

85-97 WATERLOO ROAD, MACQUARIE PARK BTR HOUSING

85-97 WATERLOO ROAD, MACQUARIE PARK, NSW

NOISE AND VIBRATION IMPACT ASSESSMENT

RWDI # 2305660

27 June 2024

SUBMITTED TO

James Crouch

Head of Project Delivery, Redevelopment
James.Crouch@goodman.com

Goodman

The Hayesbery,
1-11 Hayes Road,
Rosebery NSW, 2018

SUBMITTED BY

Remi Larmandieu

Senior Engineer
remi.larmandieu@rwdi.com

John Wassermann

Senior Technical Director
john.wassermann@rwdi.com

Henry Kuo

Project Manager
Henry.kuo@rwdi.com

RWDI Australia Pty Ltd (RWDI)

ABN: 86 641 303 871



DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
A	Draft	31 August 2023	Remi Larmandieu	John Wassermann/ Henry Kuo
B	Final	6 September 2023	Ginn Cheng	Remi Larmandieu
C	Final with comments addressed	24 May 2024	Remi Larmandieu	Ben Lawrence
D	Final with updates to introduction	27 June 2024	Henry Kuo	Remi Larmandieu

NOTE

All materials specified by RWDI Australia Pty Ltd (RWDI) have been selected solely on the basis of acoustic performance. Any other properties of these materials, such as fire rating, chemical properties etc. should be checked with the suppliers or other specialised bodies for fitness for a given purpose.

The information contained in this document produced by RWDI is solely for the use of the client identified on the front page of this report. Our client becomes the owner of this document upon full payment of our **Tax Invoice** for its provision. This document must not be used for any purposes other than those of the document's owner. RWDI undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.

RWDI

RWDI is a team of highly specialised consulting engineers and scientists working to improve the built environment through three core areas of practice: building performance, climate engineering and environmental engineering. More information is available at www.rwdi.com.

AAAC

This firm is a member firm of the Association of Australasian Acoustical Consultants and the work here reported has been carried out in accordance with the terms of that membership.



QUALITY ASSURANCE

RWDI Australia Pty Ltd operates a Quality Management System which complies with the requirements of AS/NZS ISO 9001:2015. This management system has been externally certified by SAI Global and Licence No. QEC 13457 has been issued for the following scope: The provision of consultancy services in acoustic engineering, air quality and wind engineering; and the sale, service, support and installation of acoustic monitoring and related systems and technologies.



GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

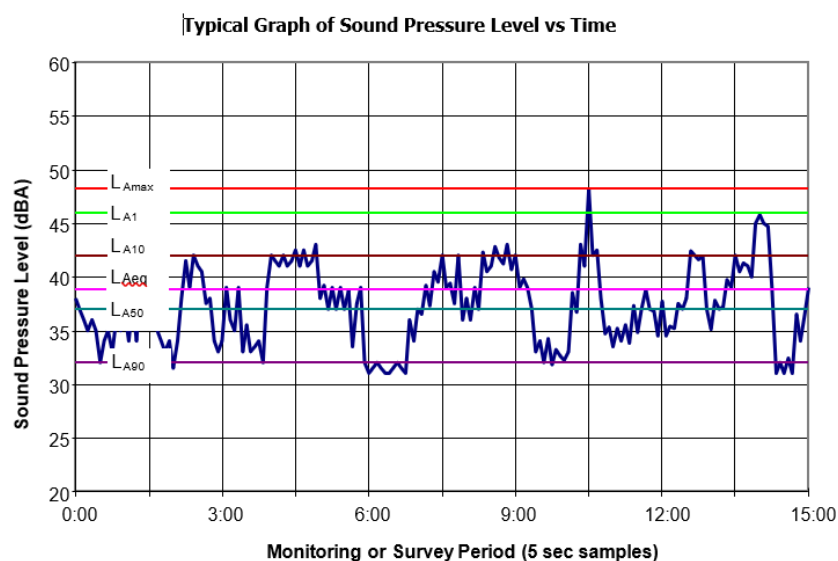




TABLE OF CONTENTS

1	INTRODUCTION	6
1.1	Objectives	7
1.2	Project Description	8
2	ENVIRONMENTAL NOISE SURVEY	12
2.1	Long-Term Noise Monitoring	12
2.2	Short-Term Noise Measurements	13
2.3	Short-Term Vibration Measurements	14
2.3.1	Measurements equipment and results	15
3	NOISE AND VIBRATION CRITERIA	16
3.1	External Noise and Vibration Intrusion Criteria	16
3.1.1	Noise Criteria	16
3.1.2	Vibration Criteria	18
3.2	Noise Emission Criteria	19
3.2.1	NSW EPA Noise Policy for Industry 2017	19
3.2.2	Sleep Disturbance	23
4	EXTERNAL NOISE INTRUSION ASSESSMENT	24
4.1	Recommendations	24
4.1.1	Glazing and Glazed Doors	24
4.1.2	External Walls	26
4.1.3	Roof/Ceiling	26
4.1.4	Ventilation	26
5	OPERATIONAL NOISE ASSESSMENT	28
5.1	Vehicle Noise in Ramp and Drop-Off Zone	28
5.1.1	Noise Modelling Procedure	28
5.1.2	Predicted Noise Levels	29
5.1.3	Mechanical Plant	29
5.2	Operational Noise Recommendations	30
5.2.1	Car park ramp	30
5.2.2	Childcare Centre	30
5.2.3	Retail tenancies	30
5.2.4	Mechanical Plant	30
5.3	Noise Impacts on Sensitive Spaces Within Development	30
5.3.1	Mechanical Plant	31



6	CONSTRUCTION NOISE & VIBRATION IMPACT ASSESSMENT	32
6.1	Acoustic Criteria / Management Levels	32
6.1.1	Noise – Interim Construction Noise Guideline (EPA, 2009)	32
6.1.2	Vibration – Construction Noise & Vibration Strategy (TfNSW, 2018)	33
6.2	Proposed Construction Activities.....	34
6.2.1	Construction Hours.....	34
6.3	Construction Noise Assessment	34
6.3.1	Proposed Works	34
6.3.2	Predicted Construction Noise Impacts.....	36
6.3.3	Construction Noise Mitigation.....	37
6.4	Predicted Construction Vibration Impacts.....	38
6.5	Construction Traffic Noise Assessment.....	39
7	NATIONAL CONSTRUCTION CODE	40
8	CONCLUSION	42
9	STATEMENT OF LIMITATIONS	43

LIST OF FIGURES

Figure 1-1	Aerial View of the Existing Site and Surroundings.....	9
Figure 1-2:	Plan View of the Proposed Development.....	10
Figure 1-2	Site Plan – Aerial View of Site and Surroundings	11
Figure 2-1	Location 1 (L1) Figure 2-2 Location 2 (L2)	12
Figure 2-3	Attended vibration measurements.....	15

APPENDIX

Appendix A: Unattended noise monitoring data



1 INTRODUCTION

RWDI was retained to conduct a noise and vibration impact assessment for the proposed mixed-use development to be located at 85-97 Waterloo Road, Macquarie Park, NSW.

This Noise and Vibration Impact Assessment is submitted to the Department of Planning and Environment (DPE) in support of a State Significant Development Application (SSDA) (SSD-52604208) for a new build-to-rent housing (BTR) development at 85-97 Waterloo Road, Macquarie Park (the site).

The proposed development will specifically comprise the following:

- Site preparation and excavation;
- Construction of a new build-to-rent development comprising six new BTR buildings ranging between 10 to 20 storeys and a new 3 storey amenities building, known as the 'Club House'. Specifically, the following is proposed:
 - 3,079m² of non-residential floor area at ground level, including commercial and retail uses,
 - 57,473m² of build to rent housing, including a total of 736 dwellings
 - 4,581m² of communal residential amenity facilities located throughout the building.
- Provision of a new public park at the centre of the site as well as several through site links to facilitate activation and pedestrian movement throughout the site.
- Shared basement carparking, comprising a total of 670 car parking spaces and 84 bicycle spaces, but no motorcycle spaces (not required under DCP).
- Vehicular access for residential and retail uses is provided from both Banda Road and Khartoum Road, while loading services can only be accessed via Banda Road.
- Associated landscaping and public domain works; and
- Augmentation of, and connection to, existing utilities as required.

This report presents the project objectives, discusses the results from RWDI's on-site environmental noise and vibration survey, and provides our recommendations in order for the development to comply with the relevant acoustic requirements.

The following report forms part of the State Significant Development Application (SSD 52604208) for the proposed development and addresses the Secretary's Environmental Assessment Requirements (SEARs) relevant to the development issued 19 December 2022.

This report responds to the Secretary's Environmental Assessment Requirements (SEARs) as they relate to noise and vibration. This report supports an Environmental Impact Statement (EIS) prepared in respect of the proposal and should be read in conjunction with the EIS and development plans submitted with the SSDA.

The SEARs relevant to this report have been considered and are addressed as outlined in Table 1-1.

Table 1-1: Secretary's Environmental Assessment Requirements (SEARs)

Relevant SEARs	Response
<i>The EIS must:</i>	Noise and vibration emissions associated with the construction and operation of the proposed development have been assessed against the relevant EPA and State

Relevant SEARs	Response
12. Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protection Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.	guidelines, with noise and vibration mitigation recommendations provided to ensure that the acoustic amenity of sensitive receivers in the vicinity of the site is preserved. This report includes assessment of operational noise impacts associated with the development. In principle noise mitigation recommendations have been presented in section 4.1 to facilitate compliance with the relevant EPA Noise Policy for Industry. A preliminary assessment of construction noise and vibration impacts from the development has been presented in section 6, with noise and vibration mitigation strategies presented in section 6.3.3 to ensure that impacts are managed in accordance with the EPA's Interim Construction Noise Guideline.

The following documents have been referenced in establishing noise and vibration criteria for the proposed development:

- Noise from the operation of the development has been assessed in accordance with the *NSW Noise Policy for Industry* (NPfI), NSW EPA, 2017;
- NSW Department of Planning's Development Near Rail Corridors and Busy Roads (Interim Guideline) and AS 2107;
- Construction noise has been assessed in accordance with the EPA's Interim Construction Noise Guideline (ICNG), 2009;
- Construction vibration has been assessed in accordance with Transport for NSW's (TfNSW) Construction Noise and Vibration Strategy (CNVS);

Our assessment and recommendations have been based on the architectural drawings set supplied by DKO Architecture, dated 1st September, 2022.

1.1 Objectives

The objectives of the assessment are to:

- Assess the impact of existing external noise sources on the proposed development (traffic, rail and other sources) and provide recommendations for the sound isolation performance of the building envelope to achieve the internal noise requirements. Internal noise criteria for the development have been formulated with reference to the requirements of the NSW Department of Planning's (DoP) Development Near Rail Corridors and Busy Roads - Interim Guideline (NSW DoP, 2008), City of Ryde Development Control Plan (DCP) (Ryde Council, 2014) and Australian/New Zealand Standard (AS/NZS) 2017:2016 (AS/NZS, 2016).
- Assess vibration impacts on the development from the underground rail corridor located under Waterloo Road. Vibration impacts on human comfort and groundborne noise will be assessed with reference to the guidelines outlined in the EPA's Assessing Vibration: A Technical Guideline (NSW EPA, 2006), and the NSW



Department of Planning's (DoP) Development Near Rail Corridors and Busy Roads - Interim Guideline (NSW DoP, 2008).

- Establish noise emission criteria for the development based on the requirements of the Ryde Council DCP, the NSW EPA Noise Policy for Industry (NPI) 2017 (NSW EPA, 2017).
- Assess noise impacts associated with additional traffic noise generation from the site.

1.2 Project Description

The site is located at 85-97 Waterloo Road, Macquarie Park and is within the City of Ryde Local Government Area. The site is legally described as Lot 1 in DP 1259121 and Lot 2 in DP 1249920 and has a total area of approximately 21,730sqm. It is owned by Goodman and currently comprises the Macquarie Corporation Centre.

The site is situated within the Waterloo Park Precinct under the Macquarie Park Place Precinct Strategy. It is located approximately 350m south of the Macquarie University Station and 750m north-west of the Macquarie Park Metro Station. A summary of the surrounding development is provided below:

- North-east: The site is bounded by Banfield Road to the immediate north-east. Generally, the development to the north-east comprises commercial, light industrial and business park uses.
- South-east: The site is bounded by Khartoum Road to the south-east. Beyond that is a range of commercial and light industrial uses for a range of tenants. Further and approximately 750m south-east is the Macquarie Park Metro Station.
- North-west: The site is bounded by Banda Road to the north-west. Immediately across from the site is a high-density residential development. Further north-west is the Macquarie Centre, and Macquarie University Metro Station and Campus (350m).
- South-west: The site is bounded by Waterloo Road to the south-west. Directly adjacent to the road and opposite the site are a range of development uses, including residential, commercial, retail, and light industrial.

The location of the site within its broader existing surrounding context is shown in Figure 1-3.

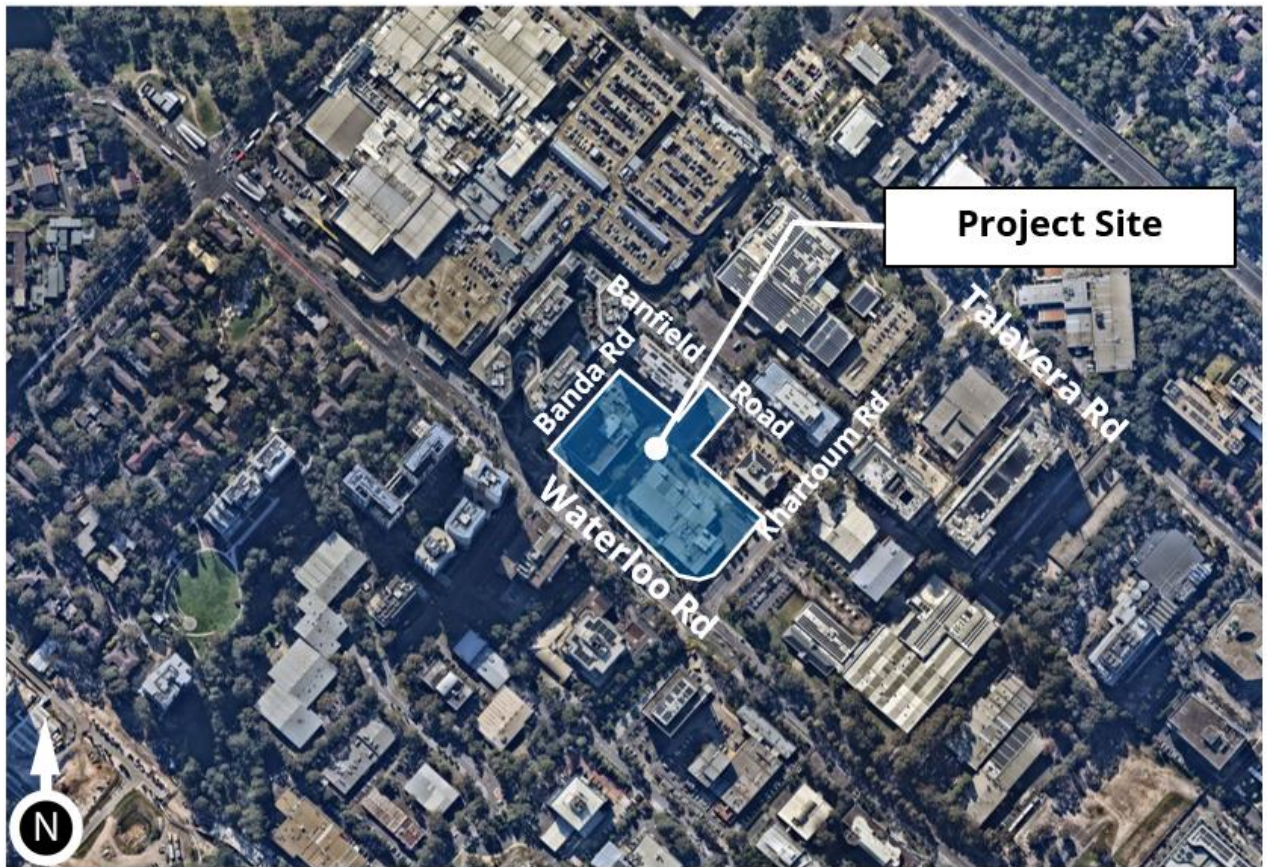


Figure 1-1 Aerial View of the Existing Site and Surroundings

The proposed development consists of seven buildings (Buildings A-G), the majority being residential build-to-rent (BTR) with communal open spaces and retail elements on the ground level (Figure 1-2). The buildings range in height between 3-20 storeys with the tallest Building G located at the corner of Khartoum Road & Waterloo Road. The key outdoor pedestrian accessible areas of interest associated with the development include the pedestrian footpaths & through-site links within and around the site, the various entrances to the buildings, and the amenity spaces on ground and upper levels.

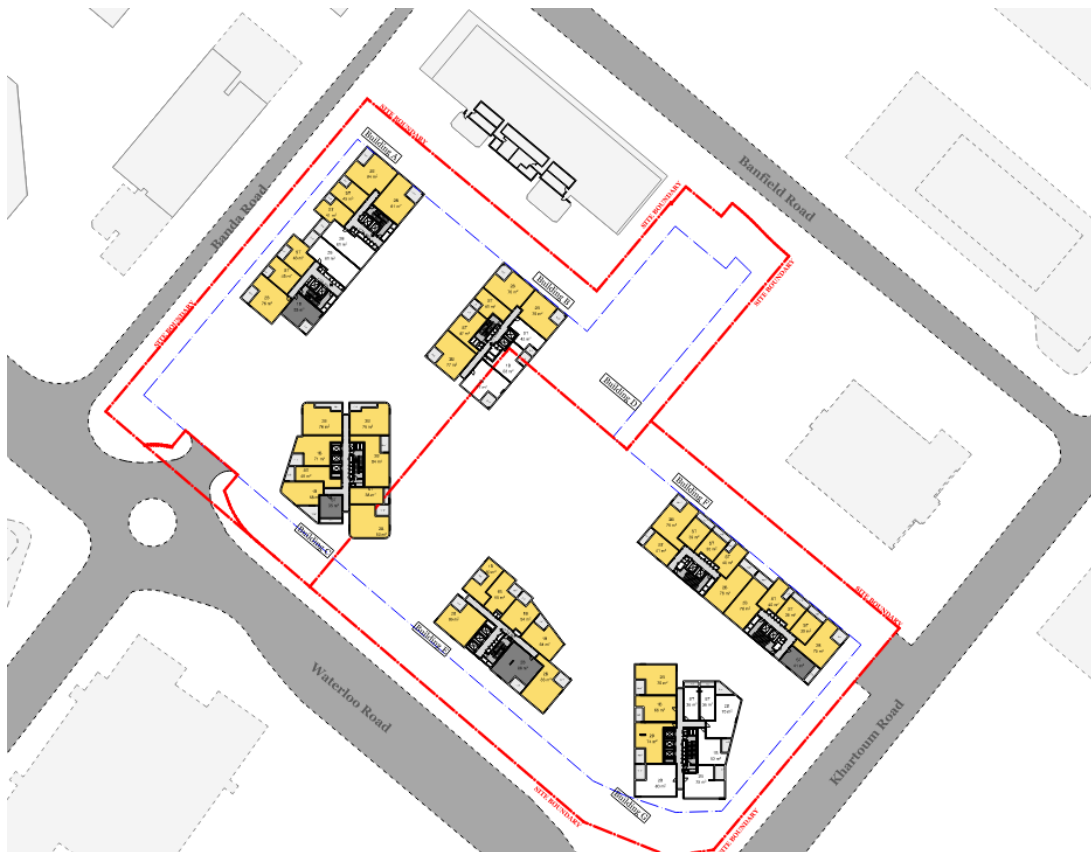


Figure 1-2: Plan View of the Proposed Development

Currently, the property is occupied by a mix of commercial uses, ground floor car parking, and a childcare centre.

The nearest noise sensitive developments surrounding the site are:

- Receiver 1 (R1): Multi-storey residential receivers located to the immediate northwest of the site;
- Receiver 2 (R2): Multi-storey residential receivers located to the immediate southwest of the site;
- Receiver 3 (R3): Multi-storey commercial buildings located to the south of the site;
- Receiver 4 (R4): Commercial receivers located to the southeast of the site;
- Receiver 5 (R5): Commercial receivers located to the northeast of the site at the northside of Banfield Rd;
- Receiver 6 (R6): Commercial receivers located to at the southside of Banfield Rd and adjacent to the site.

Notable external noise sources in the vicinity of the proposed development are:

- Traffic noise from the bounding roadways, especially Khartoum Road to the northeast and Waterloo Road to the southwest;
- Sydney Metro West line running approximately 40m under Waterloo Road.

An aerial photo of the site and the surrounding development are presented in Figure 1-3 below.



Figure 1-3 Site Plan – Aerial View of Site and Surroundings

2 ENVIRONMENTAL NOISE SURVEY

To characterise the existing noise environment of the project location, RWDI personnel attended site to conduct short and long-term unattended noise measurements as described in the sub-section below.

The noise environment of the site consists primarily of traffic noise from the surrounding roadways, and noise from the neighbouring commercial developments.

2.1 Long-Term Noise Monitoring

Two unattended noise monitors were installed at the following locations to measure the ambient and background noise levels (refer also to Figure 1-3):

- Location 1 (L1): 16 metres from Waterloo Road and adjacent to mid of the southwestern site boundary. The noise environment at this location was dominated by traffic noise and intermittent noise from the service station (vacuum cleaner, trucks manoeuvring);
- Location 2 (L2): 36 metres from Banfield Road and adjacent to the northeastern site boundary. The noise environment at this location was dominated by traffic noise.

Photos of the noise monitor locations are shown in Figure 2-1 and Figure 2-2 below.

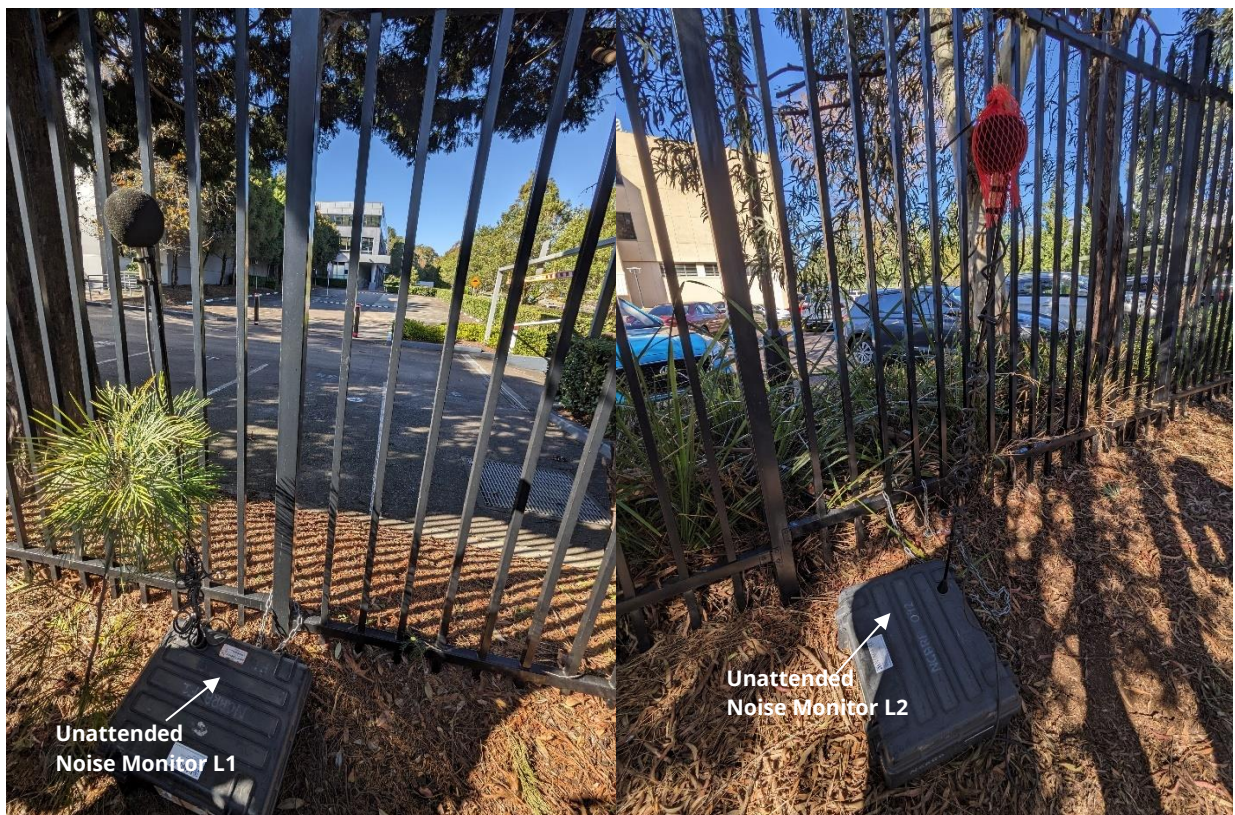


Figure 2-1 **Location 1 (L1)**

Figure 2-2 **Location 2 (L2)**

The unattended noise measurements were conducted using noise monitors which were programmed to measure A-weighted, statistical noise levels stored at 15-minute intervals on fast response mode. The noise



monitors were calibrated at the beginning and end of the monitoring period, with no significant drift being observed.

The noise monitors were on site between June 20 and June 30, 2023.

The measured noise levels at the unattended noise monitoring locations are presented in Table 2-1 and Table 2-2. Refer to Appendix A for a graph of the unattended noise monitoring data.

The unattended noise monitoring data has been analysed in conjunction with weather data obtained from the nearest weather station. Any noise measurement data that has been adversely affected by inclement weather as defined by the EPA Noise Policy for Industry (i.e., periods where average wind speeds exceed 5 m/s and periods that are rain affected) have been excluded in determining the existing noise levels on site.

Table 2-1: Unattended Noise Measurements – Ambient (L_{eq}) Noise Levels

Noise Monitor Location	Time of Day	Measured Ambient Noise Levels
Location 1 (L1)	Day (7 am – 10 pm)	61 dBA L_{eq} , 15-hr
	Night (10 pm – 7 am)	54 dBA L_{eq} , 9-hr
Location 2 (L2)	Day (7 am – 10 pm)	54 dBA L_{eq} , 15-hr
	Night (10 pm – 7 am)	51 dBA L_{eq} , 9-hr

Table 2-2: Unattended Noise Measurements – Background (L_{90}) Noise Levels

Noise Monitor Location	Time of Day	Rating Background Noise Level ^[1]
Location 1 (L1)	Day (7 am – 6 pm)	55 dBA $L_{90}(\text{period})$
	Evening (6pm – 10 pm)	49 dBA $L_{90}(\text{period})$
	Night (10 pm – 7 am)	42 dBA $L_{90}(\text{period})$
Location 2 (L2)	Day (7 am – 6 pm)	51 dBA $L_{90}(\text{period})$
	Evening (6pm – 10 pm)	49 dBA $L_{90}(\text{period})$
	Night (10 pm – 7 am)	46 dBA $L_{90}(\text{period})$

Note [1] The rating background noise level has been calculated in accordance with the requirements of section B1.3 of the EPA Noise Policy for Industry 2017.

2.2 Short-Term Noise Measurements

RWDI personnel also conducted short-term attended noise measurements around the site to supplement the long-term unattended noise monitoring the locations are shown in Figure 1-1. The measurements were conducted on June 20 and June 30, 2023 using a Class 1 NTi Audio XL2 Sound Level Meter. The sound level meter was calibrated at the beginning and end of the measurement periods and no significant drift was observed.

The weather conditions during the attended noise measurements were clear with little to no wind.

The short-term noise measurement results are summarised in Table 2-3.

Table 2-3 Short-Term Noise Measurement Results (Conducted on June 20 and June 30, 2023)

Measurement Location (Refer to Figure 1-3)	Measurement Time	Measured Ambient Noise Level dB(A) L_{eq}	Measured Background Noise Level dB(A) L_{90}	Noted Noise Source(s)
AM 1: 5m from Waterloo Road	11:30pm	65	59	Traffic noise from Waterloo Road
AM2: 5m from Banda Road	3.50pm	56	52	Distant traffic noise (primarily from Waterloo Road)
AM3: 10m from Banfield Road	4.09pm	56	54	Distant traffic noise
AM4: 7m from Khartoum Road	3.17pm	61	53	Noise from 7-Eleven car wash and traffic noise on Lane Cove Road.
AM5: 12m from Khartoum Road and 12m from Waterloo Road	3.33pm	63	57	Traffic noise from Khartoum Road and Waterloo Road

2.3 Short-Term Vibration Measurements

Measurements of vibration levels were conducted on 20 June 2023 at 85 Waterloo Road, directly above the Sydney Metro West underground line. Measurements were conducted on undisturbed ground at the location shown in Figure 2-3. The attended vibration measurements were carried out between 12:00pm to 1:00pm on 20th June 2023.



Figure 2-3 Attended vibration measurements.

2.3.1 Measurements equipment and results

Equipment used to measure vibration consisted of a SVAN 958A Class 1 Four-channel Sound & Vibration Analyser. The analyser was connected to a SV84 four channel input module fitted with a triaxial accelerometer (tri-axial measurements).

Table 2-4 Measured vibration dose value (VDV) (Conducted on June 20 between 11.39am and 12.02pm)

Sydney Metro West line Passby	Calculated Passby VDV (m/s ^{1.75})
1	0.001698
2	0.001685
3	0.001732
4	0.008141
5	0.001525
6	0.000679



3 NOISE AND VIBRATION CRITERIA

The following sub-sections detail the acoustic criteria that are applicable to the proposed development.

3.1 External Noise and Vibration Intrusion Criteria

3.1.1 Noise Criteria

3.1.1.1 City of Ryde - Development Control Plan 2014

The proposed development is located within the City of Ryde and as such the controls of the City of Ryde DCP (2014) are applicable to the site.

The City of Ryde DCP does not provide quantitative internal noise requirements for other commercial uses or residential development. It is noted that the development is located adjacent to a rail corridor. As such, the acoustic requirements of the State Environmental Planning Policy (Infrastructure) 2008 apply to the development. Internal noise criteria from AS/NZS 2107:2016 will also be considered.

3.1.1.2 NSW Department of Planning's Development Near Rail Corridors and Busy Roads (Interim Guideline)

Section 3.5 of the NSW Department of Planning's Development Near Rail Corridors and Busy Roads - Interim Guideline (SEPP) states:

"The following provides an overall summary of the assessment procedure to meet the requirements of clauses 87 and 102 of the Infrastructure SEPP. The procedure covers noise at developments for both Road and Rail.

- *If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:*
 - *in any bedroom in the building: 35dB(A) at any time 10pm-7am*
 - *anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40dB(A) at any time."*

3.1.1.3 AS/NZS 2107:2016 – Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors

AS/NZS 2107:2016 provides recommended internal noise criteria for different spaces depending on their intended use. This internal noise recommendations apply to steady or quasi-steady state noise source, including road traffic. The applicable internal noise criteria from the Standard that have been adopted for this development are presented in Table 3-1 below.

Table 3-1 AS/NZS 2107:2016 Internal Noise Level Recommendations

Type of Occupancy	Time of Day	Internal Noise Criteria
Apartment Sleeping Areas	Night (10 pm – 7 am)	35 dBA L_{eq} , 9-hr
Apartment Living Areas	Day (7 am – 10 pm)	45 dBA L_{eq} , 15-hr



Type of Occupancy	Time of Day	Internal Noise Criteria
Indoor Communal Spaces	Day (7 am – 10 pm)	45 dBA Leq, 15-hr
General Office Areas	Day (7 am – 10 pm)	40 dBA Leq, 15-hr
Small Retail Stores	Day (7 am – 10 pm)	50 dBA Leq, 15-hr
Gym	Day (7 am – 10 pm)	45 dBA Leq, 15-hr
Library	Day (7 am – 10 pm)	40 dBA Leq, 15-hr
Pool	Day (7 am – 10 pm)	50 dBA Leq, 15-hr

3.1.1.4 Summary of Internal Noise Criteria

Based on the sub-sections above, a summary of the most stringent internal noise criteria for the development have been summarised in Table 3-2.

Table 3-2: Summary of Internal Noise Level Recommendations

Type of Occupancy	Time of Day	Internal Noise Criteria
Apartment Sleeping Areas	Night (10 pm – 7 am)	35 dBA Leq, 9-hr
Apartment Living Areas	Day (7 am – 10 pm)	40 dBA Leq, 15-hr
Indoor Communal Spaces	Day (7 am – 10 pm)	45 dBA Leq, 15-hr
General Office Areas	Day (7 am – 10 pm)	40 dBA Leq, 15-hr
Small Retail Stores	Day (7 am – 10 pm)	50 dBA Leq, 15-hr
Gym	Day (7 am – 10 pm)	45 dBA Leq, 15-hr
Library	Day (7 am – 10 pm)	40 dBA Leq, 15-hr
Pool	Day (7 am – 10 pm)	50 dBA Leq, 15-hr

3.1.2 Ground Borne Noise and Vibration Criteria

3.1.2.1 Ground Borne Noise

The Department of Planning 'Development Near rail Corridors and Busy Road – Interim Guideline' only require structure borne noise assessment to be conducted where buildings are over or adjacent land over tunnels. The existing Sydney Metro line railway tunnel is located underground, approximately 40m under Waterloo Road adjacent the southwestern boundary of the development.

Vibration generated by train passbys within the train line below the proposed development will potentially generate structure born vibration which will be radiated of internal building elements such as walls, floors and ceiling as audible noise. We know that this track is equipped with high attenuation fasteners to reduce the vibration impacts generated by train passby to surrounding buildings, especially residential buildings subject to more stringent objectives.

Section 3.6.2 of the NSW DoP's Development Near Rail Corridors and Busy Roads - Interim Guideline provides the following criteria with respect to ground-borne noise impacts on residential development where the development is located on land over or adjacent to a rail tunnel:

"Generally, ground borne noise is associated more closely with rail operations than roads. Where buildings are constructed over or adjacent to land over tunnels, ground-borne noise may be present without the normal masking effect of airborne noise. In such cases, residential buildings should be designed so that the 95th percentile of train pass-bys complies with a ground-borne L_{Amax} noise limit of 40dBA (daytime) or 35dBA (night-time) measured using the "slow" response time setting on a sound level meter."

3.1.2.2 NSW EPA's Assessing Vibration: A Technical Guideline

The EPA's document Assessing Vibration: A Technical Guideline provides criteria for intermittent vibration impacts on residential and commercial development from external vibration sources to protect the amenity of occupants. The criteria presented in the Guideline are consistent with the recommendations outlined in British Standard BS6472:1992 – Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz).

The vibration criteria presented in the EPA's Assessing Vibration: A Technical Guideline is in terms of the vibration dose value (VDV) parameter. The relevant VDV criteria are summarised in Table 3-3.

Table 3-3 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7 am – 10 pm)		Night-time (10 pm – 7 am)	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, Schools, Educational Institutions and Places of Worship	0.40	0.80	0.40	0.80



3.2 Noise Emission Criteria

3.2.1 NSW EPA Noise Policy for Industry 2017

The NPfI provides a framework for assessing environmental noise impacts from industrial premises and industrial development proposals in New South Wales.

The NPfI recommends the development of project noise trigger levels, which provide a benchmark for assessing a proposal or site. The project noise trigger levels should not be interpreted as mandatory noise criteria but, rather, as noise levels that, if exceeded, would indicate a potential noise impact on the community.

The project noise trigger level is the lower value of the project intrusiveness noise level and the project amenity noise level. The project intrusiveness noise level assesses the likelihood of noise being intrusive above the ambient noise level and is applied to residential receivers only. The project amenity noise level ensures the total industrial noise from all sources in the area does not rise above a maximum acceptable level.

3.2.1.1 Project Intrusiveness Noise Levels

The intrusiveness noise level is the noise level 5 dBA above the background noise level for each time period (daytime, evening or night time) of interest at a residential receiver. The background noise level is derived from the measured L_{A90} noise levels.

The project intrusiveness noise levels for residential receivers R1 and R2 are shown in Table 3-4.

Table 3-4 Project intrusiveness noise levels.

Type	Receiver	Time of Day ¹	Intrusiveness Noise Level $L_{Aeq,period}$ dBA
Residential	R1	Day	56
		Evening	54
		Night	51
	R2	Day	60
		Evening	54
		Night	47



3.2.1.2 Project Amenity Noise Levels

Project amenity noise levels aim to set a limit on continuing increases in noise levels from all industrial noise sources affecting a variety of receiver types; that is, the ambient noise level in an area from all industrial noise sources remains below recommended amenity noise levels.

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include transportation noise (when on public transport corridors), noise from motor sport, construction noise, community noise, blasting, shooting ranges, occupational workplace noise, wind farms, amplified music/patron noise.

The amenity noise level aims to limit continuing increases in noise levels which may occur if the intrusiveness level alone is applied to successive development within an area.

The recommended amenity noise level represents the objective for total industrial noise at a receiver location. The project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

To prevent increases in industrial noise due to the cumulative effect of several developments, the project amenity noise level for each new source of industrial noise is set at 5dBA below the recommended amenity noise level.

The following exceptions apply to determining the project amenity noise level:

- For high-traffic areas, the amenity criterion for industrial noise becomes the $L_{Aeq,period}$ (traffic) minus 15dBA.
- In proposed developments in major industrial clusters.
- If the resulting project amenity noise level is 10dB or more, lower than the existing industrial noise level, the project amenity noise level can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.
- Where cumulative industrial noise is not a consideration because no other industries are present in, or likely to be introduced into the area, the relevant amenity noise level is assigned as the project amenity noise level for the development.

Amenity noise levels are not used directly as regulatory limits. They are used in combination with the project intrusiveness noise level to assess the potential impact of noise, assess mitigation options and determine achievable noise requirements.

The project amenity noise levels are calculated from the recommended amenity noise levels presented in Table 3-5.

Table 3-5 Recommended Amenity Noise Levels

Receiver	Noise Amenity Area	Time of Day ¹	Recommended Amenity Noise Level $L_{Aeq,period}$ dBA
Residential	Rural	Day	50
		Evening	45

Receiver	Noise Amenity Area	Time of Day ¹	Recommended Amenity Noise Level L_{Aeq,period} dBA
	Suburban	Night	40
		Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5dBA above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day.
School classroom-internal	All	Noisiest 1-hour period when in use	35
Hospital ward internal external	All	Noisiest 1-hour	35
Place of worship-internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5dB(A) to recommended noise amenity area

Note 1: Day = 7am – 6pm; Evening = 6pm – 10pm; Night = 10pm – 7am

The project amenity trigger level sets limits on the total noise level from all industrial noise sources affecting a receiver. Different amenity noise levels apply for different types of receivers (e.g. residential, commercial, industrial – or for areas specifically reserved for passive recreation) and different areas (e.g. urban, suburban, rural). The amenity noise level applies to the $L_{Aeq,period}$ during the full day (or evening or night). To ensure that industrial noise levels remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise. This is calculated as the recommended amenity noise level for the receiver type minus 5 dBA. Where noise sources are not continuous for the whole period it is allowable to add 3 dB to convert from a period level to a 15-minute level.

The project amenity noise levels for the Project are presented in Table 3-6.

Table 3-6 Project Amenity Noise Levels

Receiver	Time of Day ¹	Recommended Amenity Noise Level L _{Aeq,period} dBA ¹	Project Amenity Noise Level L _{Aeq,15min} dBA
Commercial premises	When in use	65	63
Residential premises (Urban)	Day	60	58
	Evening	50	48
	Night	45	43

Note 1: Amenity noise level assigned based on high traffic areas, as per section 2.4.1 of the NPfI

3.2.1.3 Project Noise Trigger Level

The project noise trigger levels for the project are presented in Table 3-7.

Table 3-7 NPfI Overall Project Trigger Noise Level Criteria

Receiver Type	Time of Day	Intrusiveness Criteria L _{Aeq,15min} dBA	Amenity Criteria L _{Aeq,15min} dBA	Project Noise Trigger Criteria L _{Aeq,15min} dBA
R1 Residential	Day	56	58	56
	Evening	54	48	48
	Night	51	43	43
R2 Residential	Day	60	58	58
	Evening	54	48	48
	Night	47	43	43
R3 Commercial	When in use	-	63	63
R4 Commercial	When in use	-	63	63
R5 Commercial	When in use	-	63	63
R6 Commercial	When in use	-	63	63
R7 Commercial	When in use	-	63	63



3.2.2 Sleep Disturbance

Guidance for assessing the potential for sleep disturbance impacts on nearby residences is provided in Section 2.5 of the NPfI, which states:

Where the subject development/premises night-time noise levels at a residential location exceed:

- $L_{Aeq,15min}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{Amax} 52 dBA or the prevailing RBL plus 15 dB, whichever is the greater,

a detailed maximum noise level event assessment should be undertaken.



4 EXTERNAL NOISE AND VIBRATION INTRUSION ASSESSMENT

The most significant source of external noise intrusion on the development will be from traffic noise from roads surrounding the site.

4.1 Recommendations

To meeting the internal noise criteria, using the measured noise levels presented in Section 2, noise modelling was performed to determine the internal noise levels within the development as a result of noise transmission through the building façade elements (glazing, external walls and roof/ceiling). This modelling considered the transmission loss performance of the façade elements, the estimated surface area of each façade element exposed to external noise and the absorption characteristics of the internal spaces due to room finishes.

Based on RWDI's analysis, the indicative weighted sound reduction index (R_w) performance for the building façade elements have been presented in the sub-sections below. These recommendations should be reviewed at detailed design stage once room layouts and glazing areas have progressed sufficiently to ensure that the internal noise criteria are achieved (refer to section 3.1).

4.1.1 Glazing and Glazed Doors

The indicative minimum glazing performances for the development are presented in Table 4-1 below. These recommendations will require to be revised once layouts, glazing sizes and apartments finishes are finalised.

Glazing suppliers are to provide acoustic laboratory test reports confirming that the acoustic performance of their window systems (combined performance of the glass and window frame) meets the R_w requirements.

Table 4-1 Recommended Minimum Acoustic Performance for Glazing

Building	Room Type	Façade	Minimum Glazing and Frame Performance
A	Apartment Bedrooms	All	R_w 31
	Apartment Living Rooms	All	R_w 29
B	Apartment Bedrooms	All	R_w 29
	Apartment Living Rooms	All	R_w 29
C	Apartment Bedrooms	Southwest (facing Waterloo Road)	R_w 31
		Other façades (not facing Waterloo Road)	R_w 29
	Apartment Living Rooms	Southwest (facing Waterloo Road)	R_w 31



Building	Room Type	Façade	Minimum Glazing and Frame Performance
		Other façades (not facing Waterloo Road)	R _w 29
E	Apartment Bedrooms	Southwest (facing Waterloo Road)	R _w 31
		Other façades (not facing Waterloo Road)	R _w 29
	Apartment Living Rooms	Southwest (facing Waterloo Road)	R _w 31
		Other façades (not facing Waterloo Road)	R _w 29
F	Apartment Bedrooms	Southeast (facing Khartoum Road)	R _w 31
		Other façades (not facing Khartoum Road)	R _w 29
	Apartment Living Rooms	Southeast (facing Khartoum Road)	R _w 31
		Other façades (not facing Khartoum Road)	R _w 29
G	Apartment Bedrooms	Southeast, South and Southwest (facing Waterloo and/or Khartoum Road)	R _w 31
		Other façades (not facing Khartoum Road)	R _w 29
	Apartment Living Rooms	Southeast, South and Southwest (facing Waterloo and/or Khartoum Road)	R _w 31
		Other façades (not facing Khartoum Road)	R _w 29
All	Apartment Bathrooms/Laundries	All	R _w 22
	Lobbies/Common Areas	All	R _w 29
	Commercial uses	All	R _w 29
	Childcare centre	All	R _w 31



4.1.2 External Walls

Any proposed concrete or masonry external walls will provide adequate acoustic isolation to meet the internal noise requirements. No additional acoustic treatment is expected to be required for these external walls.

Any lightweight external walls should be reviewed at detailed design stage to determine the appropriate construction to meet in the internal noise requirements.

Any penetrations in the external walls (e.g. for services) should be adequately sealed so as not to reduce the acoustic performance of the external walls.

4.1.3 Roof/Ceiling

Any concrete roof will provide adequate acoustic isolation to meet the internal noise requirements. No additional acoustic treatment is expected to be required for the roof/ceiling to mitigate external noise intrusion.

Any lightweight roof constructions should be reviewed at detailed design stage to determine the appropriate construction to meet in the internal noise requirements.

4.1.4 Ventilation

Regarding natural ventilation of the dwelling, the NSW Department of Planning document "Development near Busy Roads and Rail Corridors – Interim Guideline" dictates that:

- "If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia."

With windows open, the allowable internal noise goal is permitted to be 10dBA higher than when the windows are closed (ie – allowable level in bedrooms becomes 45dBA L_{eq} (9hr)).

Internal levels within habitable rooms directly facing both Waterloo Road and Khartoum Road for Buildings C, E, F and G cannot be achieved with windows open. Alternative systems required to be investigated to allow room to be ventilated so as to meet the requirements of AS1668.1. These mitigation treatments include:

- Acoustically treated balconies;
- Partially enclosed balconies,
- Acoustic plenums;
- Wintergardens;
- Trickle ventilation systems
- Mechanical ventilation/air-conditioning system

Any system that is installed should be acoustically designed such that the acoustic performance of the recommended constructions is not reduced by any element penetrating the wall/ceiling/roof.

4.2 Ground Borne Noise and Vibration – Underground Sydney Metro Line

4.2.1 Measurements equipment and results

Equipment used to measure vibration consisted of a SVAN 958A Class 1 Four-channel Sound & Vibration Analyser. The analyser was connected to a SV84 four channel input module fitted with a triaxial accelerometer (tri-axial measurements).

Table 4-2 Measured vibration dose values (VDVs) (Conducted on June 20 between 11.39am and 12.02pm)

Sydney Metro West line Passby	Calculated Passby VDV ($\text{m/s}^{1.75}$)
1	0.001698
2	0.001685
3	0.001732
4	0.008141
5	0.001525
6	0.000679

4.2.2 Calculated Vibration Dose Values

The maximum train passby ground vibration acceleration, the typical passby period (gained from both the noise and vibration measurements) and the number of train passbys were used calculate the overall eVDV values for each period of the day. The results are presented in Table 2-4.

eVDV values were determined based on the daily train timetable information. The VDV per train used in the eVDV calculation was determined by using the measured vibration levels during passbys.

Table 4-3 Internal Railway Noise Level Criteria

Test Location	Time Period	Calculated eVDV $\text{m/s}^{1.75}$	Criteria eVDV $\text{m/s}^{1.75}$	Complies
Ground Level	Day (7am – 10pm)	0.008	0.2	Yes
	Night (10pm -7am)	0.006	0.13	Yes

In the event the future train use increases, say by 10%, predicted eVDV will not increase significantly (no more than approximately 0.02 more than the levels predicted in the table above) and will not impact recommended vibration isolation treatments.

4.2.3 Ground Borne Noise Levels

Initial vibration measurements indicate ground borne noise levels will achieve compliance with ground borne noise objectives. Additional measurements will be conducted at detailed design when more is known about the building foundation design and more detailed site geotechnical information is known.



5 OPERATIONAL NOISE ASSESSMENT

Modelling of noise emissions from the Proposal has been undertaken using the ISO 9613 noise prediction algorithm in the CadnaA modelling software.

At relatively large distances from a source, the resultant noise levels at receivers can be influenced by meteorological conditions, particularly temperature inversions and gradient winds. Where these factors are a feature of an area, their effect on resultant noise levels should be taken into account. The NPfI recommends that noise predictions be conducted under these meteorological conditions favourable for noise propagation.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable for noise propagation.

The primary sources of noise generation from the site are as follows:

- Vehicle noise from the use of the car park ramp leading to the two underground car parks, accessible from Banda Road and Khartoum Road; and
- Mechanical plant noise.

We note that noise emissions from vehicles manoeuvring within the enclosed basement carpark, as well as from delivery vehicles unloading within the basement carpark will have a negligible impact on the surrounding residences and so have not been considered in this assessment.

Our noise modelling methodology and noise predictions of the various noise sources are presented in the sub-sections below.

5.1 Vehicle Noise in Ramp

5.1.1 Noise Modelling Procedure

Modelling of noise emissions from vehicle movements in the car park ramp within the site have been based on the following:

- The SWL noise emissions from a car are as presented in Table 5-1 (based on measurements conducted by RWDI);

Table 5-1 SWL from Cars

Noise Source	Sound Power Level, L_{Aeq} , dBA
SWL Car Manoeuvring at 10km/hr	85

- It is noted that the exact traffic numbers are not available at this stage. Based on one vehicle movement per parking space during peak hour (7am-9am), there may be approximately:

- Up to 139 vehicle movements in or out of the car park ramp on Banda Road in a one-hour period;
- Up to 226 vehicle movements in or out of the car park ramp on Khartoum Road in a one-hour period;

We note that noise emissions from cars manoeuvring within the basement level carpark will be negligible and will have no appreciable contribution to noise impacts on surrounding receivers.

5.1.2 Predicted Noise Levels

The predicted noise levels at the surrounding receivers from vehicle movements are presented in Table 5-2. Noise emissions will be assessed against the requirements of the project noise trigger levels of the NPfI (refer to section 0).

Table 5-2 Predicted Noise Levels from Vehicle Movements

Receivers	Predicted Noise Level ¹ L _{Aeq, 15min}	NPfI Noise Criteria ¹ L _{Aeq, 15min}	Complies
R1	43	Day – 56 Evening – 48 Night – 43	Yes
R2	33	Day – 58 Evening – 48 Night – 43	Yes
R3	30	68	Yes
R4	39	68	Yes
R5	28	68	Yes
R6	43	68	Yes

Note 1: Day = 7am – 6pm; Evening = 6pm – 10pm; Night = 10pm – 7am, Early Night = 10pm – 12am

Our analysis indicates that noise emissions from vehicle movements will comply with the NPfI project noise trigger criteria.

5.1.3 Mechanical Plant

At this stage, selections of specific mechanical equipment and the location of the equipment have not been finalised.

No details of specific mechanical plant have been determined at this stage of the project. Likely sources of noise from the proposed development will be the mechanical plant associated with building air-conditioning and ventilation.

A detailed review of noise from mechanical plant servicing the development should be conducted once specific mechanical system details are selected by the mechanical contractor. However, at the setback distance to the residences the use of conventional air condition systems and standard mitigation measures (screens and



attenuators) the criteria can be achieved. Generally, the noise contribution from mechanical plant should be controlled to 5dB below the trigger levels to allow headroom for the noise contribution from each building/tenancy.

5.2 Operational Noise Recommendations

5.2.1 Car park ramp

Any speed bumps, drainage grates or expansion joint covering plates should be firmly down such that they do not generate any rattling noises when driven over by vehicles.

5.2.2 Childcare Centre

The layout, locations of outdoor areas and exact operating details (capacity, operating hours etc) for the childcare centre are not known at this early stage. A noise and vibration impact assessment will be required to support the Development Application for the Childcare Centre.

5.2.3 Retail tenancies

Separate retail and commercial tenancies (F&B, gym) with the potential to create noise disturbances will be subject to separate applications, which would include a noise impact assessment.

5.2.4 Mechanical Plant

An acoustic review of mechanical plant should be undertaken at detailed design stage once plant selections and locations have been finalised. Noise from the mechanical plant should be designed to comply with the project noise trigger levels of the NPfI presented in Table 3-7.

5.3 Noise Impacts on Sensitive Spaces Within Development

Consideration should also be given to the impacts of noise-generating uses in the development on noise-sensitive uses within the site (primarily residential). As the noise-generating uses are in relatively close proximity to residential facades/residential outdoor living spaces, the design should account for adequate acoustic separation and sound isolation to mitigate excess noise impact at all noise-sensitive receptors.

In this section, the potential noise impact of noise-generating uses to on-site noise-sensitive uses are discussed at a high-level, since noise mitigation could be applied at the source and receptor to ensure the applicable criteria are met. Details of noise mitigation will need to be developed during the project detailed design.

The primary sources of noise generation identified for the proposed development are as follows:

- Gym and swimming pool (patrons activity and music); and
- Rooftop mechanical plant, including noise from any outdoor/uncovered units and ventilation openings.

Mitigation treatments for the separate swimming pool / gym building will likely include:

- Standard glazing;
- No vibration treatments given there are no other sensitive within this building;



- An airlock may be required to ensure noise from the premises (music/patrons noise) does not impact neighbouring buildings.

These treatments should be determined at detailed design when the operating details (hours of operation, proposed activities, capacity, etc) are known.

5.3.1 Mechanical Plant

As discussed in section 5.2.4, selections of specific mechanical equipment and the location of the equipment have not been finalised. Given this, it is not possible to carry out an assessment of noise emissions of mechanical plant at this early stage.

It is recommended that a detailed acoustic assessment of the mechanical equipment is undertaken at detailed design stage.

Mitigation measures that are commonly employed to control noise emissions from mechanical equipment include:

- Locating mechanical equipment as far as practicable from noise sensitive receivers;
- Using in-duct treatments such as internally lined ductwork or silencers;
- Building barriers or enclosures around equipment;
- Using acoustic louvers.

6 CONSTRUCTION NOISE & VIBRATION IMPACT ASSESSMENT

6.1 Acoustic Criteria / Management Levels

6.1.1 Noise – Interim Construction Noise Guideline (EPA, 2009)

The NSW EPA Interim Construction Noise Guideline (ICNG) requires project-specific Noise Management Levels (NMLs) to be established for noise affected receivers. In the event construction noise levels are predicted to be above the NMLs, all feasible and reasonable work practices are investigated to minimise noise emissions.

Having investigated all feasible and reasonable work practices, if construction noise levels are still predicted to exceed the NMLs then the potential noise impacts would be managed via site specific construction noise management plans, to be prepared in the detailed design phase. Table 6-1 details the ICNG noise management levels.

Table 6-1 Interim Construction Noise Guideline Criteria

Time of Day	NML	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 dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq}(15min)$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly Noise Affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences; 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL+5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Based on the above, presents the applicable noise management levels for construction activities at surrounding receivers that have been adopted for all applications.

Table 6-2 Site-Specific Construction Noise Management Levels

Location	Construction Noise Management Level (NMLs)			
	- LAeq,15min			
	Day Standard Hours ¹	Day OOH	Evening OOH ²	Night OOH ³
R1	61	56	54	51
R2	65	60	54	47
R3	70	70	70	70
R4	70	70	70	70
R5	70	70	70	70
R6	70	70	70	70

Note 1: Standard Hours (7am – 6pm Monday to Friday, 8am – 1am Saturday with no work on Sundays or Public Holidays)

Note 2: Evening OOH (6pm – 10pm)

Note 3: Night OOH (10pm – 7am)

6.1.2 Vibration – Construction Noise & Vibration Strategy (TfNSW, 2018)

Minimum working distances for typical vibration intensive construction equipment are provided in the Transport for NSW's (TfNSW) Construction Noise and Vibration Strategy (CNVS).

The minimum working distances presented in Appendix D of the CNVS are for both cosmetic damage (from BS 7358) and human comfort (from the NSW EPA Vibration Guideline) and are based on empirical data which suggests that where vibration intensive works are conducted outside the minimum distances, adverse vibration impacts are unlikely.

The recommended minimum working distances for vibration intensive activities from the CNVS are presented in Table 6-3.

Table 6-3 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Approx. Size / Weight / Model	Minimum Distance	
		Cosmetic Damage (BS 7385)	Human Response (NSW EPA Guideline)
Vibratory Roller	1-2 tonne	5 m	15 m to 20 m
	2-4 tonne	6 m	20 m
	4-6 tonne	12 m	40 m

Plant Item	Approx. Size / Weight / Model	Minimum Distance	
		Cosmetic Damage (BS 7385)	Human Response (NSW EPA Guideline)
	7-13 tonne	15 m	100 m
	13-18 tonne	20 m	100 m
	> 18 tonne	25 m	100 m
Small Hydraulic Hammer	300 kg (5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m
Pile Driver – Vibratory	Sheet Piles	2 m to 20 m	20 m
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	4 m
Piling Rig – Hammer	12 t down force	15 m	50 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

6.2 Proposed Construction Activities

6.2.1 Construction Hours

Where possible, works should be completed during the standard daytime construction hours of Monday to Friday 7.00am to 6.00pm and Saturday 8.00am to 1.00pm. Where Out-of-Hours Works (OOHWs) are required (for emergency works/delivery, etc) it is likely that they would require separate approval.

6.3 Construction Noise Assessment

Noise modelling of the construction noise emissions was undertaken using the ISO9612 noise prediction algorithm in the Cadna/A modelling software.

The noise model was constructed from a combination of aerial photography, existing ground topography, design ground topography and proposed design. The local terrain, receiver buildings and structures have been digitised in the noise model to develop a three-dimensional representation of the construction works and surrounding environment.

6.3.1 Proposed Works

This report provides a preliminary assessment of the potential construction noise and vibration impacts associated with the proposed development. The construction noise and vibration assessment has considered the following construction stages in-principle:

- Demolition and clearing works
- Excavation and piling
- Building construction

Sound power levels (SWLs) for the typical operation of construction equipment applied in the modelling are listed in Table 6-4 and have been based on measurements conducted by RWDI and Appendix C of the CNVS. To assess construction noise levels against the NMLs, the noise levels have been converted to equivalent $L_{Aeq,15min}$ noise emissions based on the expected period of operation of the individual pieces of construction plant.

Table 6-4 Construction Noise Sources

Stage	Equipment	Operating minutes in 15-min period	Quantity	Sound Power Level (dB)		
				Individual Item (SWL)	L_{Aeq} Activity	L_{Amax} Activity
Demolition and Clearing	Excavator (30 t)	15	2	110	113	114
	Truck & Dog (30 t)	15	1	108	108	
Excavation and Piling	Dozer (D10)	10	2	116	117	122
	Truck & Dog (30 t)	15	2	108	111	
	Excavator (40 t)	15	2	115	118	
	Piling Rig	5	1	116	111	
	Concrete Truck	15	1	109	109	
Construction	Concrete Truck / Agitator	15	2	106	109	117
	Concrete Pump	15	1	109	109	
	Truck (20 t)	15	1	103	103	
	Mobile Crane	10	1	113	113	
	Hand Tools	7.5	5	105	109	
	Elevated Work Platform	10	2	97	98	

Consistent with the requirements of the ICNG, and to inform the scheduling of construction activity and management of noise during the detailed design phase, the construction noise impacts are based on an expected typical worst-case scenario. The ICNG recommends that the realistic worst-case or conservative noise levels from the source should be predicted for assessment locations representing the most noise exposed residences or other sensitive land uses. For each receiver area the noise levels are predicted at the most noise-exposed location, which would usually be the closest receiver.

For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted at the most-exposed receiver as the noise levels presented in this report are based on a realistic worst-case assessment.

6.3.2 Predicted Construction Noise Impacts

Preliminary noise impacts have been quantitatively assessed of construction activities for the NCAs surrounding the site. The activities considered are described in Table 6-4.

The typical $L_{Aeq,15min}$ noise levels at the surrounding NCAs are provided in Table 6-5. Each of the construction activities are representative of the 'noisiest' construction periods where there may be simultaneous operation of noise intensive construction plant on site.

Table 6-5 Predicted Construction Noise Impacts

Stage	Receivers	Predicted Noise Level	Noise Level – $L_{Aeq,15min}$ dBA			
			Noise Affected Noise Management Levels (NMLs)			
			Day ¹	Day	Eve	Night
			Standard	OOH	OOH ²	OOH ³
Demolition and Clearing	R1	66	61	56	54	51
	R2	62	65	60	54	47
	R3	65	70	70	70	70
	R4	65	70	70	70	70
	R5	57	70	70	70	70
	R6	63	70	70	70	70
Excavation and Piling	R1	74	61	56	54	51
	R2	70	65	60	54	47
	R3	73	70	70	70	70
	R4	73	70	70	70	70
	R5	65	70	70	70	70
	R6	71	70	70	70	70
Construction	R1	69	61	56	54	51
	R2	65	65	60	54	47
	R3	68	70	70	70	70
	R4	68	70	70	70	70
	R5	60	70	70	70	70
	R6	66	70	70	70	70

Note 1: Standard Hours (7am – 6pm Monday to Friday, 8am – 1am Saturday with no work on Sundays or Public Holidays)

Note 2: Evening OOH (6pm – 10pm)

Note 3: Night OOH (10pm – 7am)



Exceedances of the noise affected NMLs are generally expected at receivers R1, R2, R3, R4 and R6 due to the proximity of the site.

Measures to manage construction noise emissions are discussed in section 6.3.3.

6.3.3 Construction Noise Mitigation

As discussed in section 6.3.2, noise levels from construction activities during standard hours are predicted to exceed the NMLs of the ICNG at several receivers surrounding the site. Therefore, in accordance with the ICNG, all reasonable and feasible measures should be applied to manage construction noise emissions from the site. In particular, the following is recommended:

A detailed Construction Noise and Vibration Management Plan (CNVMP) should be prepared and should include, but not be limited to the following:

- Identification of nearby residences and other sensitive land uses;
- Description of approved hours of work;
- Description and identification of construction activities, including work areas, equipment and duration;
- Description of what work practices (generic and specific) will be applied to minimise noise;
- Consider the selection of plant and processes with reduced noise emissions;
- A complaints handling process;
- Noise monitoring procedures;
- Overview of community consultation required for identified high impact works;
- Overview of community consultation process and assessment required for identified additional works outside of standard construction hours; and
- Induction and training will be provided to relevant staff and sub- contractors outlining their responsibilities with regard to noise.

Examples of typical construction noise mitigation measures are provided in Table 6-6, along with the likely reduction in noise levels. Where reasonable and feasible, these measures should be employed during the construction of the development.

Table 6-6 Indicative Construction Noise Mitigation Measures

Mitigation Measure	Anticipated Noise Reduction, dBA
Administrative Controls	
Operate during approved hours	N/A
Undertake regular noise monitoring to determine the impact of operating plant on sensitive receivers	N/A
Appropriate training of onsite staff	N/A
Undertake community consultation and respond to complaints in accordance with established project procedures	N/A
Turning off machinery when not in use	0-5



Mitigation Measure	Anticipated Noise Reduction, dBA
Respite periods for pile drivers and rock breakers (if applicable)	N/A
Conducting regular maintenance of plant to ensure that they are operating as efficiently and quietly as practicable	N/A
Engineering Controls	
Portable temporary screens	5-10
Screen or enclosure for stationary equipment	10-15
Maximising the offset distance between noisy plant items and sensitive receivers	3-6
Avoiding using noisy plant simultaneously and / or close together, adjacent to sensitive receivers	2-3
Orienting equipment away from sensitive receivers	3-5
Carrying out loading and unloading away from sensitive receivers	3-5
Using dampened tips on rock breakers	3-6
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks	5-10
Selecting site access points and roads as far as reasonably practicable away from sensitive receivers	3-6
Using spotters, closed circuit television monitors, "smart" reversing alarms, or "squawker" type reversing alarms in place of traditional reversing alarms	2-5
Employ non noise-generating structures such as site offices, storage sheds, stockpiles and tanks as noise barriers	5-10

6.4 Predicted Construction Vibration Impacts

The nearest neighbouring building to the site is approximately 10m to the north of the site.

Based on the CNVS's recommended minimum working distances for vibration sensitive equipment (refer to 6.3), the vibration intensive activities that could potentially occur at distances less than the recommended minimum working distances from the sensitive receivers with respect to cosmetic building damage and human comfort are listed in Table 6-7.

Table 6-7 Vibration Intensive Equipment that Could Operate within the Minimum Recommended Distances of Sensitive Receivers

Equipment Potentially Operating Within Recommended Minimum Distances to Sensitive Receivers	
Cosmetic Damage (BS 7385)	Human Response (NSW EPA Guideline)
Vibratory Roller < 4 tonne	Vibratory Roller < 4 tonne
	Medium Hydraulic Hammer – 900 kg
	Piling Rig – Bored

Should these pieces of plant be operated within the minimum recommended distances of the CNVS of a sensitive receiver, or if there are any other vibration intensive plant items that the Contractor has concerns for causing disruption at neighbouring development, it is recommended that a preliminary vibration survey (typically attended vibration measurements) be undertaken of each vibration generating piece of plant.

This vibration survey will determine whether there will be any exceedances of the relevant construction vibration criteria. If exceedances are observed, vibration mitigation and management strategies can be developed to minimise vibration impacts as far as practicable, and ideally to be compliant with the vibration criteria.

The vibration management strategy may also include the installation of unattended vibration monitors at sensitive receivers to notify the contractor of any exceedances of the vibration criteria. Any such vibration management strategy should be developed as part of a CNVMP.

6.5 Construction Traffic Noise Assessment

Given the existing traffic volumes on Waterloo Road and Khartoum Road, it is unlikely that traffic generated during construction works will result in any appreciable change to the levels of road traffic noise currently experienced at surrounding receivers along the construction traffic route.

Access to the site for construction vehicles should be done via Waterloo Road and/or Khartoum Road.

7 NATIONAL CONSTRUCTION CODE

The bounding walls and floors of the residential components of the development should, at minimum, be designed to meet the acoustic requirements of Part F5 of the National Construction Code (NCC), which are presented in Table 23. Where apartments adjoin high noise generating spaces (e.g. a plant room, cinemas) the separating partition construction may be required to exceed the requirements of the NCC in order to maintain an adequate acoustic amenity for the apartment spaces.

Specific constructions required to meet the requirements of the NCC (or any more stringent requirements to preserve acoustic amenity) will be determined at detailed design stage.

Table 7-1: NCC Acoustic Requirements

Construction	NCC Requirements	
	Laboratory Rating	Verification
Walls between sole occupancy units	$R_w + C_{tr} \geq 50$	$D_{nT,w} + C_{tr} \geq 45$
Walls between a bathroom, sanitary compartment, laundry or kitchen in one sole occupancy unit and a habitable room (other than a kitchen) in an adjoining unit	$R_w + C_{tr} \geq 50$ and Must have a minimum 20mm cavity between two separate leaves ¹	$D_{nT,w} + C_{tr} \geq 45$
Walls between sole occupancy units and a plantroom or lift shaft	$R_w \geq 50$ and Must have a minimum 20mm cavity between two separate leaves ¹	$D_{nT,w} \geq 45$
Walls between sole occupancy units and a stairway, public corridor, public lobby or the like, or parts of a different classification	$R_w \geq 50$	$D_{nT,w} \geq 45$
Door assemblies located in a wall between a sole-occupancy unit and a stairway, public corridor, public lobby or the like	$R_w \geq 30$ ²	$D_{nT,w} \geq 25$
Floors between sole-occupancy units or between a sole-occupancy unit and a plantroom, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification	$R_w + C_{tr} \geq 50$ $L_{n,w} \leq 62$	$D_{nT,w} + C_{tr} \geq 45$ $L'_{nT,w} \leq 62$



Construction	NCC Requirements	
	Laboratory Rating	Verification
Soil, waste, water supply and stormwater pipes and ductwork to habitable rooms	$R_w + C_{tr} \geq 40$	N/A
Soil, waste, water supply and stormwater pipes and ductwork to kitchens and other rooms	$R_w + C_{tr} \geq 25$	N/A
Intra-tenancy Walls	There is no statutory requirement for airborne isolation via intra-tenancy walls.	

Note 1: A wall must be of “discontinuous construction” if it separates a sole occupancy unit from a plantroom or lift shaft. Clause F5.3(c) defines “discontinuous construction” as a wall having a minimum 20mm cavity between two separate leaves with no mechanical linkage except at the periphery.

Note 2: Clause FP5.3(b) in the NCC states that the required insulation of a floor or wall must not be compromised by a door assembly.



8 CONCLUSION

This report has presented a noise and vibration impact assessment for the proposed mixed-use development to be located at 85-97 Waterloo Road, Macquarie Park. This assessment has been prepared to address the noise and vibration clauses of the SEARs for the State Significant Development Application (SSD-52604208).

Existing ambient noise levels have been established via long-term unattended noise monitoring as presented in section 2. The noise monitoring data has been processed in accordance with the NPfI to establish the RBLs at sensitive receivers. Short-term attended noise and vibration measurements were conducted to measure road traffic noise and underground rail impacts.

Noise impacts associated with the operation of the development (primarily vehicle noise and mechanical plant noise) have been assessed with reference to the NPfI as presented in section 3. The results of the assessment indicate in-principle that noise emissions from the site are capable of complying with the relevant acoustic requirements through considered design and the implementation of appropriate acoustic treatments and noise management controls.

Noise intrusion from road traffic noise from Waterloo Road have been assessed with reference to the internal noise recommendations of NSW Department of Planning's Development Near Rail Corridors and Busy Roads (Interim Guideline) and AS2107. Indicative recommendations for the building façade construction have been presented in section 4 to achieve the internal noise requirements. These recommendations should be reviewed once the room layouts, glazing areas and ventilation systems have progressed sufficiently.

Noise and vibration impacts from the construction of the development have been assessed in-principle in section 6 of the report in accordance with the ICNG. Construction NMLs have been established for sensitive receivers based on the established RBL. A computer noise model has been developed to predict $L_{Aeq,15min}$ construction noise levels at sensitive receivers.

Construction noise levels have been predicted for a range of construction activities. The predicted $L_{Aeq,15min}$ construction noise levels are expected to slightly exceed the established NMLs for receivers in close proximity to the site. It is therefore recommended that a CNVMP be developed for the site and that all reasonable and feasible measures be implemented to minimise construction noise and vibration impacts.



9 STATEMENT OF LIMITATIONS

This report entitled Noise and Vibration Impact Assessment was prepared by RWDI Australia Pty Ltd ("RWDI") for Goodman Sydney ("Client"). The findings and conclusions presented in this report have been prepared for the Client and are specific to the project described herein ("Project"). The conclusions and recommendations contained in this report are based on the information available to RWDI when this report was prepared.

Because the contents of this report may not reflect the final design of the Project or subsequent changes made after the date of this report, RWDI recommends that it be retained by Client during the final stages of the project to verify that the results and recommendations provided in this report have been correctly interpreted in the final design of the Project.

The conclusions and recommendations contained in this report have also been made for the specific purpose(s) set out herein. Should the Client or any other third party utilise the report and/or implement the conclusions and recommendations contained therein for any other purpose or project without the involvement of RWDI, the Client or such third party assumes any and all risk of any and all consequences arising from such use and RWDI accepts no responsibility for any liability, loss, or damage of any kind suffered by Client or any other third party arising therefrom.

Finally, it is imperative that the Client and/or any party relying on the conclusions and recommendations in this report carefully review the stated assumptions contained herein and to understand the different factors which may impact the conclusions and recommendations provided.