	38-42	24-35	19-39	23-30	23-48	31-50	34-37	47-61	17-37	44-48	19-27	29-33	30-34	30-48	28-45	54-59	51-63
12	Concrete pump	18-39	35-39	21-32	16-36	20-27	20-45	28-47	31-34	44-58	14-34	41-45	16-24	26-30	27-31	27-45	25-42	51-56	48-60
13	Concrete vibrator	15-36	32-36	18-29	13-33	17-24	17-42	25-44	28-31	41-55	11-31	38-42	13-21	23-27	24-28	24-42	22-39	48-53	45-57
14	Non-powered hand tools	14-35	31-35	17-28	12-32	16-23	16-41	24-43	27-30	40-54	10-30	37-41	12-20	22-26	23-27	23-41	21-38	47-52	44-56
Three noisiest plant operating concurrently		**28-50**	**46-50**	**32-42**	**26-46**	**31-37**	**30-56**	**38-57**	**41-45**	**54-69**	**24-44**	**51-56**	**26-35**	**37-40**	**38-42**	**38-55**	**35-53**	**62-67**	**58-70**
Stage 3 - Building fit-out – External works or works prior to building fabric completion																			
15	Delivery trucks	24-45	41-45	27-38	22-42	26-33	26-51	34-53	37-40	50-64	20-40	47-51	22-30	32-36	33-37	33-51	31-48	57-62	54-66
16	Hand tools	23-44	40-44	26-37	21-41	25-32	25-50	33-52	36-39	49-63	19-39	46-50	21-29	31-35	32-36	32-50	30-47	56-61	53-65

Plant Item	Plant description	Predicted $L_{Aeq(15min)}$ construction noise levels																	
		NCA1	**NCA2**	**NCA3**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**	**R17**	**R18**	**R19**	**R20**	**R21**	**R22**
17	Bobcat	18-39	35-39	21-32	16-36	20-27	20-45	28-47	31-34	44-58	14-34	41-45	16-24	26-30	27-31	27-45	25-42	51-56	48-60
18	Scissor lift	15-36	32-36	18-29	13-33	17-24	17-42	25-44	28-31	41-55	11-31	38-42	13-21	23-27	24-28	24-42	22-39	48-53	45-57
19	Non-powered hand tools	14-35	31-35	17-28	12-32	16-23	16-41	24-43	27-30	40-54	10-30	37-41	12-20	22-26	23-27	23-41	21-38	47-52	44-56
Three noisiest plant operating concurrently		**27-48**	**44-48**	**31-41**	**25-45**	**29-36**	**29-55**	**37-56**	**40-44**	**53-67**	**23-43**	**50-54**	**25-33**	**35-39**	**36-40**	**37-54**	**34-52**	**61-66**	**57-69**
Stage 3 - Building fit-out – Internal works once building fabric is complete[1]																			
16	Hand tools	24	24	17	21	12	30	32	19	43	19	30	9	15	16	30	27	41	45
19	Non-powered hand tools	15	15	8	12	3	21	23	10	34	10	21	0	6	7	21	18	32	36

Notes 1. Includes a modest 20 dB(A) loss from outside to inside through the completed building fabric. Only the maximum prediction shown.

4.5.1.1 Standard construction hours

The predicted noise levels presented above indicate that the noise levels during the three stages of construction are likely to achieve the NML at most of the nearby sensitive receivers and at all residential locations. At two receivers adjacent to the site R13 (Excelsia College - 63-71 Waterloo Road) and R22 (1-5 Khartoum Road, Macquarie Park), there may be times when loud equipment or a number of concurrent construction activities may result in construction noise levels being over the NML, particularly when these activities are operating near to the corresponding receiver location.

In addition, no residential receivers are predicted to be highly noise affected (i.e., exposed to noise levels greater than 75 dB(A)).

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise. Further details on construction noise mitigation and management measures are provided in Section 4.5.2 below.

4.5.1.2 Outside standard construction hours - Period 1

Once Stage 1 (Minor Earthworks and Civil Works) is complete, Stage 2 (Building Construction) and Stage 3 (Building fit-out) are proposed to be undertaken during the defined Outside Standard Construction Hours Period 1 (OSH Period 1).

The predicted noise levels presented above indicate that the noise levels during these two stages of construction are likely to achieve the NML at all of the nearby sensitive receivers, including the residential locations. Predictions show that construction noise levels might be slightly above the noise management levels at R13 (Excelsia College - 63-71 Waterloo Road) but this receiver is not operational during this period.

It is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise. Further details on construction noise mitigation and management measures, including noise monitoring recommendations, are provided in Section 4.5.2 below.

4.5.1.3 Outside standard construction hours - Period 2

Once Stage 1 (Minor Earthworks and Civil Works) and Stage 2 (Building Construction) is complete, certain Stage 3 (Building fit-out) works are proposed to be undertaken during the defined Outside Standard Construction Hours Period 2 (OSH Period 2).

During this period, the internal fit-out works will be restricted to hand tools only and only occur when the building fabric has been completed. In addition, there will be no external activities other than construction workers in light vehicles arriving/departing the site.

The predicted noise levels presented above indicate that the noise levels during these works are likely to be inaudible at the nearby sensitive receivers and/or the receivers will not be in use. The highest external prediction at each receiver type is outlined below. In addition, once losses from outside to inside are accounted for through open and closed windows, the predicted noise levels are minimal.

- Residential: 24dB(A)
- Childcare: 32dB(A)
- Education: 43dB(A)
- Medical: 30dB(A)
- Commercial: 45dB(A)

In regard to sleep disturbance from the light vehicles on site, based on a L_{Amax} sound power level of 97dB for engine starting/door closing, the maximum noise level prediction at the nearest residential receivers is less than 10dB(A). As such, the potential for sleep disturbance impacts is negligible.

It is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise. Further details on construction noise mitigation and management measures, including noise monitoring recommendations, are provided in Section 4.5.2 below.

4.5.2 Construction noise mitigation measures

4.5.2.1 General engineering noise controls

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', are expected to reduce predicted construction noise levels.

Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 23 below presents noise control methods, practical examples and expected noise reductions according to AS 2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 23: Relative effectiveness of various forms of noise control

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Screening	Acoustic barriers such as temporary or permanent noise barriers where barrier breaks line-of-sight between the source and receiver	5 to 10	5 to 10	15	15
Acoustic enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 24 below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 24: Possible noise control measures for likely construction plant

Plant Description	Screening	Acoustic enclosures	Silencing	Alternative process
Tracked Excavator	✔	✖	✔	✖
Piling Rig	✔	✖	✔	✖
Grader	✔	✖	✔	✖
Concrete truck	✔	✖	✔	✖
Delivery trucks	✔	✖	✔	✖
Mobile crane	✔	✔	✖	✖
Hand tools	✔	✖	✔	✖

4.5.2.2 Noise management measures

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers. A strong justification must be provided for not implementing the proposed measures if they are later determined on-site not to be feasible or reasonable.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

<u>General noise management measures</u>

The following general noise management measures are recommended for all receiver locations:

- Use less noisy plant and equipment, where feasible and reasonable.

- Plant and equipment must be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods during construction work must be switched off.
- Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be limited/avoided where possible.
- The offset distance between noisy plant and adjacent sensitive receivers is to be maximised where practicable.
- Plant used intermittently to be throttled down or shut down when not in use where practicable.
- Noise-emitting plant to be directed away from sensitive receivers where possible.
- Staging of construction works so as to erect solid external walls first and utilising them to provide noise shielding to the noise sensitive receivers. However, the structural integrity of the external walls should be investigated prior to implementing this measure and should be prioritised over the noise benefits.
- In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the community must be adequately trained and experienced in such matters.

Additional measures to be considered

Other potential mitigation measures include:

- Use of broadband "quacker" type of reverse/movement alarms instead of the tonal 'beeping" type.

- All employees, contractors and subcontractors are to receive site induction and toolbox talks and ongoing training so that the above noise management measures are implemented accordingly. Content within toolboxes will include, location of nearest sensitive receivers; relevant project specific and standard noise and vibration mitigation measures; permissible hours of work, truck route and truck loading restrictions and construction employee parking areas.
- Consultation with Excelsia College (R13) (63-71 Waterloo Road, Macquarie Park), to inform consideration of appropriate feasible and reasonable noise management measures during noise intensive periods of construction.

Noise Monitoring

The following approach should be adopted with regard to noise monitoring procedures during the construction works.

- Where potential noise impacts are predicted to be 10dB(A) above the noise criteria during standard construction hours, the potential construction noise nuisance is considered to be moderate. Noise monitoring should be carried out to confirm predicted noise impacts within two weeks of commencement of construction. Reasonable and feasible noise reduction measures must be investigated, where necessary.
- Where potential noise impacts are predicted to be 5dB(A) above the noise criteria during outside of standard construction hours, noise monitoring should be carried out to confirm predicted noise impacts within two weeks of commencement of construction. Reasonable and feasible noise reduction measures must be investigated, where necessary.
- In the event of noise complaints, noise reduction measures (where reasonable and feasible) must be implemented and noise monitoring should undertaken to assist in managing noise levels.

4.5.3 Vibration assessment

4.5.3.1 Minimum working distances

The pattern of vibration radiation is very different to the pattern of airborne noise radiation and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building’s construction and structure.

The recommended minimum working distances for vibration intensive plant are presented in Table 25.

Table 25: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m				
	Cosmetic damage			Human disturbance	
	Commercial and industrial buildings[1]	Dwellings and similar structures[1]	Sensitive structures (e.g. heritage)[1]	Residences Day[2]	Offices
Truck traffic (over irregular surfaces)	5	5	10	15	10
Excavator 35T (travelling / digging)	5	5	10	20	10
Piling Rig (bored)	5	5	10	15	10
Grader	5	5	10	20	10
Vibratory Roller 6T	5	15	20	40	20

Notes: 1. Vibration limits referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration.
2. Daytime is 7 am to 10 pm;

Site specific buffer distances for vibration significant plant items must be measured on site where plant and equipment is likely to operate close to or within the minimum working distances for cosmetic damage.

As previously identified, unlike noise, vibration cannot be 'predicted' due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS 5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

4.5.3.2 Potential vibration impacts

Based on the proposed plant items presented, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 26 below.

The assessment is relevant to the identified residential buildings and other similar type structures in the project area and has been assessed against the vibration limits DIN 4150-3:2016 (see Section 3.2.2.2). Receivers R1 to R12 and R14 to R18 are located greater than 100m from the works and considered to have a low to negligible risk of vibration impact.

Table 26: Potential vibration for residential and commercial properties

Receiver location[1]	Approx. distance to nearest buildings from works (m)	Group classification in accordance with Table 12	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
R13	50 m	Group 1 (commercial /industrial)	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required

Receiver location[1]	Approx. distance to nearest buildings from works (m)	Group classification in accordance with Table 12	Assessment on potential vibration impacts		
			Structural damage risk	Human disturbance	Vibration monitoring
R19	65 m	Group 1 (commercial /industrial)	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required
R20	90 m	Group 1 (commercial /industrial)	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required
R21	80 m	Group 1 (commercial /industrial)	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required
R22	35 m	Group 1 (commercial /industrial)	Very low risk of structural damage from construction works	Low risk of adverse comment as a result of construction works	Vibration monitoring not required

Note: 1. The sources of vibration levels is the vibratory roller 6T. If alternative equipment with higher vibration levels are used, there is an additional risk.

Based on the above assessment for the receivers surrounding the site, there is a low risk of vibration impact. Nevertheless, potential vibration impacts should be reviewed during construction considering site specific buffer distances for vibration significant plant items where plant and equipment is likely to operate close to or within the minimum working distances for cosmetic damage at nearby vibration sensitive receivers, and recommendations for reducing or managing potential vibration impacts are provided in the following section.

4.5.3.3 Vibration mitigation measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort and building damage vibration limits:

1. A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

3. Where construction activity occurs in close proximity to sensitive receivers (i.e. within the minimum working distances within Table 25), vibration testing of actual equipment on site should be carried out prior to their commencement of site operation to determine site-specific acceptable buffer distances to the nearest affected receiver locations.

4.5.4 Complaints management

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

Owners and occupants of nearby affected properties are to be informed by direct mail of a direct telephone line and contact person, where any noise and/or vibration complaints related to the operation of the construction activities are to be reported.

5 Operational noise assessment

5.1 Operations noise sources

The noise sources associated with the operation of the Project are as follows:

- fixed mechanical plant, including emergency equipment (i.e. generators)
- staff vehicle movements and car parking
- loading dock activities

5.1.1 Mechanical equipment

5.1.1.1 Existing IC2 and IC3e

In order to address cumulative impacts, equipment from the existing IC2 and IC3e datacentres has been considered. Currently, IC2 is operating at full capacity and IC3e is operating partial capacity, which will increase over the next years.

Table 27 below summarises the plant and equipment for IC2 and IC3e that will be in place when these datacentres operate at full capacity. The location of the main items of plant is shown in **Figure 2**. The sound level data for the equipment and operational quantities were provided by the client based upon information for the existing facility or measurements undertaken on site at the existing facility.

Table 27: IC2 and IC3e noise level data

Plant/equipment and quantity	Location	Descriptor	Overall dB(A)	Octave Band Centre Frequency - Hz dB								Notes[1]
				63	125	250	500	1k	2k	4k	8k	
IC2 Datacentre												
DRUPS x 5	Level 1	L_p L_{eq} @1m	105	82	94	97	96	98	99	99	98	-
Chillers x 5	Roof	L_W	95	93	96	98	93	89	84	77	74	-
Chiller x 1	Roof	L_W	97	93	99	96	95	93	86	82	74	-
Transformers x 6	Ground	L_W	81	68	86	84	83	70	60	54	57	-
AHU x 1	Roof	L_W	86	64	69	69	86	80	78	74	64	-
FCU Condenser x 1	Roof	L_W	94	106	102	100	91	84	73	63	57	-
Condenser x 4	Roof	L_W	75	76	80	76	74	69	63	57	55	-
Condenser x 2	Roof	L_W	80	82	82	80	80	74	68	65	60	-
Generators within acoustic enclosure and attenuators x 4	Roof – eastern side	L_p L_{eq} @1m	73	88	86	74	64	61	57	57	66	Based on measurements conducted on site on 02/05/2019
IC3e Datacentre												
Cooling Towers x 6	Roof	L_W	95	99	97	98	93	89	81	77	74	-
Transformers x 7	Level 1&5	L_p L_{eq} @1m	70	56	74	72	71	58	48	42	45	-

Plant/equipment and quantity	Location	Descriptor	Overall dB(A)	Octave Band Centre Frequency - Hz dB								Notes[1]
				63	125	250	500	1k	2k	4k	8k	
Chillers x 6	Level 5	L_W	104	90	95	95	93	92	96	101	90	-
Pumps x 6	Level 5	L_W	92	87	85	85	84	83	83	89	74	-
Pumps x 4	Level 5	L_W	90	85	83	83	82	81	81	87	72	-
Pumps x 6	Level 5	L_W	88	83	81	81	80	79	79	85	70	-
Pumps x 2	Level 5	L_W	81	76	74	74	73	72	72	78	63	-
AHU x 2	Roof	L_W	82	97	85	83	81	75	73	68	62	-
Condenser x 5	Roof	L_W	82	82	82	80	80	74	68	65	60	-
Condenser	Ground	L_W	82	82	82	80	80	74	68	65	60	-
Supply fan x 2	Roof	L_W	90	83	85	87	90	86	79	72	65	-
Exhaust fan x 3	Roof	L_W	77	64	75	76	74	72	69	63	49	-
Exhaust fan x 2	Roof	L_W	86	71	77	81	85	81	77	70	63	-
Generators with attenuators x 8[2]	Ground – eastern side	Outlet (atmosphere side) L_p L_{eq} @1m	60	77	67	65	53	49	46	47	33	Based on measurements conducted on site on 04/03/2021

Note: 1. All noise levels, except for generators are based on unmitigated equipment
2. Generator engine is located within the data centre building (inlet located within the semi-enclosed ground level)

5.1.1.2 IC3w equipment

Table 28 below summarises new mechanical services plant and equipment associated with IC3w. The location of the main items of plant is shown in **Figure 2**. The sound level data for the equipment and proposed quantities were provided by the client. Further detailed information about the main noise generating equipment items is outlined in the sections following Table 28.

Table 28: IC3w noise level data

Plant/equipment and quantity	Location	Descriptor[1]	Overall dB(A)	Octave Band Centre Frequency - Hz dB							
				63	125	250	500	1k	2k	4k	8k
Chillers x 8	Level 1	L_W	105	91	96	96	94	93	97	102	91
Chilled water pump x 8	Level 1	L_p L_{eq} @1m	77	-	-	-	-	-	-	-	-
AHU x 8	Level 1	L_W	83	95	95	87	78	72	67	60	54
CRAC x 84	Levels 2-5	L_W	82	97	91	87	77	72	68	59	48
Cooling Towers x 8	Roof	L_W	93	99	96	90	88	87	85	84	84
Carpark Exhaust fan x 1	Outlet on roof	L_W	90	90	92	86	86	86	82	78	75
Condenser water Pumps x 8	Roof	L_p L_{eq} @1m	77	-	-	-	-	-	-	-	-
Generators within acoustic enclosure x 18	Roof	Inlet with attenuator L_p L_{eq} @1m[2]	75	-	-	-	-	-	-	-	-
		Outlet with attenuator L_p L_{eq} @1m[3]	77	-	-	-	-	-	-	-	-
		Side of enclosure L_p L_{eq} @1m[4]	74	-	-	-	-	-	-	-	-

Plant/equipment and quantity	Location	Descriptor[1]	Overall dB(A)	Octave Band Centre Frequency - Hz dB							
				63	125	250	500	1k	2k	4k	8k

Note:
1. All noise levels, except for generators are based on unmitigated equipment, that is no mitigation additional to that adopted by the manufacturer.
2. Inlet area = 6.8m2
3. Outlet area = 12.8m2
4. Side of enclosure = 37.7m2

Figure 2: Location of main items of mechanical plant

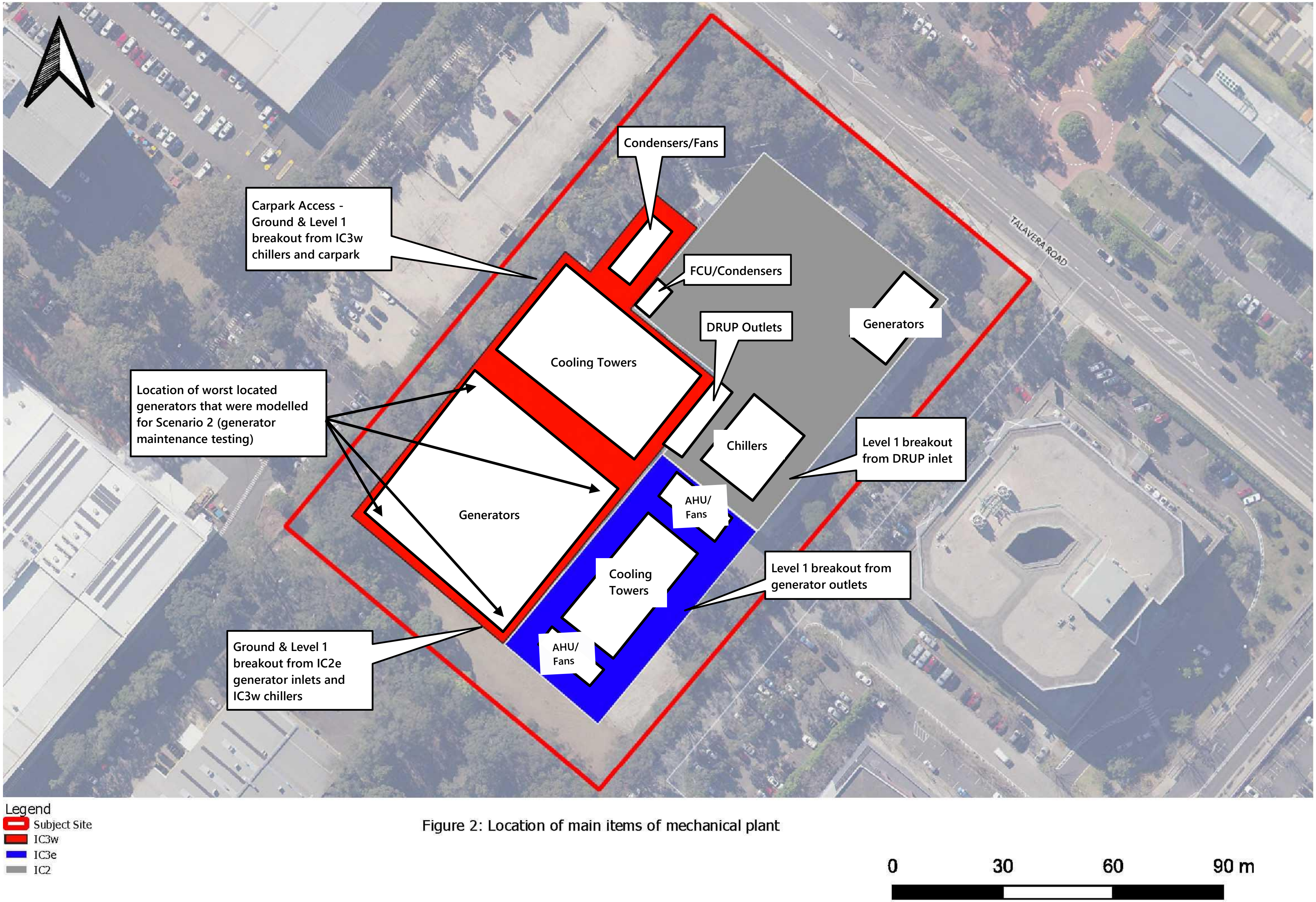


Figure 2: Location of main items of mechanical plant

5.1.1.2.1 Mechanical plant noise assumptions and mitigation measures

The following acoustic mitigation was developed with the project team in order to determine a design that would achieve the required NPfI project trigger levels detailed in Section 3.3.3.

Generators acoustic treatment

The backup generator(s), listed in Table 28, will be located on the roof and housed within an acoustic enclosure. Allowance within the purpose built enclosures has been made for intake and discharge attenuators to each be up to 4.5 metres long. The backup generators would only be used temporary in an emergency situation (i.e. where there is a grid power outage). During an emergency situation 16 of the 18 generators would operate concurrently.

The exception is periodic maintenance testing, which would only occur during the daytime and one generator would be operating at any one time.

Chillers and pumps

The chillers and pumps, listed in Table 28, will be located on the Level 1 plant zone. The plant zone will be primarily enclosed. Any openings for ventilation and temperature control, may require acoustic louvres to minimise noise emission emanating from the Ground Level and First Level of the building. Internal noise levels within the Level 1 plant zone have been calculated, and the insertion loss of in-principle acoustic louvres is presented below has been assumed in the modelling based upon 50m^2 of façade louvres. The required performance of the acoustic louvres will be reviewed during detailed design, subject to the final plant selection and required louvre areas.

Table 29: Level 1 plant zone acoustic louvre insertion loss

Item	Octave Band Centre Frequency - Hz dB							
	63	125	250	500	1k	2k	4k	8k
Acoustic louvres	3	7	9	13	15	16	15	14

Cooling towers

The cooling towers, listed in Table 28, will be located on the roof. This equipment has been carefully selected to minimise noise emission. The modelled cooling towers have been assumed to include a a manufacturer supplied super low sound fan.

Condensers and carpark extract fan

The condenser water pumps and outlet for the carpark exhaust fan, listed in Table 28, will be located on the roof. It has been assumed that a minimum of 4 metres of 50mm internally lined ductwork will be installed the discharge side of the carpark exhaust fan prior to the discharge point. In addition, a small screen/parapet will be places on the northern side of the condenser water pumps. The screen is to extend 0.5 metres above the top of the pumps.

5.1.1.2.2 In principle mechanical plant measures

At this stage of the development, appropriate detail for all of the mechanical plant is not available. However, the biggest noise emitting items have been reviewed and addressed above and the remaining items of plant would be readily treated with the below in-principle noise management measures, so that they would not increase to the overall site noise emissions in order to achieve the criteria presented in Section 3.3.3 during further design development stages. To ensure this, the following is required:

- Acoustic assessment of mechanical services equipment should be undertaken during the detailed design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - procurement of 'quiet' plant
  - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
  - commercially available acoustic attenuators for air discharge and air intakes of plant
  - acoustically lined and lagged ductwork
  - acoustic barriers between plant and sensitive neighbouring premises
  - partial or complete acoustic enclosures over plant
- The specification and location of mechanical plant should be confirmed prior to installation on site, and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery - Mechanical Vibration*'.

5.1.2 Staff vehicle movements and car parking

A carpark of 71 spaces will be provided on the ground level of the IC3w building. In accordance with The Transport Planning Partnership prepared, *17-23 Talavera Road, Macquarie Park Transport Impact Assessment*, dated 25 October 2021 (Traffic Report) the carpark will service the 49 staff associated with the entire site (IC2, IC3e and IC3w) and the number of vehicle trips per hour in the AM and PM peak periods is 38.

Noise generated by car park activities includes vehicle doors closing, vehicle engines starting, vehicles accelerating and vehicles moving. To assess this noise, the $L_{Aeq\ 15\text{-minute}}$ noise level at the nearest affected receivers was determined for each relevant period based on the number of vehicle movements expected to occur during that period. For this assessment, the proposed staff requirements for the Project has been reviewed to determine the maximum number of car movements within the carpark during each assessment period. This distribution has considered the following:

- The data centres operate on a 24-hour, 7-days a week basis, so staff operate in shifts. For each shift change, staff will arrive/depart 30mins either side of this time.
- The highest number of vehicle trips per hour during day, evening and night period is 38.
- In accordance with the Traffic Report, 77% of staff and visitors will arrive via car which will generate a parking demand of 71 spaces (or 142 vehicle trips) per 24hr period. The potential worst-case number of car movements is 89 during the daytime (7am to 10pm) and 53 during the night-time (10pm to 7am).
- Staff are expected to travel either direction on Talavera Road and so the numbers were evenly distributed in both directions.

The sound power levels generated by carpark activities on site are presented in the following table sourced from the Renzo Tonin & Associates database. The majority of the noise will remain within the carpark structure, with the main source of breakout being at the carpark entrance/exit located on the western side of the building.

Table 30: Carpark activity sound power levels

Activity	Metric	Individual noise source sound power level, $L_{Aeq,t}$ dB(A) re. 1pW
Vehicle moving (10km/h)	Passby LW	79
Door slam	LW+10log(t)	86
Engine start	LW+10log(t)	92

5.1.3 Loading dock

The loading dock is located on the eastern side of the site. In accordance with the Traffic Report, waste collection (the most common usage) is undertaken by an 9m Medium Rigid Vehicle. On very rare occasions (1-2 times a year) a larger truck (19m length) maybe required to accommodate pant upgrades.

Trucks would enter and exit via the Talavera Road eastern and western entries. Modelling of loading dock operations were based upon sound power levels presented in Table 31, which have sourced from the Renzo Tonin & Associates database of previous measured levels.

Table 31: Loading dock area activities sound power levels

Equipment / Plant	Noise source / noise generating operation	Individual source/activity sound power level (SWL, re. 1pW), $L_{Aeq,t}$, dB(A)
9 metre rigid	Moving onsite (20km/h)	106
	Idling	96

Equipment / Plant	Noise source / noise generating operation	Individual source/activity sound power level (SWL, re. 1pW), $L_{Aeq,t}$, dB(A)
Prime mover	Moving onsite (20km/h)	107
	Idling	96

5.2 Noise prediction methodology

5.2.1 Modelling overview

Modelling and assessment of airborne noise impacts from the Project were determined by modelling the noise sources, receiver locations and topographical features, and possible noise mitigation measures using a 3D noise modelling package, CadnaA (Version 2021 MR 1). Noise modelling algorithms were used to calculate the contribution of each noise source at each identified sensitive receiver location and to predict the total noise from the site.

Internal spaces within the facility such as the semi-enclosed ground floor, were modelled using CadnaR (Version 2021) to determine the noise levels at the openings to these spaces.

The noise prediction model considers:

- Location of noise sources and sensitive receiver locations (including multi-storey buildings).
- Heights of sources and receivers referenced to digital ground contours with a 1 m contour interval, or relative to the Project.
- Noise source levels of individual plant and equipment.
- Separation distances between sources and receivers.
- Ground type and reflections between sources and receivers (ground absorption value of 0 for the site, and 0.5 for remaining areas).
- Attenuation from barriers, buildings and structures (natural terrain and purpose built).
- Atmospheric losses and meteorological conditions.
- The noise mitigation/treatments within Section 0, that have been determined for the Project

The CONCAWE noise propagation algorithm was implemented for assessing potential noise impacts because:

- CONCAWE allows for the standard and noise-enhancing meteorological conditions presented in NPfI Fact Sheet D to be directly considered.
- The CONCAWE algorithm at the receiver distances relevant to this assessment provides for a conservative assessment.

5.2.2 Meteorological conditions

In accordance with the NPfI, the noise assessment considers the effects of adverse meteorological conditions such as wind and temperature inversions. The following noise-enhancing meteorological conditions have been considered in the noise assessment scenarios.

Table 32: Prevailing noise-enhancing assessment meteorological conditions

Assessment period	Assessment meteorological condition	
	Standard meteorological conditions	Noise-enhancing meteorological conditions
Day (7am – 6pm)	Class D with 0.5 m/s winds[1]	Class D with 3 m/s[1]
Evening (6pm – 10pm)		
Night (10pm – 7am)		Class F with 2 m/s winds[1]

Notes: 1. All directions considered

5.3 Noise predictions

Predictions have been undertaken for the following reasonable worst case 15-minute scenarios:

- **Scenario 1 (normal operations):**
  - All of the IC2, IC3e and IC3w mechanical equipment within Section 5.1.1 operating at full capacity, except for the emergency backup generators.
  - Operating during daytime, evening and night-time.
  - Standard and noise-enhancing meteorological conditions applied.
- **Scenario 2 (generator maintenance testing):**
  - All of the IC2, IC3e and IC3w mechanical equipment within Section 5.1.1 operating at full capacity.
  - One IC3w emergency backup generator operating at full capacity (worst case generator selected i.e. nearest), see Figure 2
  - Operating during daytime only
  - Standard and noise-enhancing meteorological conditions applied

Predicted noise levels have been assessed to all the nearby representative receivers, and a summary of these results are presented in Table 33. From Table 33, it can be seen that the Project is predicted to comply for both scenarios at all the identified receiver locations.

Noise contour maps at 1.5 metres above the local ground level for each of the scenarios assessed are presented in APPENDIX C.

Table 33: Predicted noise levels at representative receivers

Rec No.	Assessment location[7]	Receiver type	Scenario 1 (normal operations)					Scenario 2 (generator maintenance testing)				
			Std Cond[1]	Enhancing Cond		Criteria[4]	Comply	Std Cond[1]	Enhancing Cond		Criteria[5]	Comply
				Wind 3m/s[2]	Inver[3]				Wind 3m/s[2]	Inver[3]		
R1	Level 7 (top floor)	Residential	42	43	43	**43**	**Yes**	46	47	47	**50**	**Yes**
R2	Level 2 (top floor)		40	41	41	**43**	**Yes**	42	43	43	**50**	**Yes**
R3	Level 3 (top floor)		39	40	40	**43**	**Yes**	41	42	42	**50**	**Yes**
R4	Level 19 (top floor)		40	41	41	**43**	**Yes**	42	43	43	**57**	**Yes**
R5	Level 18 (top floor)		37	39	39	**43**	**Yes**	40	42	42	**57**	**Yes**
R6	Ground Floor at boundary		30	31	31	**43**	**Yes**	36	37	37	**57**	**Yes**
R7	Level 1 (top floor)		34	35	35	**38**	**Yes**	37	38	38	**47**	**Yes**
R8	Ground floor of tenancy	Childcare[6]	39	40	40	**53**	**Yes**	42	43	43	**53**	**Yes**
R9	Ground floor of tenancy		33	34	34	**53**	**Yes**	36	37	37	**53**	**Yes**
R10	Ground floor of tenancy		44	44	44	**53**	**Yes**	47	47	47	**53**	**Yes**
R11	Ground floor of tenancy		40	41	41	**53**	**Yes**	42	43	43	**53**	**Yes**
R12	Level 1 of tenancy		35	36	36	**53**	**Yes**	38	40	40	**53**	**Yes**
R13	Level 1 of building	Education	52	52	52	**60**	**Yes**	54	55	55	**60**	**Yes**
R14	Ground floor of building		39	40	40	**58**	**Yes**	40	41	41	**58**	**Yes**
R15	Ground floor of building	Medical	44	44	44	**48**	**Yes**	45	46	46	**48**	**Yes**
R16	Level 7 (top floor)	Hotel/motel	46	47	47	**48**	**Yes**	48	49	49	**63**	**Yes**
R17	Level 8 (top floor)		34	35	35	**48**	**Yes**	36	37	37	**63**	**Yes**
R18	Level 7 (top floor)		34	35	35	**48**	**Yes**	39	40	40	**63**	**Yes**
R19	Level 7 (top floor)	Commercial	61	61	61	**65**	**Yes**	61	61	61	**65**	**Yes**
R20	Level 9 (top floor)		57	57	57	**65**	**Yes**	58	58	58	**65**	**Yes**
R21	Level 6 (top floor)[8]		49	49	49	**63**	**Yes**	50	50	50	**63**	**Yes**
R22	Level 3 (top floor)		52	52	52	**65**	**Yes**	55	55	55	**65**	**Yes**

Notes
1. Class D with 0.5 m/s winds (all wind directions considered)
2. Class D with 3 m/s (all wind directions considered)
3. Class F with 2 m/s winds (all wind directions considered)
4. For residential and hotel receivers the night-time criterion is presented to represent worst case assessment situation
5. Daytime criterion as emergency generators only tested during the daytime
6. The criteria for childcare play area rather than external classroom criteria is presented
7. Most affected apartment / hotel room / room / play area
8. To represent new building associated with SSD-10467

5.4 Annoying noise characteristics adjustments

Where the character of the industrial noise is assessed as particularly annoying at a receiver location (ie. if the resulting noise level at a receiver location is tonal, low frequency or is intermittent at night), then an adjustment would be added to penalise the predicted noise for its potential increase in annoyance. The Fact Sheet C of the NPfI provides definitive procedures for determining whether a modifying factor should be applied which will be assessed as part of the Project. The corrections are to be added to the predicted noise levels at the receiver before comparison with the project noise trigger levels.

Measurements of the noise source levels from the key noise generating plant/equipment were undertaken at with the existing facility with a sufficient duration to capture typical total activity noise levels along with all relevant statistical measurement parameters (L_{Amax}, $L_{A1,T}$, $L_{A10,T}$, $L_{A90,T,}$ L_{Amin}) in accordance with AS1055:2018.

5.4.1 Tonality

One noise source was identified as having the potential to be tonal at the nearby receivers, this being the tonal reversing alarms on heavy vehicles.

Reviewing the contribution from this individual noise source, and that the overall noise levels are generally controlled but the steady-state or quasi-steady-state mechanical and electrical plant/equipment and building services the resulting noise levels at nearby receivers are unlikely to have tonal characteristics.

5.4.2 Intermittent noise

The NPfI details that the test for intermittent noise that applies during the night period to be *"The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible."* and *"…where the level suddenly drops/increases several times during the assessment period…"*. During the environmental assessment phase it is not possible to listen and subjectively assess the noise at the receiver as required by the guideline. However, only where all of the following tests are met shall a penalty be applicable to the predicted noise level at the relevant receiver:

- the noise level fluctuates / cycles by more than 5 dB(A);
- this difference relates to a 'sudden' drop/increase in the activity noise level;
- this activity may occur multiple times during a 15-minute assessment period; and
- the predicted noise level from the subject source at a receiver is clearly audible over the ambient noise environment.

The only noise source which potentially exhibits intermittent characteristic, such as cycling on and off, would be the reversing alarms fitted to the heavy vehicles that access the loading bay. However, the loading bay would not be utilised at night-time.

As such, the noise emissions during the night-time period are unlikely to require an intermittent penalty as identified in the NPfI.

5.4.3 Impulsiveness noise

The *Draft Industrial Noise Guidelines Technical Background Paper* (EPA, 2015), proposed to seek the views of acoustical practitioners as part of the review/consultation process, and impulsiveness had not been included in the NSW *EPA draft Industrial Noise Guideline* (draft ING). Subsequently, impulsiveness was not included in the NPfI released by the EPA in 2017.

AS1055-2018 describes how potentially annoying characteristics, such as impulsiveness, should be assessed. Section 6.7.4 Impulse adjustment (K2) of AS1055-2018 states:

"If impulsiveness is a significant characteristic of the sound within a measurement time interval, an adjustment shall be made over this time interval.'

Also, Appendix E of AS1055-2018 provides an objective method for application of an impulse adjustment to measured receiver noise at receivers where deemed necessary. Impulsive noise is defined in this standard as a sound with a sudden onset. The definition includes only the onset of a sound, not the sound as a whole. Onset is defined in the standard as a sound having a positive slope time history where the gradient exceeds 10 dB/s.

Section E9 *'Care in the use of methods'* of AS1055-2018 also states that:

"It is recommended that the impulse method only be applied where the occurrence of impulsive sounds caused by a subject source are identified audibly to occur at the receiver locations by attended monitoring."

Given that the noise sources associated with the Project are steady-state or quasi-steady-state, no impulsive noises with a sudden onset of significant level at the receiver areas are anticipated from the proposed development. Therefore, the procedure for objective determination of an impulse adjustment to measured noise at receiver locations provided in Appendix E of the Australian Standard, does not apply here and no adjustment for impulsiveness is necessary.

5.5 Sleep disturbance assessment

The night-time noise sources associated with the Project are steady-state or quasi-steady-state, and therefore there is unlikely to be significant variation between $L_{Aeq,15min}$ values and L_{AFmax} values, hence compliance with the more stringent project trigger noise level presented in Table 16 and Table 33 will result in compliance with the project's sleep disturbance criteria set out in Table 17.

5.6 Traffic assessment

The site is expected to generate a worst-case 89 movements during the daytime (7am to 10pm) and 53 movements during the night-time (10pm to 7am). This amount of traffic is not expected to significantly alter existing traffic noise and any increases are expected to be insignificant, well below the 2 dB increase threshold within the RNP and have minor impact.

Furthermore, there are no residential receivers located along Talavera Road and any other sensitive land uses (i.e. childcare centres) are set back from Talavera road and have a significant amount of intervening shielding from neighbouring buildings.

5.7 Operational noise management

As per Section 5.1.1.2.2, as the majority of noise generator items are mechanical and electrical plant/equipment and building services, final selection of specific plant/equipment and associated acoustic mitigation measures would be undertaken during the detailed design phase. During the detailed design phase of the development, it is important that an acoustic assessment of mechanical services equipment be undertaken to ensure that the cumulative noise emissions of all equipment is consistent with this report, and does not exceed the applicable noise criteria in this report.

Following the commencement of operation, and at a point in time that normal full capacity operations are being undertaken, noise measurements should be undertaken to confirm the noise emissions from the facility are consistent with this assessment. The method for measuring the performance of the facility should be undertaken in accordance with Section 7 ‘Monitoring performance’ of the NPfI.

As part of the site’s Operational Noise Management Plan, not only should reviewing the site noise emissions against the predicted noise levels in this assessment be incorporated, there should also be regular reviews of on-site noise mitigation and management practices to incorporate and capture opportunities for reductions of site noise emissions with considerations of at minimum the following:

- Review of noise reduction opportunities during changes or refinements of site noise generating activities.
- Reviewing noise levels of plant, equipment and activities, during both ongoing compliance checks and in response to complaints.
- Improvements in Best Management Practice (BMP), as defined in the NPfI.
- Improvements in Best Available Technology Economically Achievable (BATEA), as defined in the NPfI.

6 Conclusion

Renzo Tonin & Associates was engaged to prepare a noise and vibration impact assessment to accompany the State Significant Development (SSD) 24299707 for the proposed Macquarie Park Data Centre Campus IC3 Super West (IC3w) at 17-23 Talavera Road, Macquarie Park.

This report assesses noise and vibration impacts during the construction and operational stages for the Project. It proposes mitigation and management measures to reduce impacts during the construction and operation phases of the Project. The report has been prepared to address the requirements of the Secretary of the Department of Planning, Industry and Environment (DPIE) ('the Secretary's environmental assessment requirements') (SEARs) and EPA requirements.

6.1 Operational noise assessment

Operational noise impacts from the proposed datacentre has been assessed, and a range of feasible and reasonable mitigation measures incorporated into the design to minimise noise impacts on sensitive receivers nearby and further removed from the site.

The assessment has reviewed the existing noise environment and established the noise emission objectives in accordance with the NSW *Noise Policy for Industry* (NPfI) (EPA 2017).

A review of the potential noise generating activities that will likely take place as part of operations of the facility was undertaken, and cumulative impacts from the existing datacentres on site was assessed.

The assessment has predicted the potential noise impacts under both standard meteorological conditions and noise-enhancing meteorological conditions, and following the implementation of a range of mitigation and management measures, the predicted noise levels have demonstrated that the facility can comply with the requirements of the NPfI for Industry at all potentially impacted receivers that surround the site.

The assessment has found that any potential sleep disturbance and operational road traffic noise increases attributed to the Project, would respectively meet the NPfI and RNP requirements.

6.2 Construction noise and vibration assessment

An assessment of potential construction noise and vibration impacts from the site establishment & civil works, building construction and building fit-out stages of the Project has been undertaken.

The expected construction noise levels have been predicted and presented in Section 4.5.1. Noise mitigation and management measures have been presented in Section 4.5.2 to aid in providing additional noise reduction benefits where exceedance of the objectives occurs.

During the building construction and building fit-out phases vibration intensive plant and equipment are not proposed to be typically used as part of the construction works and so the risk of vibration impacts is minimal. Vibration intensive equipment is expected to be required for the civil works and management measures have been presented in Section 4.5.3 to aid in minimising any potential vibration impacts.

The noise impact of construction traffic on the existing road network has been reviewed and is considered not to be significant.

APPENDIX A Glossary of terminology

A.1 Glossary of terminology - Noise

The following is a brief description of the technical terms used to describe noise and to assist in understanding the technical issues presented.

Absorption Coefficient α	The absorption coefficient of a material, usually measured for each octave or third-octave band and ranging between zero and one. For example, a value of 0.85 for an octave band means that 85% of the sound energy within that octave band is absorbed on coming into contact with the material. Conversely, a low value below about 0.1 means the material is acoustically reflective.
Adverse weather	Weather effects that enhance noise (particularly wind and temperature inversions) occurring at a site for a significant period of time. In the NSW INP this occurs when wind occurs for more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of nights in winter.
Air-borne noise	Noise which is fundamentally transmitted by way of the air and can be attenuated by the use of barriers and walls placed physically between the noise source and receiver.
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Amenity	A desirable or useful feature or facility of a building or place.
AS	Australian Standard
Assessment period	The time period in which an assessment is made. e.g. Day 7am-10pm & Night 10pm-7am.
Assessment Point	A location at which a noise or vibration measurement is taken or estimated.
Attenuation	The reduction in the level of sound or vibration.
Audible Range	The limits of frequency which are audible or heard as sound. The normal hearing in young adults detects ranges from 20 Hz to 20 kHz, although some people can detect sound with frequencies outside these limits.
A-weighting	A filter applied to the sound recording made by a microphone to approximate the response of the human ear.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the LA90 noise level if measured as an overall level or an L90 noise level when measured in octave or third-octave bands.
Barrier (Noise)	A natural or constructed physical barrier which impedes the propagation of sound and includes fences, walls, earth mounds or berms and buildings.
Berm	Earth or overburden mound.
Buffer	An area of land between a source and a noise-sensitive receiver and may be an open space or a noise-tolerant land use.
Bund	A bund is an embankment or wall of brick, stone, concrete or other impervious material, which may form part or all of the perimeter of a compound.
BS	British Standard
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)"
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our environment:

	threshold of hearing	0 dB	The faintest sound we can hear, defined as 20 micro Pascal
		10 dB	Human breathing
	almost silent	20 dB	
		30 dB	Quiet bedroom or in a quiet national park location
	generally quiet	40 dB	Library
		50 dB	Typical office space or ambience in the city at night
	moderately loud	60 dB	CBD mall at lunch time
		70 dB	The sound of a car passing on the street
	loud	80 dB	Loud music played at home
		90 dB	The sound of a truck passing on the street
	very loud	100 dB	Indoor rock band concert
		110 dB	Operating a chainsaw or jackhammer
	extremely loud	120 dB	Jet plane take-off at 100m away
	threshold of pain	130 dB	
		140 dB	Military jet take-off at 25m away

dB(A)	A-weighted decibel. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in 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 is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies. The dB(C) level is not widely used but has some applications.
Deemed-to-Satisfy Provisions	The Deemed-to-Satisfy Provisions are an optional means of achieving compliance with the mandatory Performance Requirements of the National Construction Code. (also see Alternate Solution)
Diffraction	The distortion of sound waves caused when passing tangentially around solid objects.
DIN	German Standard
Discontinuous Construction	A wall system having a minimum 20mm cavity between two separate leaves, where, for other than masonry there is no mechanical linkage between leaves except at the periphery.
DnT,w	Weighted Standardised Field Level Difference A measure of sound insulation performance of a building element. It is characterised by the difference in noise level on each side of a wall or floor. It is measured in-situ. It is a field measurement that relates to the Rw laboratory measured value but is not equal to it because an in-situ space is not of the same quality as a laboratory space. The value is indicative of the level of speech privacy between spaces. The higher its value the better the insulation performance.
ECRTN	Environmental Criteria for Road Traffic Noise, NSW, 1999
ENMM	Environmental Noise Management Manual, Roads and Maritime Services (Transport for NSW)
EPA	Environment Protection Authority
Field Test	A test of the sound insulation performance in-situ. See also 'Laboratory Test' The sound insulation performance between building spaces can be measured by conducting a field test, for example, early during the construction stage or on completion. A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element accurately as the results can be affected by numerous field conditions.

FIIC	Field Impact Isolation Class. A measure of the noise impact performance of a floor. The value indicates the resistance of the floor to the transmission of impact sound and is measured using a standard tapping machine. It is measured in-situ and is therefore subject to the inherent accuracies involved in such a measurement. The term is defined in ASTM E492 and E1007. It is a field measure of the level of impact sound transmitted to a space via a floor. The equivalent measurement in a laboratory is termed the IIC. The higher the value the better the performance.
Flanking	Flanking is the transfer of sound through paths around a building element rather than through the building element material directly. For example, sound travelling through a gap underneath a door or a gap at the top of a wall.
Fluctuating Noise	Noise that varies continuously to an appreciable extent over the period of observation.
Free-field	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground.
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.
FSTC	Field Sound Transmission Class A measure of the sound insulation performance of a building element. . It is characterised by the difference in noise level on each side of a wall or floor. It is measured in the field and is therefore subject to the inherent inaccuracies involved in such a measurement. The term was referred to in older superseded versions of the Building Code of Australia and has now been replaced with the term DnT,w.
Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Heavy Vehicle	A truck, transporter or other vehicle with a gross weight above a specified level (for example: over 8 tonnes).
IGANRIP	Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects, NSW DEC 2007
IIC	Impact Isolation Class A measure of the noise impact performance of a floor. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from the operation a standard tapping machine placed on the floor. The term is defined in ASTM E492 and E1007. The higher the number the better the performance.
Impact Noise	The noise in a room, caused by impact or collision of an object onto the walls or the floor. Typical sources of impact noise are footsteps on the floor above a tenancy and the slamming of doors on cupboards mounted on the common wall between tenancies.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
INP	NSW Industrial Noise Policy, EPA 1999
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation.
Intertenancy wall	Walls that separate buildings or units within a building. They may provide sound resistance or serve as a fire wall. Synonymous with 'party wall'.
Intrusive noise	Refers to noise that intrudes above the background level by more than 5 dB(A).

ISEPP	State Environmental Planning Policy (Infrastructure), NSW, 2007
ISEPP Guideline	Development Near Rail Corridors and Busy Roads - Interim Guideline, NSW Department of Planning, December 2008
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L10(1hr)	The L10 level measured over a 1 hour period.
L10(18hr)	The arithmetic average of the L10(1hr) levels for the 18 hour period between 6am and 12 midnight on a normal working day.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq or Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time, which would produce the same energy as a fluctuating sound level. When A-weighted, this is written as the LAeq.
LAeq(1hr)	The LAeq noise level for a one-hour period. In the context of the NSW EPA's Road Noise Policy it represents the highest tenth percentile hourly A-weighted Leq during the period 7am to 10pm, or 10pm to 7am (whichever is relevant).
LAeq(8hr)	The LAeq noise level for the period 10pm to 6am.
LAeq(9hr)	The LAeq noise level for the period 10pm to 7am.
LAeq(15hr)	The LAeq noise level for the period 7am to 10pm.
LAeq (24hr)	The LAeq noise level during a 24 hour period, usually from midnight to midnight.
Lmax	The maximum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmax.
Lmin	The minimum sound pressure level measured over a given period. When A-weighted, this is usually written as the LAmin.
Ln,w	Weighted Normalised Impact Sound Pressure Level A measure of the sound level transmitted from impacts on a floor to a tenancy below. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from a standard tapping machine. A lower value indicates a better performing floor.
LnT,w	Weighted Standardised Field Impact Sound Pressure Level As for Ln,w but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The equivalent measurement in a laboratory is the Ln,w. A lower value indicates a better performing floor.
Laboratory Test	The performance of a building element when measured in a laboratory. The sound insulation performance of a building element installed in a building however can differ from its laboratory performance for many reasons including the quality of workmanship, the size and shape of the space in which the measurement is conducted, flanking paths and the specific characteristics of the material used which may vary from batch to batch.
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. That is, the sound of 85 dB is four times or 400% the loudness of a sound of 65 dB.
Microphone	An electro-acoustic transducer which receives an acoustic signal and delivers a corresponding electric signal.
NCA	Noise Catchment Area. An area of study within which the noise environment is substantially similar.
NCG	Noise Criteria Guideline, Roads and Maritime Services (Transport for NSW)

NMG	Noise Mitigation Guideline, Roads and Maritime Services (Transport for NSW)
Noise	Unwanted sound
Normalised	A method of adjusting the measured noise indices in a laboratory so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the Ln,w impact sound pressure level measured in a laboratory is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the sound absorption in the receiving room is set at 10m2. This enables all laboratories to report the same value when measured under slightly different conditions. See also 'Standardised'.
NRC	Noise Reduction Coefficient. A measure of the ability of a material to absorb sound. The NRC is generally a number between 0 and 1 but in some circumstances can be slightly greater than 1 because of absorption at the edges of the material. A material with an NRC rating of 1 absorbs 100% of incoming sound, that is, no sound is reflected back from the material. The NRS is the average of the absorption coefficient measured in the octave bands 250Hz, 500Hz, 1kHz & 2kHz which correspond to the predominant frequencies associated with the human voice.
Partition wall	A wall dividing two rooms.
Party wall	A wall dividing two tenancies. Synonymous with 'Intertenancy Wall'.
Pre-construction	Work in respect of the proposed project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds, or other relevant activities determined to have minimal environmental impact (e.g. minor access roads).
RBL	Rating Background Level is the representative LA90 background noise level for a period, as defined in the NSW EPA's noise ploicies.
Reflection	Sound wave reflected from a solid object obscuring its path.
RING	Rail Infrastructure Noise Guideline, NSW, May 2013
RMS	Root Mean Square value representing the average value of a signal.
Rw	Weighted Sound Reduction Index A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory. The term supersedes the value STC which was used in older versions of the Building Code of Australa. Rw is measured and calculated using the procedure in ISO 717-1. The related field measurement is the DnT,w. The higher the value the better the acoustic performance of the building element.
R'w	Weighted Apparent Sound Reduction Index. As for Rw but measured in-situ and therefore subject to the inherent accuracies involved in such a measurement. The higher the value the better the acoustic performance of the building element.
RNP	Road Noise Policy, NSW, March 2011
Sabine	A measure of the total acoustic absorption provided by a material. It is the product of the Absorption Coefficient (alpha) and the surface area of the material (m2). For example, a material with alpha = 0.65 and a surface area of 8.2m2 would have 0.65 x 8.2 = 5.33 Sabine. Sabine is usually calculated for each individual octave band (or third-octave).
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sole-occupancy Unit	An area within a building for the exclusive use of the owner or occupier.
Sound	A fluctuation of air pressure which is propagated as a wave through air.

Sound absorption	The ability of a material to absorb sound energy by conversion to thermal energy.
Sound Insulation	Sound insulation refers to the ability of a construction or building element to limit noise transmission through the building element. The sound insulation of a material can be described by the Rw and the sound insulation between two rooms can be described by the DnT,w.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 pico watt.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone referenced to 20 mico Pascal.
Spoil	Soil or materials arising from excavation activities.
Standardised	A method of adjusting the measured noise indices in-situ so that they are independent of the measuring space. The noise level in a room is affected by reverberation in the room. For example, the L'n,w impact sound pressure level measured in a room is dependent upon the amount of absorptive material in the receiving room. The value is adjusted to what would be measured if the reverberation time in the receiving room is set at 0.5 seconds. This enables the same value to be reported independent of whether the room contains carpet and furnishings and the like. See also 'Normalised'.
STC	Sound Transmission Class A measure of the sound insulation performance of a building element. It is measured in controlled conditions in a laboratory. The term has been superseded by Rw.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'Impact Noise'.
Tonal Noise	Sound containing a prominent frequency and characterised by a definite pitch.
Transmission Loss	The sound level difference between one room or area and another, usually of sound transmitted through an intervening partition or wall. Also the vibration level difference between one point and another. For example, if the sound level on one side of a wall is 100dB and 65dB on the other side, it is said that the transmission loss of the wall is 35dB. If the transmission loss is normalised or standardised, it then becomes the Rw or R'w or DnT,w.

A.2 Glossary of terminology - Vibration

The following is a brief description of the technical terms used specifically to describe vibration and to assist in understanding the technical issues presented.

Acceleration	The rate of change of velocity, often measured in m/s^2 or g's. 1 g = 9.81 m/s^2. Commonly used to assess human response to vibration and for machine condition monitoring.
Accelerometer	A vibration transducer sensor that is used to measure acceleration.
ANC	The Association of Noise Consultants, UK.
Ambient vibration	The all-encompassing vibration occurring at a given location, at a given time, composed of all vibration sources near and far.

Amplification	Vibration amplification refers to an increase in vibration. Amplification may occur due to resonance, when an object or structure is excited at its natural frequency.
Attenuation	Attenuation refers to a reduction in vibration. This may occur due to damping of a vibration system, the inclusion of attenuating devices or, in the case of ground vibration, during propagation through the ground. Ground attenuation is determined by the dynamic properties of the site's soil and rock.
AVTG	Assessing Vibration: A Technical Guideline. NSW Department of Environment and Conservation's (DEC) 2006 guideline for assessing human responses to vibration. Based on BS 6472–1992.
Axis	A fixed reference line for the measurement for the measurement of vibration in a particular direction. Vibration is commonly measured in transverse (T), longitudinal (L) and vertical (V) axes (or X, Y and Z).
Background vibration	The underlying level of vibration present in the ambient environment, measured in the absence of the vibration sources of interest.
Blasting	Excavation or demolition using explosives.
Borehole transducer	A geophone transducer rigidly mounted at the bottom of a borehole (either permanently or temporarily) to measure underground vibration.
Broadband vibration	The overall vibration level which encompasses a wide range of frequencies. As opposed to vibration levels for specific frequency bands (see Octave) or narrowband vibration levels as produced by FFT.
BS	British Standard.
Continuous vibration	Vibration that continues uninterrupted over a defined period.
Cosmetic damage	Damage to a structure due to vibration that only affects the appearance of the structure and can be easily repaired, e.g. hairline cracks in mortar joints of brick or concrete constructions, or cracks in plasterwork.
Coupling loss	The change in vibration level when vibration is transmitted from the ground to a building's foundations.
Crest factor	The ratio of the peak value of a vibration event to the RMS value of a vibration event.
Damping	Reduction of vibrational energy due to friction or other forces.
DEC	NSW Department of Environment and Conservation, now the Department of Planning, Industry and Environment.
Decibel [dB]	The logarithmic unit used to represent sound and vibration levels. A vibration level in dB equals 20 times the logarithm to the base 10 of the ratio of the vibration level relative to the reference level. For vibration velocity, the reference level is commonly 1 nm/s. For vibration acceleration, the reference level is commonly 1 $\mu m/s^2$. Other reference values are commonly used. The reference value should always be stated.
DIN	German Standard.
Displacement	Change in position of a body from a reference point. Usually measured in m or mm.
EPA	Environment Protection Authority.
eVDV	Estimated Vibration Dose Value. See also VDV.
Filter	An electrical circuit that allows signals of certain frequency ranges to pass through, and blocks all other frequencies. Types of filters include low pass filters, high pass filters, and band pass filters.
FFT	Fast Fourier Transform. An algorithm that converts a signal from the time domain to the frequency domain.
Frequency	In the case of vibration, frequency is the number of oscillations that occurs per second. Frequency is measured in units of Hertz (Hz).
Geophone	A vibration transducer sensor that is used to measure velocity.

Ground-borne noise	Vibration propagated through the ground and then radiated as noise by vibrating building elements such as wall and floor surfaces. This noise is more noticeable in rooms that are well insulated from other airborne noise. An example would be vibration transmitted from an underground rail line radiating as sound in a bedroom of a building located above.
Ground spike	A metal stake with a flat top that is driven into the ground and used to mount a vibration transducer to measure vibration levels.
Habitable Area	Includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom. Excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.
Intermittent vibration	Either interrupted periods of continuous vibration or repeated periods of impulsive vibration.
Impulsive vibration	Vibration that rapidly builds up to a peak followed by a damped decay. May consist of multiple impulsive events, typically less then 2 seconds in duration.
Isolation	The process of reducing the vibrational energy transmitted to an object, such as a piece of equipment or building, from the source of vibrations.
Minor damage	Damage to a structure due to vibration that affects the serviceability of residential style buildings or other sensitive structures but does not affect the structural elements. E.g. cracks in plastered or rendered surfaces, existing cracks enlarged or partitions detached.
Mode	A mode of vibration is a characteristic pattern or shape in which a mechanical system will vibrate. The actual vibration of a structure is a combination of all the vibration modes, but to varying degrees, depending on the vibration source.
Natural frequency	The frequency at which a system tends to oscillate in the absence of any driving or damping force.
Noise floor	The residual level of unwanted signal measured by an instrumentation system. The signal of interest must be above the noise floor to be measured accurately. See also Signal to noise ratio.
Octave	An octave represents a doubling or halving in frequency. Noise or vibration levels across a frequency spectrum are commonly given in octave or one-third octave frequency bands.
Peak-to-peak	The difference between the highest positive peak level and the lowest negative peak of a vibration event.
Peak vibration velocity	The absolute maximum value of the vibration velocity signal measured in the X, Y or Z axis during a given time interval. Also referred to as the peak component particle velocity.
PPV	Peak Particle Velocity. The absolute maximum value of the vibration velocity signal measured in any axis during a given time interval.
PVS	Peak Vector Sum. The vector sum of the peak vibration velocities measured in the three orthogonal axes.
Resonance	The phenomenon of increased amplitude that occurs when the frequency of an applied force is equal or close to the natural frequency of the system.
RMS	Root Mean Square value representing the average value of a signal.
Sampling rate	The number of samples per second taken from a continuous signal to make a discrete or digital signal. Measured in Hertz. To accurately record the signal and determine the spectrum, the sampling rate must two or more times the maximum frequency of interest.
Settlement	The movement of soil due to vibration or other forces, often in relation to a building's foundations. The indirect effect of settlement and ground movement may cause building damage, separately from the direct of effect of building vibration.
Signal to noise ratio	A ratio of the level of a desired signal to the level of the background, often expressed in decibels.
Source vibration	A source that generates vibration. Can be quantified by the amplitude, frequency content and duration of the vibration. Common sources of vibration include rail and road traffic, construction and demolition activities and blasting.
Spectrum	The result of transforming a signal from the time domain to the frequency domain.

Structural damage	Damage to a structure due to vibration that may affect its serviceability due to damage to structural elements. May result in the reduced stability of the building and/or reduction in load-bearing capacities.
Structural fatigue	The weakening of a material caused by cyclic loading that results in progressive and localised structural damage and the growth of cracks.
Structure-borne Noise	Audible noise generated by vibration induced in the ground and/or a structure. Vibration can be generated by impact or by solid contact with a vibrating machine. Structure-borne noise cannot be attenuated by barriers or walls but requires the isolation of the vibration source itself. This can be achieved using a resilient element placed between the vibration source and its support such as rubber, neoprene or springs or by physical separation (using an air gap for example). Examples of structure-borne noise include the noise of trains in underground tunnels heard to a listener above the ground, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft.
Tactile vibration	Vibration of a level that can be felt by humans, dependant on the amplitude and frequency of the source. Note that vibration may also be perceived through indirect effects such as ground-borne noise or the shaking of building elements.
Transducer	A device that converts energy from one form to another. Vibration transducers convert either acceleration, velocity or displacement to an electrical signal that is processed by the monitoring system.
Triaxial	Three axes. Measurement systems often consist of three vibration transducers arranged triaxially – oriented at 90° from each other.
VDV	Vibration Dose Value. A measure of tactile vibration levels used to assess intermittent vibration.
Velocity	The rate of change of vibration displacement, usually measured in mm/s.
Vibration	A mechanical phenomenon whereby oscillations occur about an equilibrium point; a periodic back-and-forth motion of an elastic body or medium, commonly resulting when almost any physical system is displaced from its equilibrium condition.
Vrms	Root mean square (RMS) vibration level for the train passby, typically expressed in mm/s
Waveform	A graphical representation of a vibration event in the time domain, showing the measured vibration levels for each sample.

APPENDIX B Long-term noise monitoring graphs

Noise Logger Report

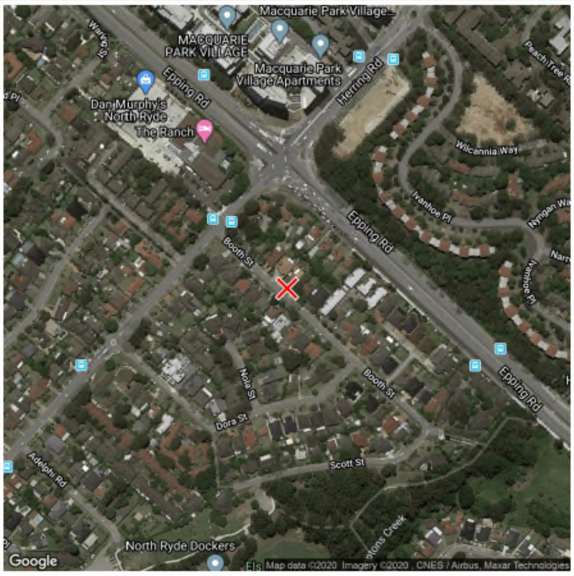
7 Booth Street, Marsfield

Item	Information
Logger Type	Svan 957
Serial number	23855
Address	7 Booth Street, Marsfield
Location	Front yard
Facade / Free Field	Free field
Environment	Dominated by road traffic noise hum to north/north east. Ambient noise controlled by plane and local traffic pass by and some vehicles along Epping road to the north and herring road. Plane pass by frequent. Local car pass by ~ 64 dB(A). Sunny, no to very slight wind, some clouds. Birds calling.

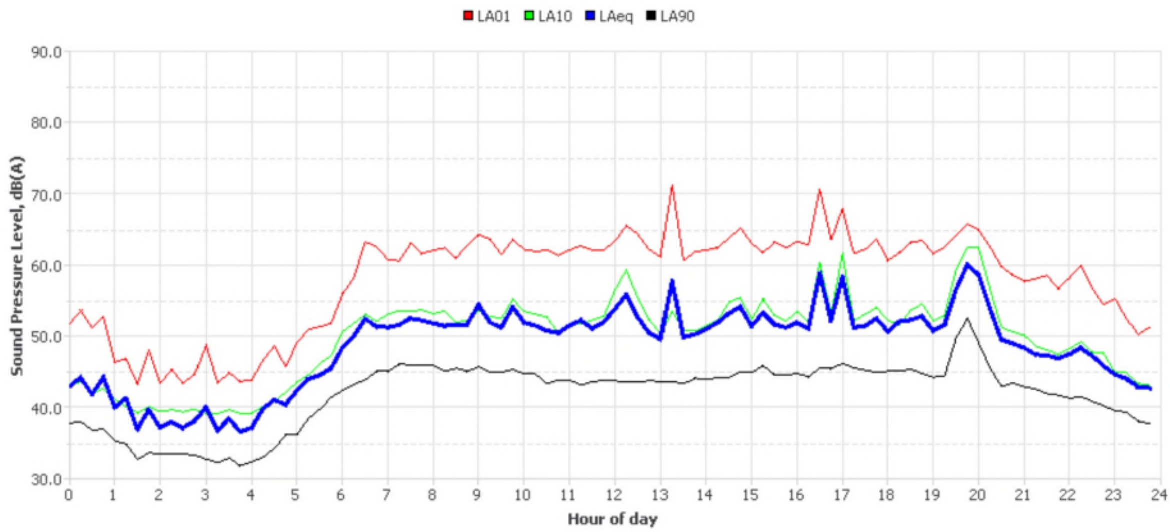
Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Tue Mar 10 2020	60	54	52	-	42	-	56	52
Wed Mar 11 2020	55	55	47	42	42	32	55	47
Thu Mar 12 2020	53	51	45	-	41	34	53	45
Fri Mar 13 2020	52	51	51	41	41	33	52	51
Sat Mar 14 2020	53	52	47	-	42	34	53	47
Sun Mar 15 2020	54	53	45	-	41	32	54	45
Mon Mar 16 2020	56	52	46	46	44	33	55	46
Tue Mar 17 2020	55	62	45	42	42	29	58	45
Wed Mar 18 2020	55	52	45	42	41	34	54	45
Thu Mar 19 2020	-	-	44	-	-	-	-	44
Summary	**55**	**56**	**47**	**42**	**42**	**33**	**55**	**47**

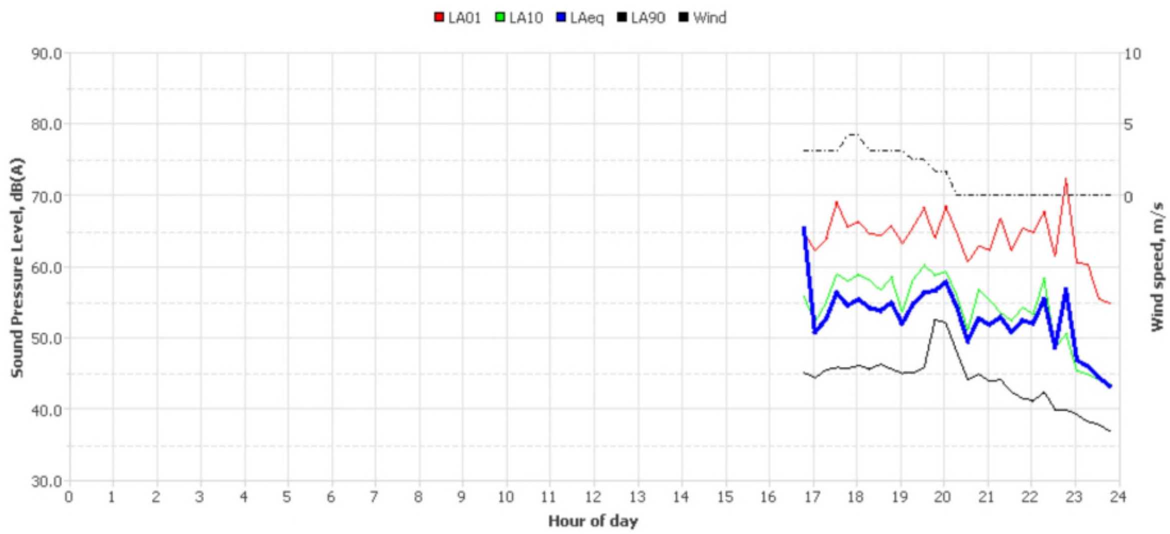
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

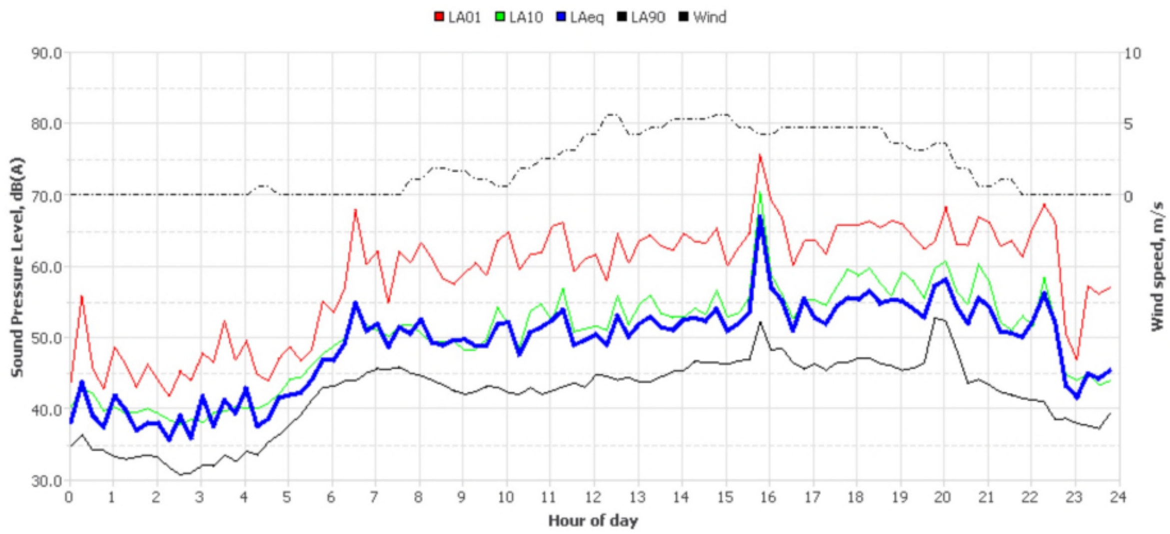
Typical Day



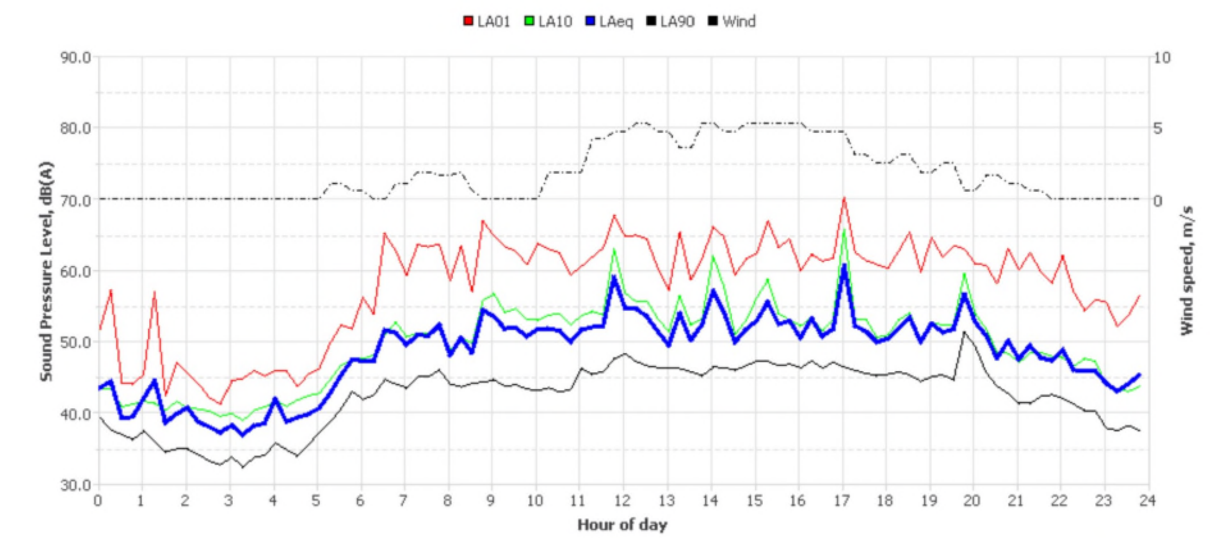
Tuesday, 10 Mar 2020



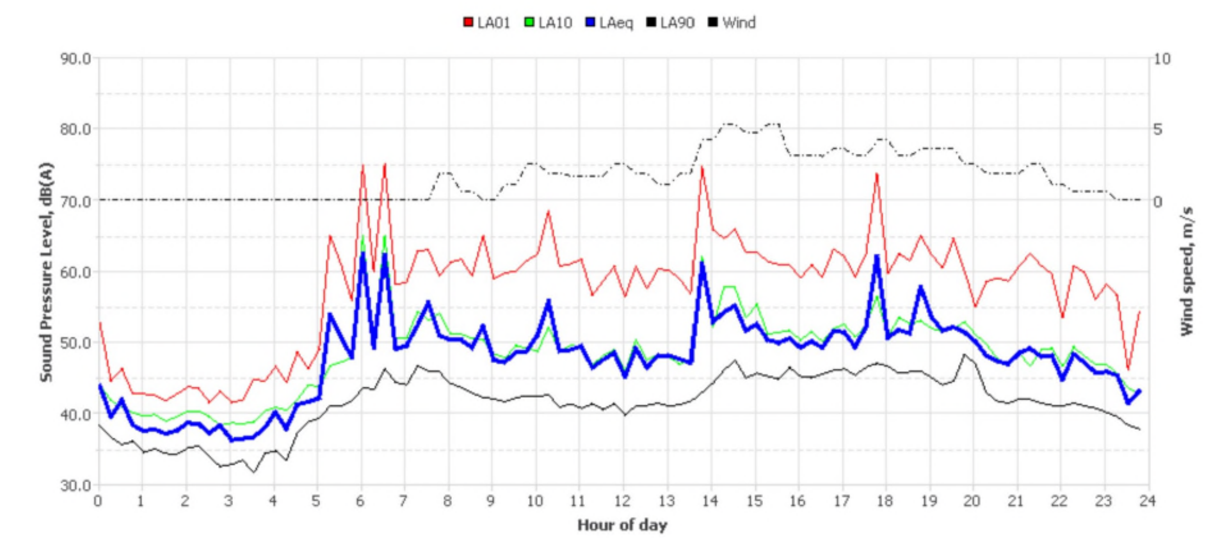
Wednesday, 11 Mar 2020



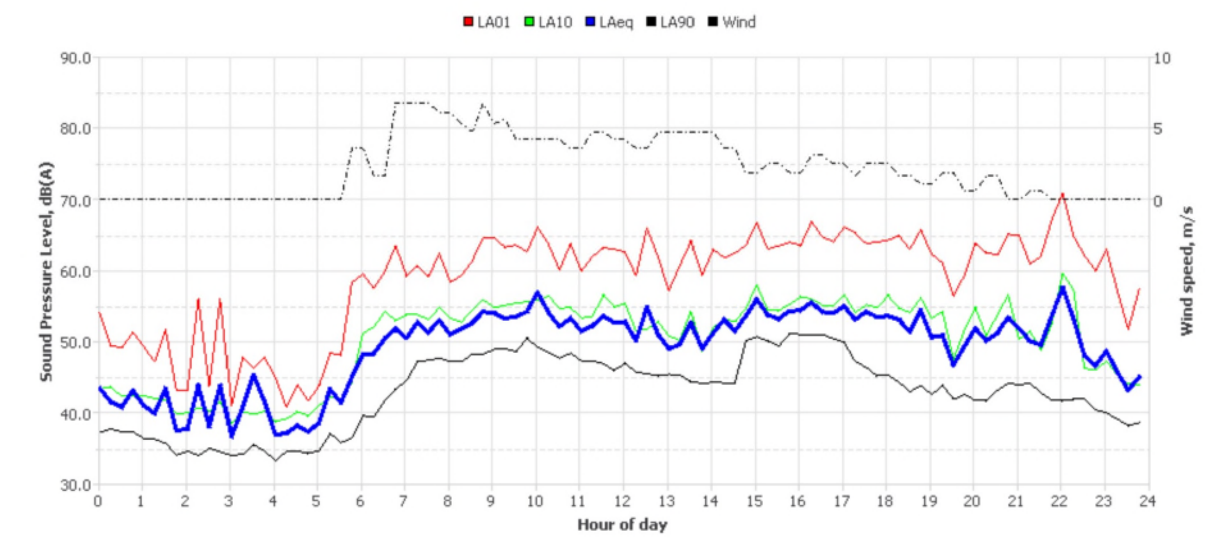
Thursday, 12 Mar 2020



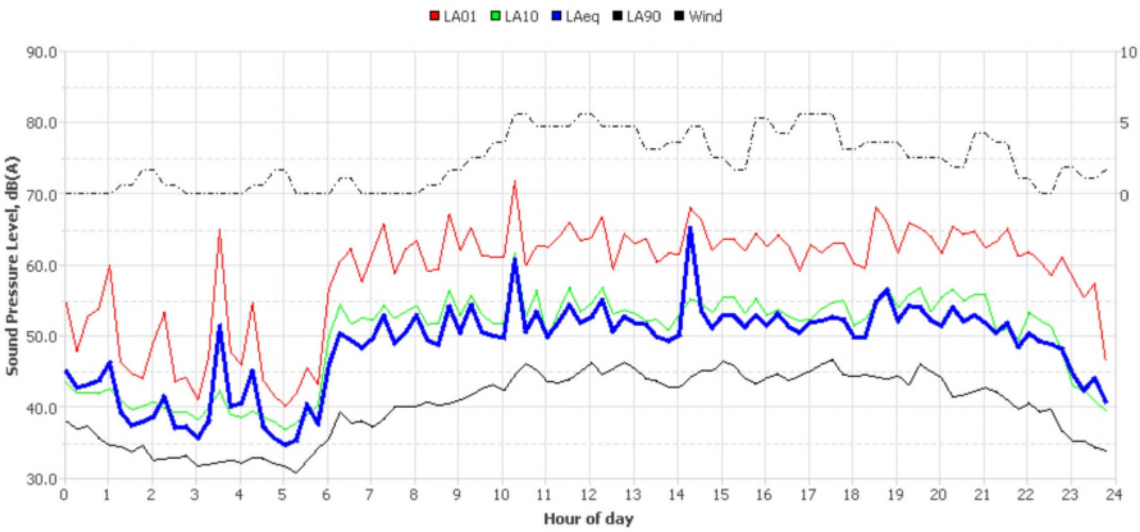
Friday, 13 Mar 2020



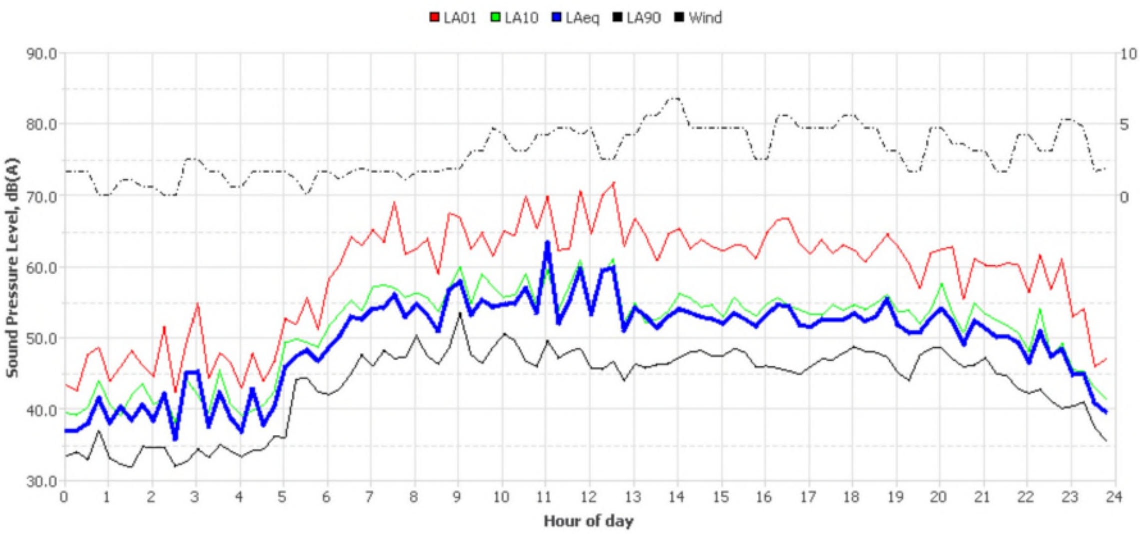
Saturday, 14 Mar 2020



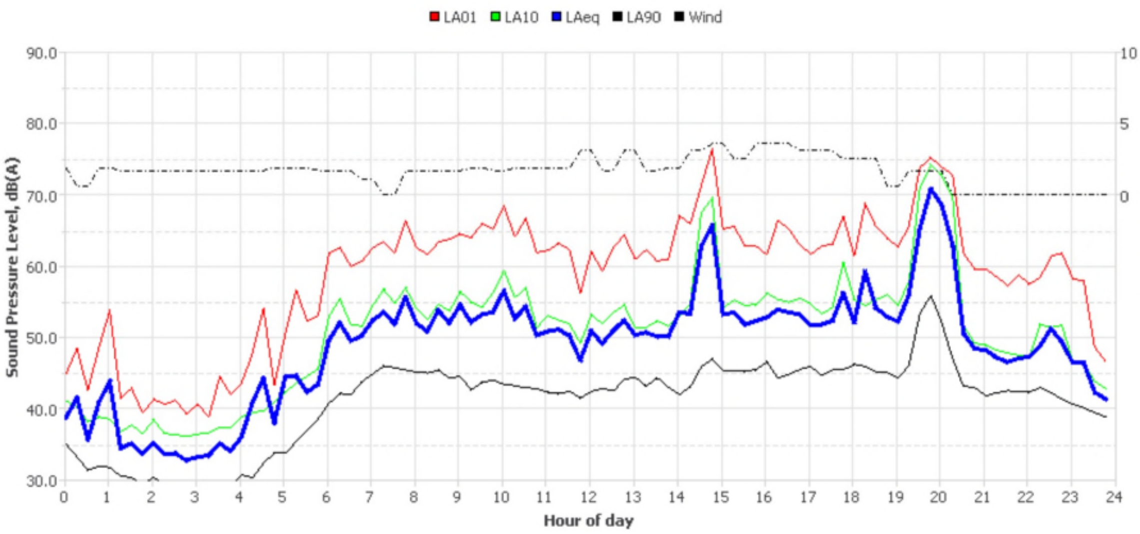
Sunday, 15 Mar 2020



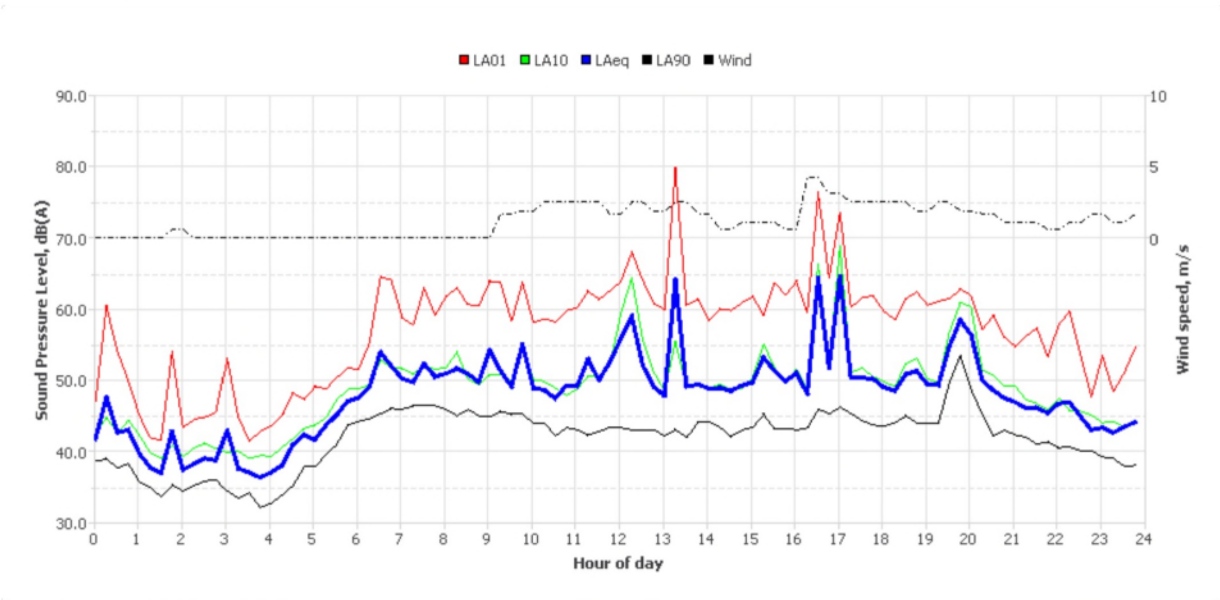
Monday, 16 Mar 2020



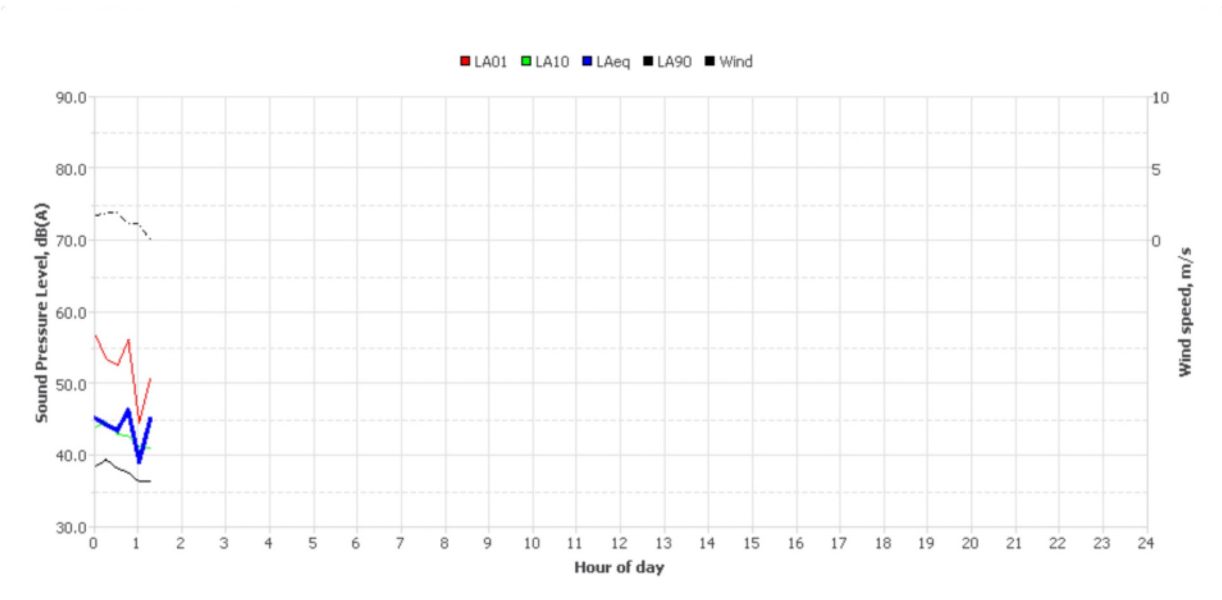
Tuesday, 17 Mar 2020



Wednesday, 18 Mar 2020



Thursday, 19 Mar 2020



RENZO TONIN & ASSOCIATES
inspired to achieve

Acoustics
Vibration
Structural Dynamics

Monitoring ID: Location L2

Address: 82 Waterloo Road, Macquarie Park

Description: The monitor was located in the free field near the northern boundary facing Waterloo Road. The microphone was located 1.5 metres above ground level

Background & Ambient Noise Monitoring Results						
	L_{A90} Background Noise Levels			L_{Aeq} Ambient Noise Levels		
Date	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Representative Week[4]	52	48	40	61	60	54

Notes:
1. Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
2. Evening: 18:00-22:00 Monday to Sunday & Public Holidays
3. Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays
4. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}

Logger location photograph

Logger location map

82 Waterloo Road, Macquarie Park - Northern Boundary

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

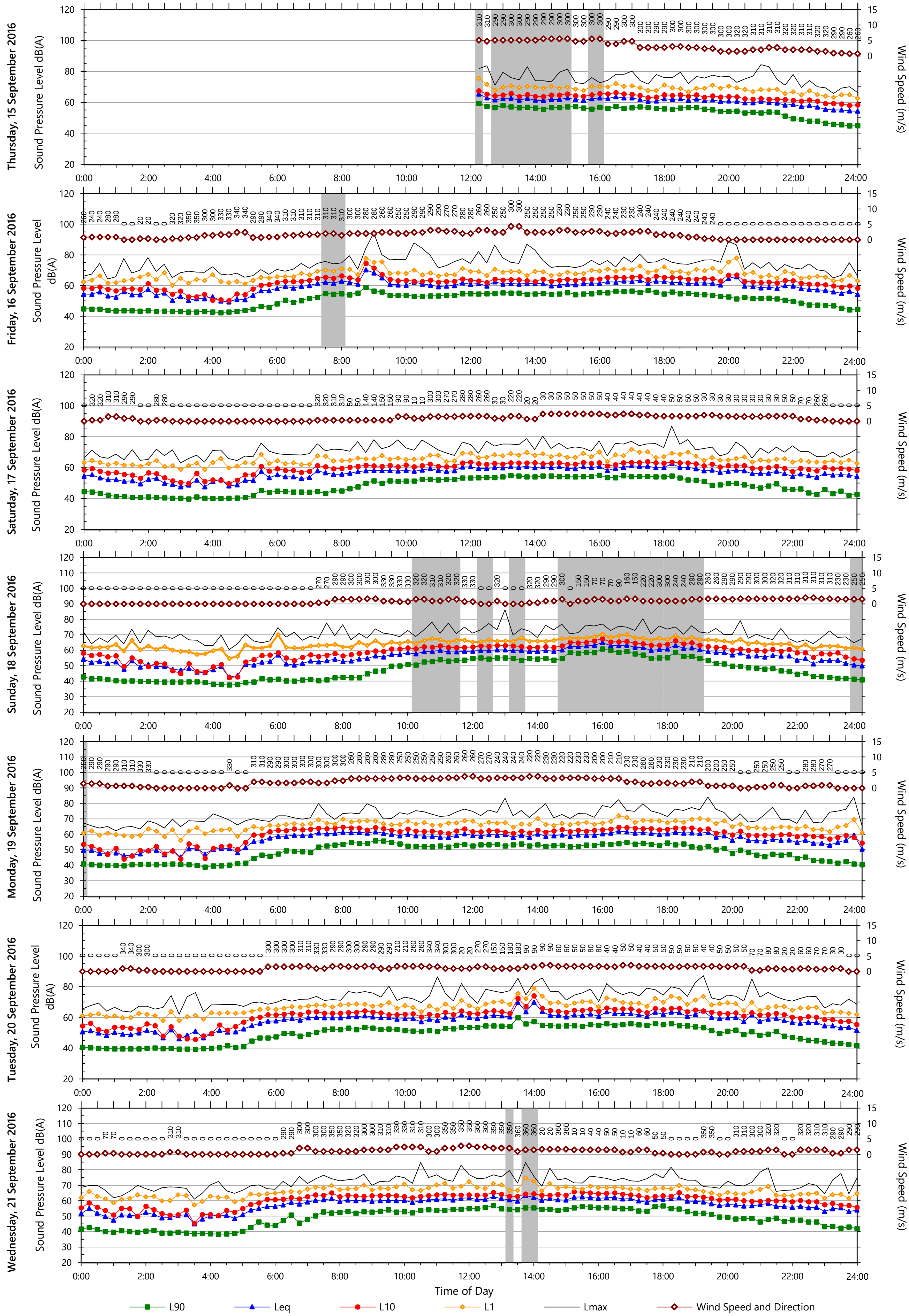
Periods with insufficient results excluded	L_{A90} Background Noise Levels[4]			L_{Aeq} Ambient Noise Levels		
Date	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Thursday-15-September-2016	-	52	43	-	61	56
Friday-16-September-2016	53	51	40	63	62	54
Saturday-17-September-2016	47	47	39	59	58	52
Sunday-18-September-2016	-	-	40	-	-	54
Monday-19-September-2016	52	46	40	60	59	54
Tuesday-20-September-2016	51	48	39	62	61	54
Wednesday-21-September-2016	53	47	39	61	58	55
Thursday-22-September-2016	-	-	-	-	-	-
Representative Weekday[5]	**52**	**48**	**40**	**62**	**60**	**55**
Representative Weekend[5]	**47**	**47**	**39**	**59**	**58**	**53**
Representative Week[5]	**52**	**48**	**40**	**61**	**60**	**54**

Notes:

1. Day is 7:00am to 6:00pm on all days except Sundays and Public Holidays when it is 8:00am to 6:00pm 2. Evening is 6:00pm to 10:00pm 3. Night is the remaining periods 4. Assessment Background Level (ABL) for individual days 5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq} 6. Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade 7. Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

Unattended Monitoring Results

Location: 82 Waterloo Road, Macquarie Park - Northern Boundary

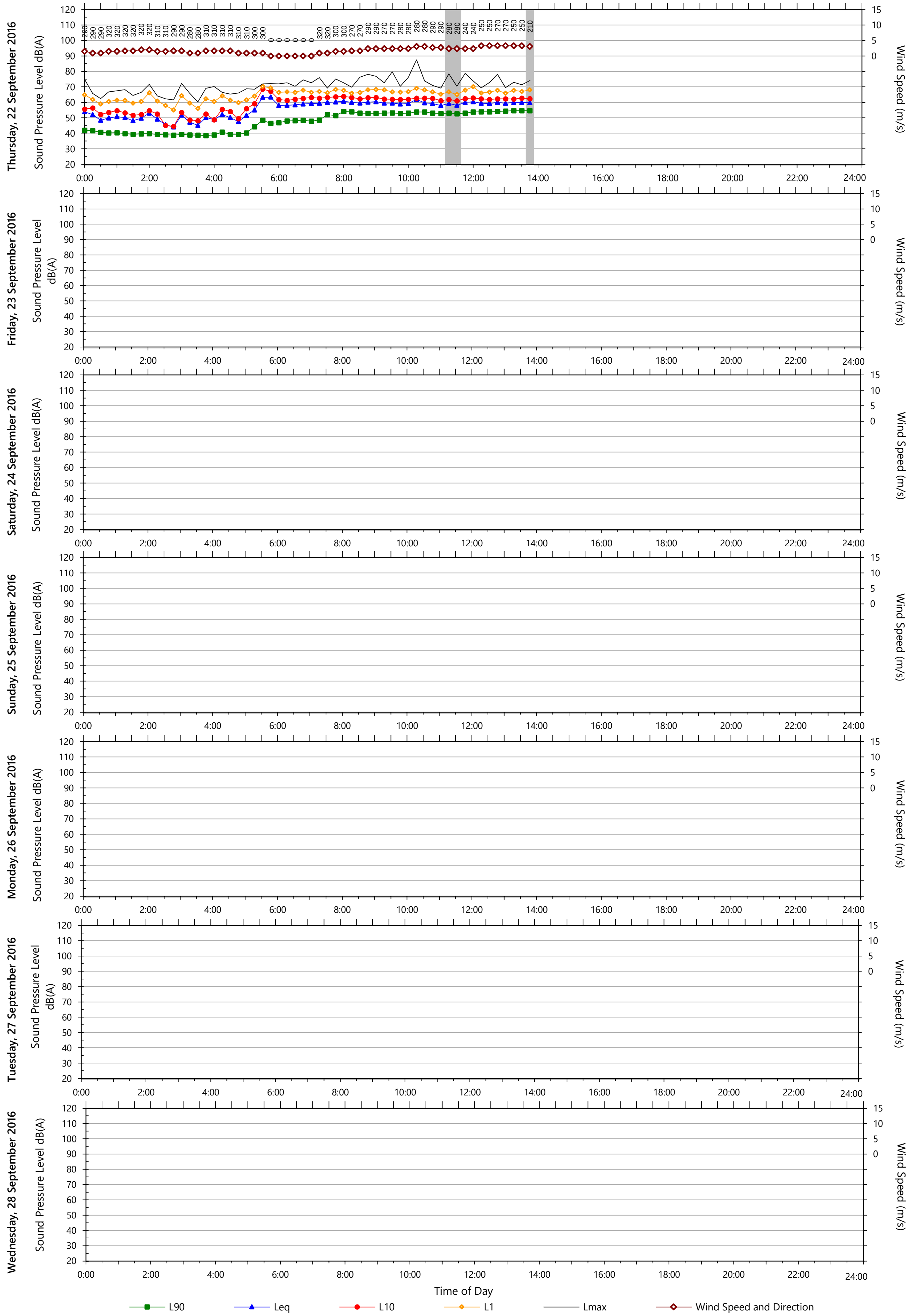


Data File: 2016-09-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r36)

Unattended Monitoring Results

Location: 82 Waterloo Road, Macquarie Park - Northern Boundary



Data File: 2016-09-15_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r36)

Noise Logger Report

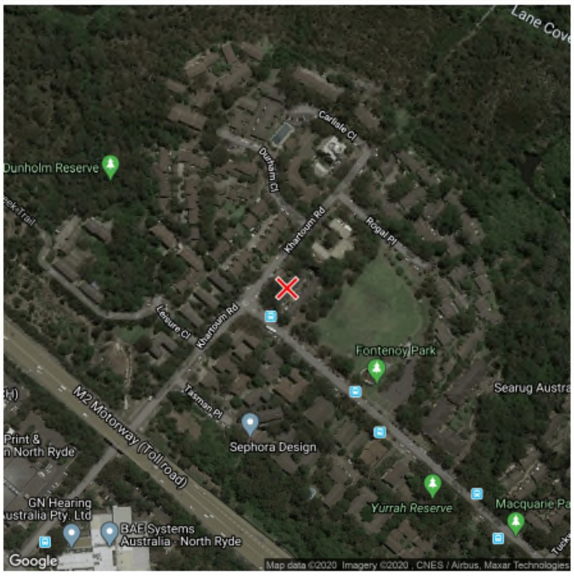
Unit 6, 37 Khartoum Road, Macquarie Park

Item	Information
Logger Type	Svan 977
Serial number	45416
Address	Unit 6, 37 Khartoum Road, Macquarie Park
Location	Front yard
Facade / Free Field	Free Field
Environment	Background controlled by environment. Noise environment dominated by road traffic noise to west along Khartoum road. Car pass by 58-62 dB(A). Minimal to little breeze, sunny, some clouds. Birds calling, trucks can be heard in distance.

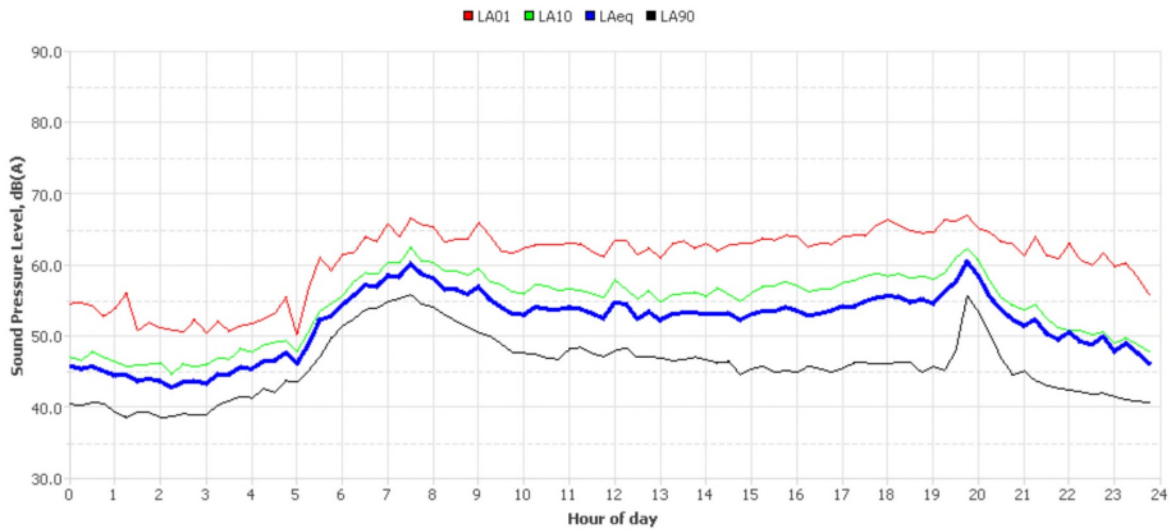
Measured noise levels

Logging Date	L_{Aeq} Day	Eve	Night	ABL Day	Eve	Night	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
Tue Mar 10 2020	56	58	53	-	46	-	58	53
Wed Mar 11 2020	56	58	50	45	46	37	57	50
Thu Mar 12 2020	56	56	52	45	46	38	56	52
Fri Mar 13 2020	60	54	49	45	43	40	59	49
Sat Mar 14 2020	59	57	50	50	46	38	59	50
Sun Mar 15 2020	57	57	51	46	44	38	57	51
Mon Mar 16 2020	59	59	52	48	45	37	59	52
Tue Mar 17 2020	58	66	51	46	43	36	62	51
Wed Mar 18 2020	53	55	50	44	43	39	54	50
Thu Mar 19 2020	55	54	50	44	42	38	55	50
Fri Mar 20 2020	55	-	50	-	-	-	55	50
Summary	**57**	**59**	**51**	**45**	**45**	**38**	**58**	**51**

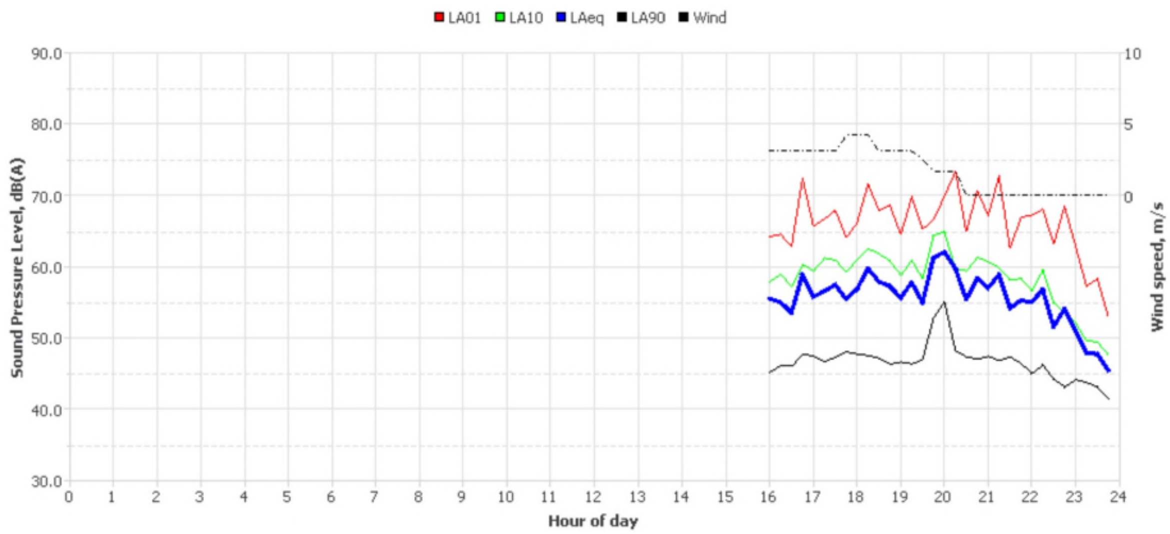
Note: Results denoted with '-' do not contain enough valid data for a value to be calculated. The data has been excluded either manually or automatically as a result of adverse weather conditions.

Logger Location	Logger Deployment Photo
	

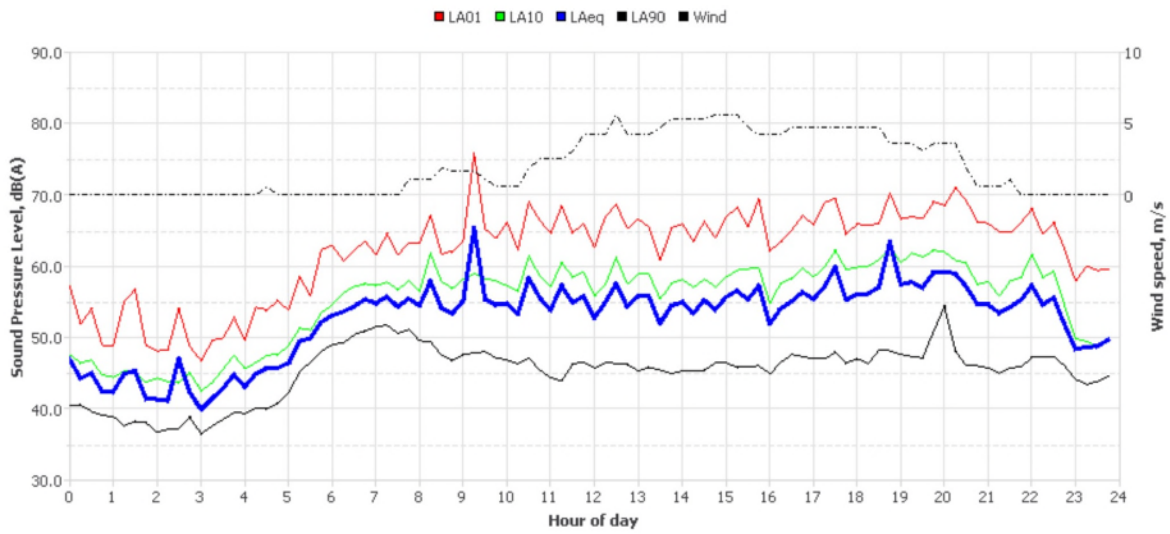
Typical Day



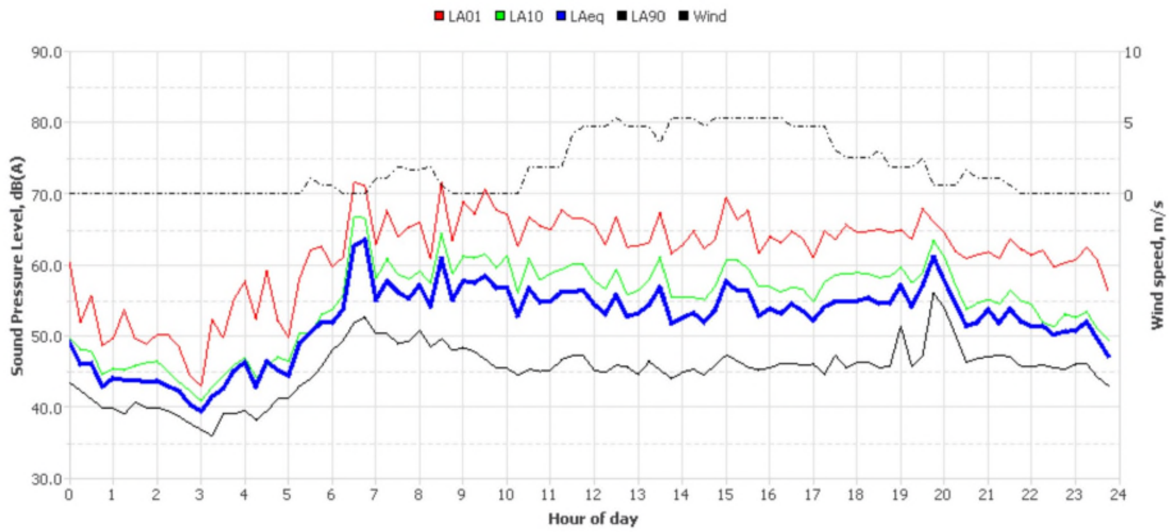
Tuesday, 10 Mar 2020



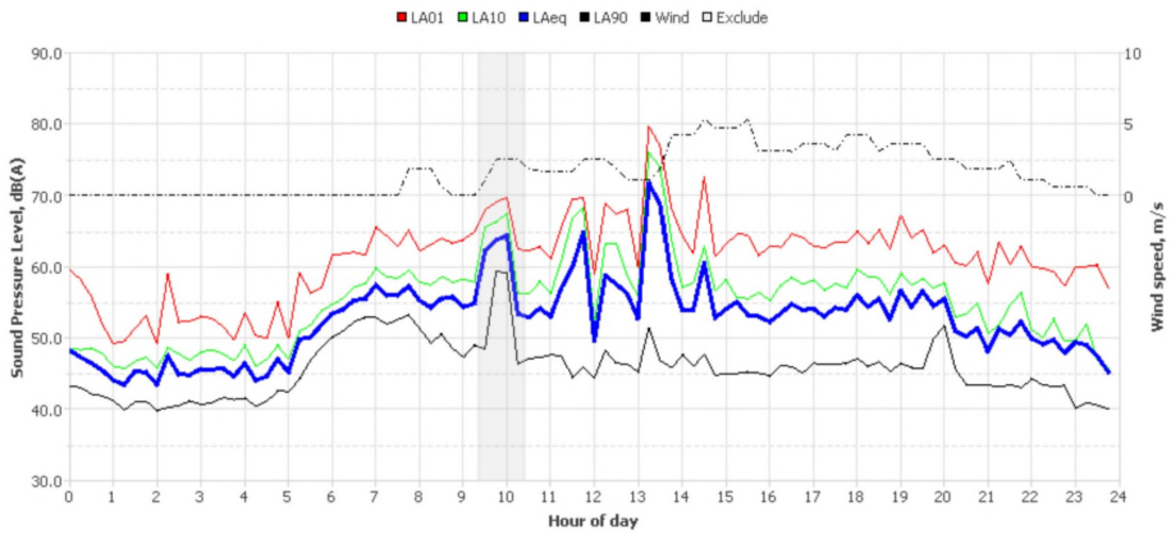
Wednesday, 11 Mar 2020



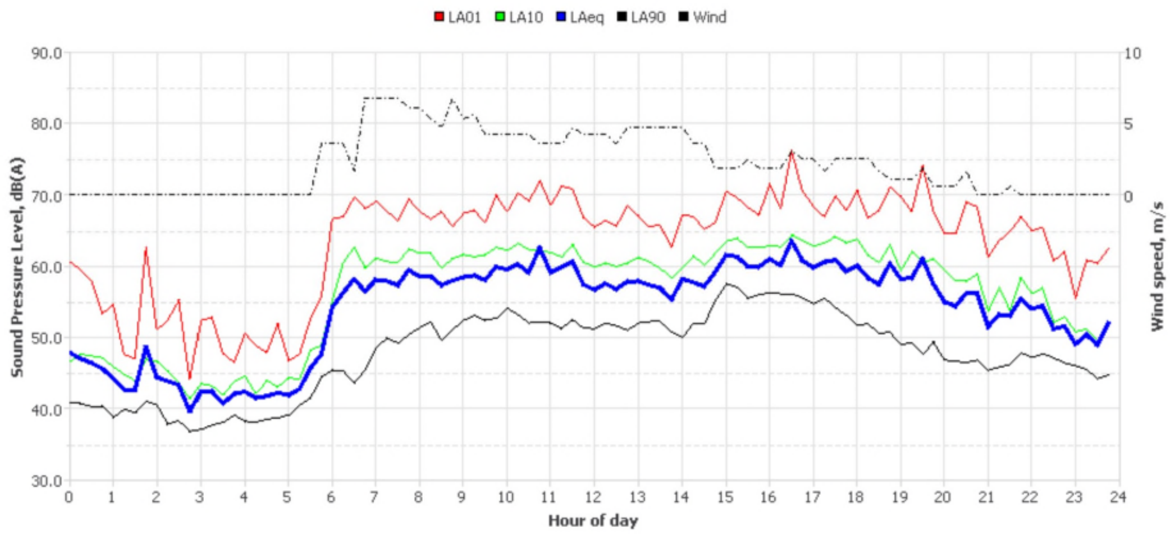
Thursday, 12 Mar 2020



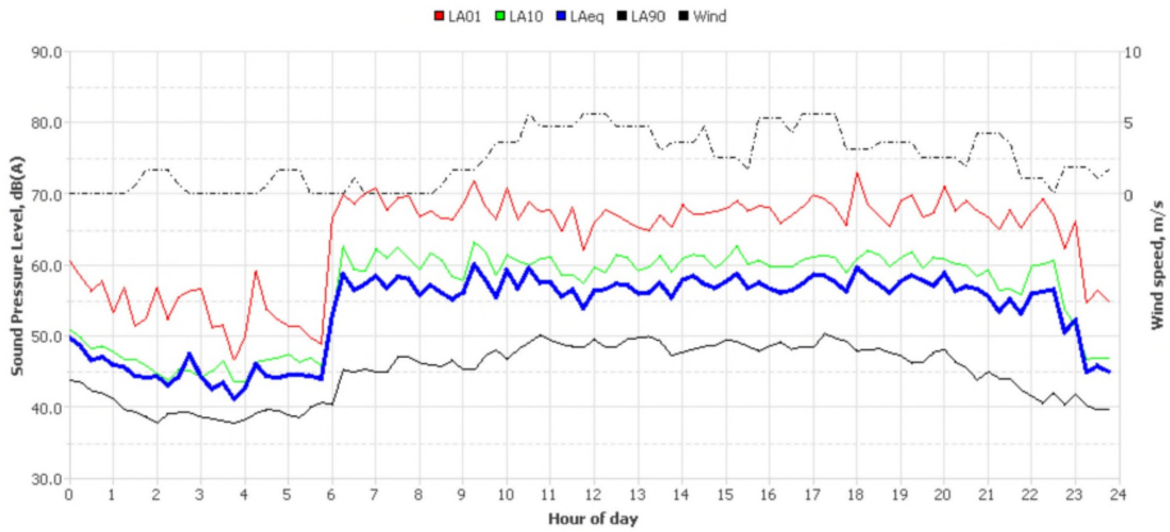
Friday, 13 Mar 2020



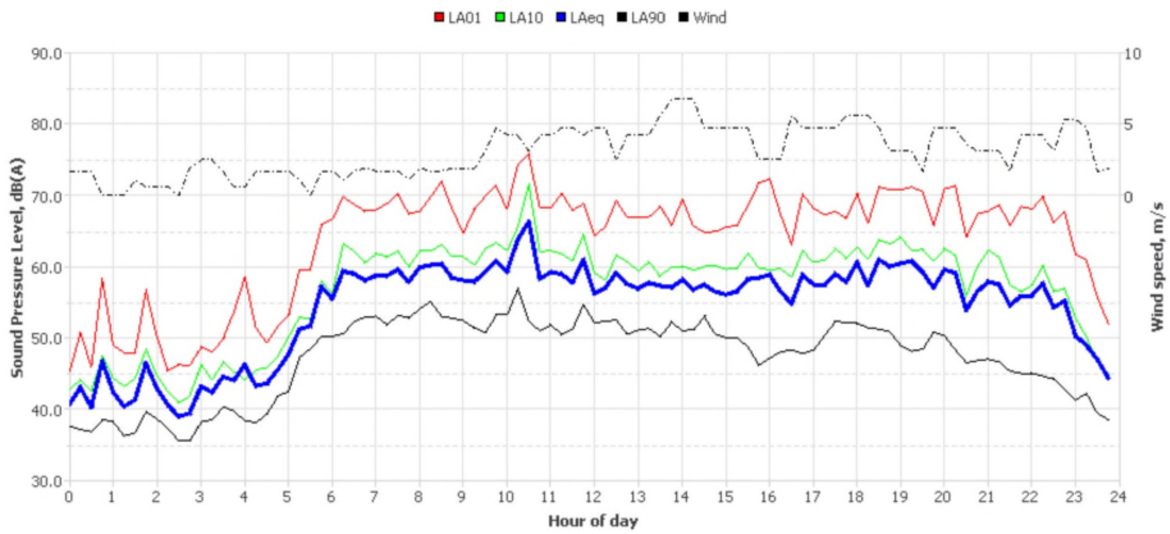
Saturday, 14 Mar 2020



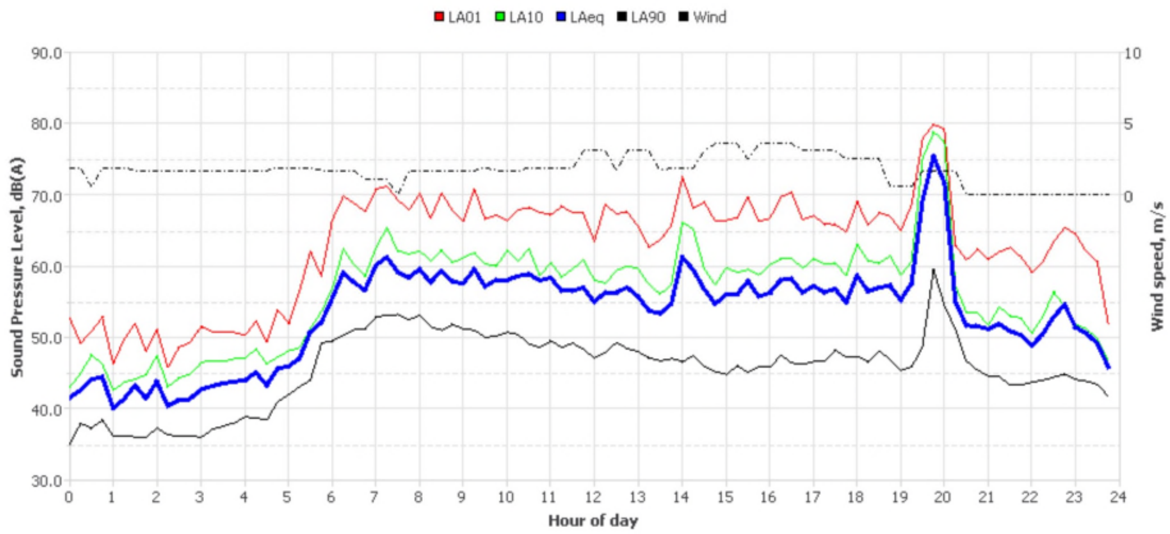
Sunday, 15 Mar 2020



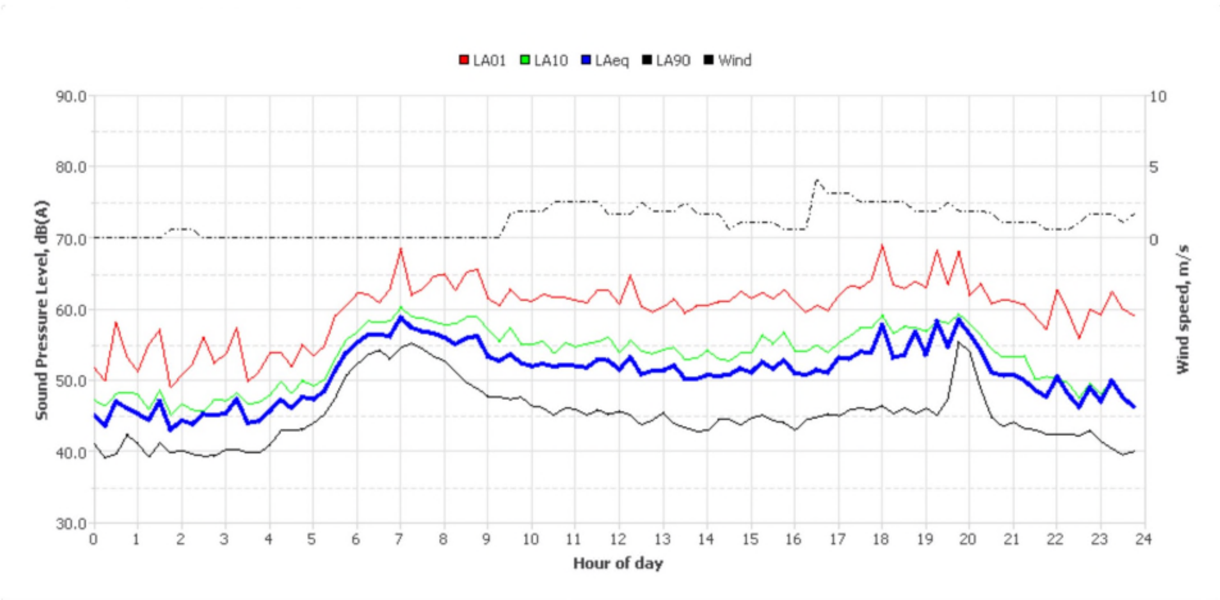
Monday, 16 Mar 2020



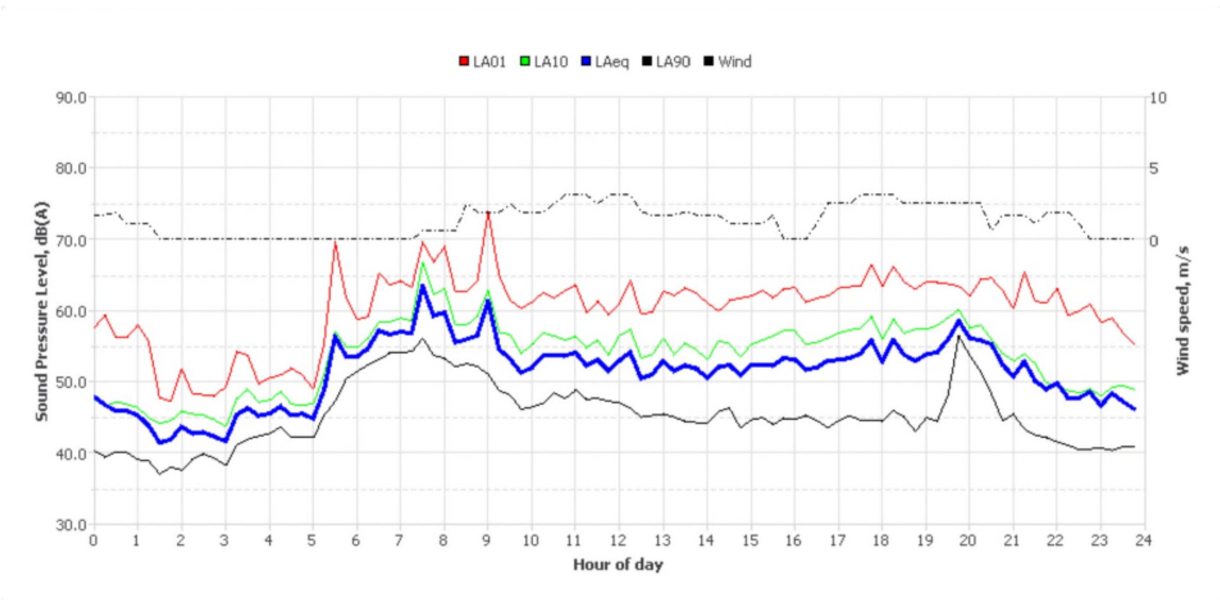
Tuesday, 17 Mar 2020



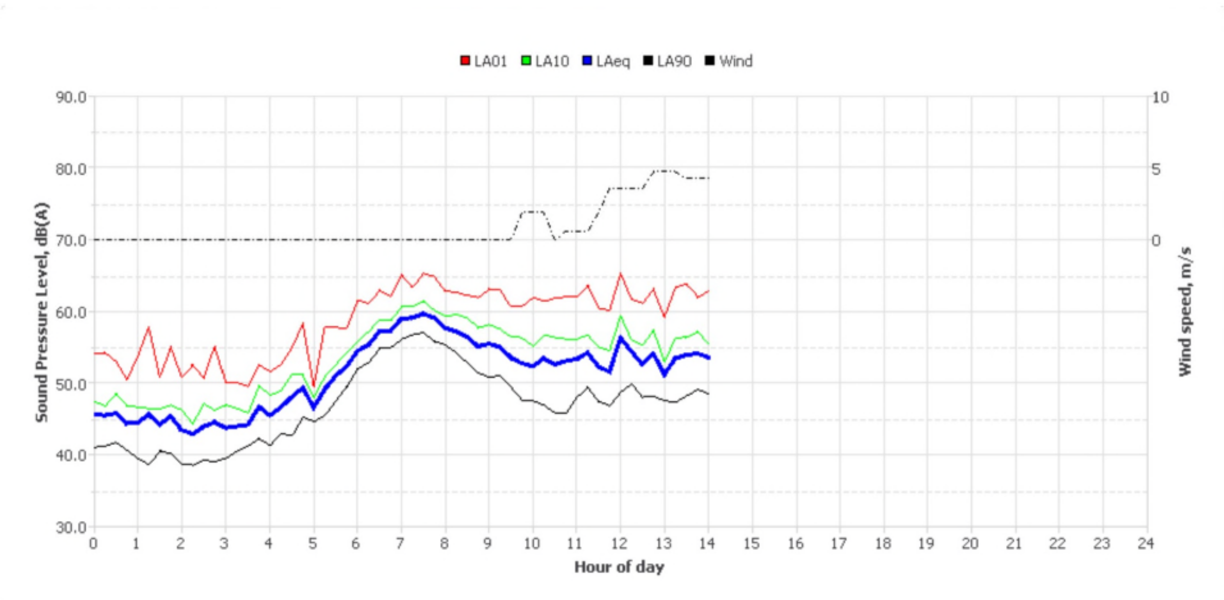
Wednesday, 18 Mar 2020



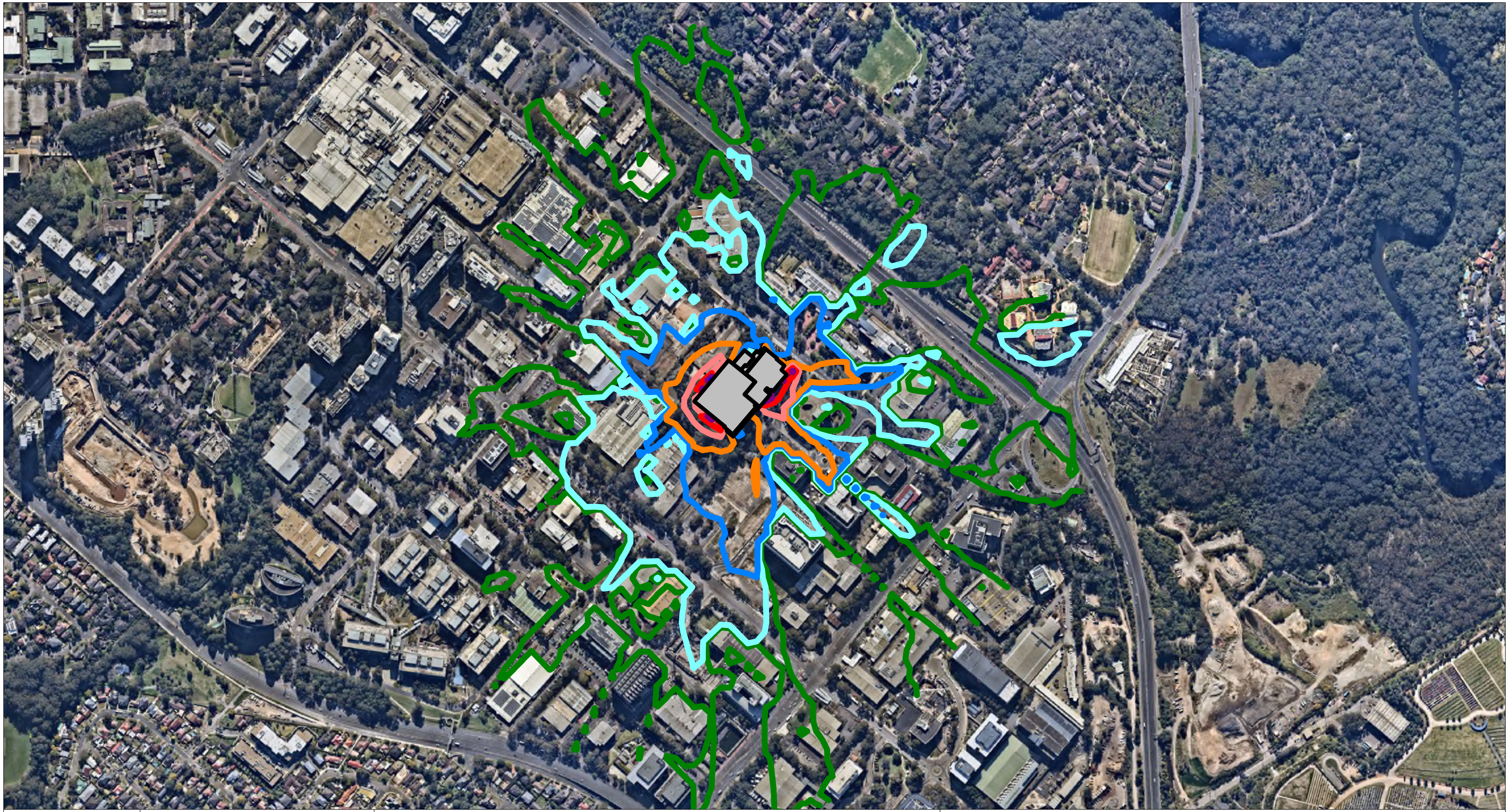
Thursday, 19 Mar 2020



Friday, 20 Mar 2020



APPENDIX C Operational noise contours



Noise Levels

- 35.0 <= ... < 40.0
- 40.0 <= ... < 45.0
- 45.0 <= ... < 50.0
- 50.0 <= ... < 55.0
- 55.0 <= ... < 60.0
- 60.0 <= ... < 65.0
- 65.0 <= ... < 70.0
- 70.0 <= ... < 75.0

Client:
Macquarie Data Centres

Project:
IC3w
17-23 Talavera Road,
Macquarie Park

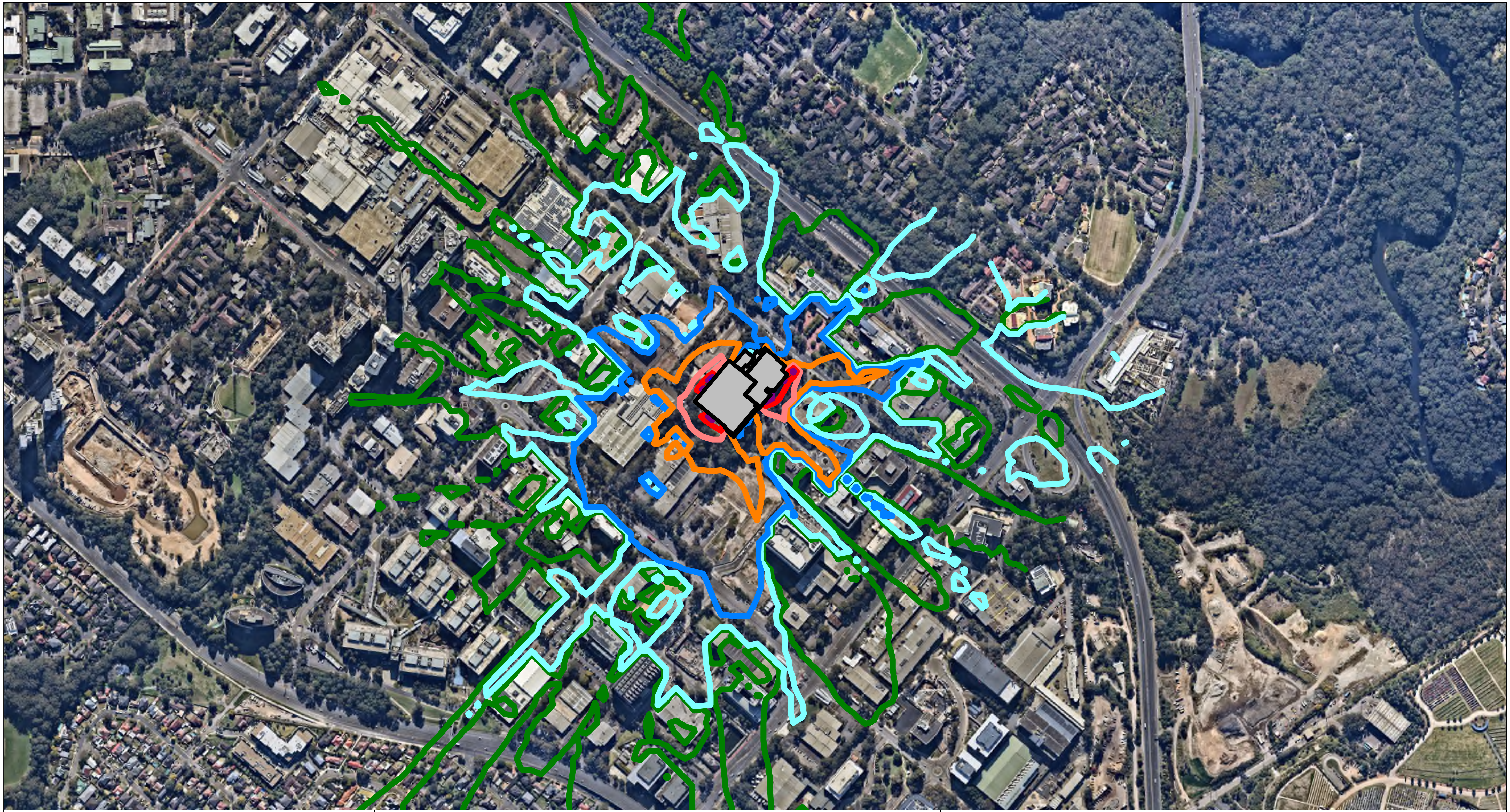
Description:
Normal Operation
Predicted LAeq 15-minute noise contour @ 1.5m NPfI assessment height
Noise-enhancing meteorological conditions

Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
Acoustics, Vibration & Structural Dynamics
Sydney Melbourne Brisbane Kuwait
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Noise levels are approximate due to interpolation of contours and should be used for reference only.

For information only and not for construction.

Project No.: TM162-01	Produced by: BC
Figure Ref: TM162-01F01 Normal (r0)	Grid: G1_Normal_LAeq_1_5m (r0).cnr
Date: 2021.09.02	Scale: 1: 6500 A3



Noise Levels

- 35.0
- 40.0
- 45.0
- 50.0
- 55.0
- 60.0
- 65.0
- 70.0
- 75.0

Client:
Macquarie Data Centres

Project:
IC3w
17-23 Talavera Road,
Macquarie Park

Description:
Generator Maintenance Testing
Predicted LAeq 15-minute noise contour @ 1.5m NPfI assessment height
Noise-enhancing meteorological conditions

Consultant:
RENZO TONIN & ASSOCIATES
inspired to achieve
Acoustics, Vibration & Structural Dynamics
Sydney Melbourne Brisbane Kuwait
1/418A Elizabeth Street, SURRY HILLS NSW 2010
P: 02 8218 0500 F: 02 8218 0501

Noise levels are approximate due to interpolation of contours and should be used for reference only.

For information only and not for construction.

Project No.: TM162-01	Produced by: BC
Figure Ref: TM162-01F02 Gen Test (r0)	Grid: G2_Gen_Test_LAeq_1_5m (r0).cnr
Date: 2021.09.02	Scale: 1: 6500 A3