CONSULTANTS

Unit 10, Level 1
1 Maitland Place
NORWEST NSW 2153

PO Box 7660
BAULKHAM HILLS NSW 1755

T 02 9634 6311

ENGINEERS
MANAGERS
INFRASTRUCTURE PLANNERS
DEVELOPMENT CONSULTANTS

Our Reference: NA230258

Your Reference: NA230258 Westmead Hospital Consent Memo Rev2

Monday, 16 September 2024

NSW Health infrastructure

Re: NA230258 Westmead Hospital Consent Memo

1 Introduction

ACOR Consultants Pty Ltd (ACOR) have been engaged by NSW Health Infrastructure to provide acoustic and vibration consulting services for the proposed new World Class End of Life Facility, to be located at the level 5 of Building K (CASB Building) of Westmead Hospital. ACOR have been engaged to undertake an acoustic and vibration assessment of the proposed project site and provide design recommendations to achieve relevant acoustic and vibration requirements.

2 Project Description

It is understood that the proposed facility would be located on Level 5 of the CASB (Building K) Building, which is just above the mechanical plant room on Level 4 for the entire building.

Architectural layout of the proposed facility is provided in Figure 1 below.

Figure 1 General Arrangement Level 5, Building K (CASB Building) – BVN Architects (Schematic Design UPDATES)

3 Regulations, Standards, and Guidelines

The following regulations, standards, and guidelines have been referred to in relation to the noise and vibration impact assessment performed:

- NSW EPA Noise Policy for Industry 2017 (NPI).
- NSW Health – Engineering Services Guidelines 2022.
- NSW EPA Noise Guide for Local Government (NGLG).
- NSW EPA Approved Methods for the Measurement and Analysis of Environmental Noise in NSW.
- AS 1055:2018 – Acoustics – Description and measurement of environmental noise (AS 1055).
- NSW DEC Assessing Vibration: A Technical Guideline (2006)
- Australian/New Zealand Standard AS/NZS 2107: 2016 Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors (AS 2107).
- Protection of the Environmental Operations (Noise Control) Regulations 2017 (POEO).
- NSW RMS Construction Noise and Vibration Guideline – August 2016.
- EPA NSW Interim Construction Noise Guidelines (ICNG) 2009.
- Association of Australasian Acoustical Consultants (AAAC) Guideline for Healthcare Facilities Version 2.
- BS ISO 2631-1:1997 Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration Part 1: General Requirements.
- ISO 2631-2:2003(E) Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 2: Vibration in buildings (1 Hz to 80 Hz).

- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE Applications Handbook – Chapter 49 Noise & Vibration control).
- Australian Standard AS 2670.2:1990 Evaluation of human exposure to whole-body vibration, Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz). N.B. – Please note that this standard was superseded by Australian Standard ISO 2631.2:2014 Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration, Part 2: Vibration in buildings (1 to 80 Hz); however, it is accepted practice within the Australian market to adopt the multiplying factors (R) as presented in Table 2 Appendix A (AS 2670.2:1990) for building vibration from human comfort.
- DIN Standard 4150-3 2016-12 – Vibration in Buildings – Part 3: Effects on Structures.
- BS 6472-1:2008 – Guide to evaluation of human exposure to vibration in buildings - Vibration sources other than blasting.
- ISO 8041:2017 Human response to vibration, ISO 5349 Human response for hand-transmitted vibration and ISO 2631 Human response for whole-body vibration exposure.

4 Reference Documents

Table 1 below shows the documents referred to during the assessment.

Table 1 Reference documents

Document Name	Drawing No.	Prepared By	Project No.	Date
General arrangement – Level 05	WCP-BVN-DRW-ARC-WMD-11B-0500001	BVN	221003	07/06/2024
240621_WCEoL_SD_WS3_Westmead	26.06.2024, WCEOLP SCHEMATIC DESIGN WORKSHOP #3	BVN	221003	26/06/2024
Level 5 Updated Plan	-	BVN	221003	27/06/2024

5 Operational Mechanical Noise Impacts and Assessment

5.1 Criteria - NSW EPA Noise Policy for Industry 2017

Industrial noise can have a significant effect on noise-sensitive receivers (see below). Both the increase in noise level above background levels, as well as the absolute level of noise are important factors in how a community will respond to noise from industrial sources. The project “noise trigger level” established in the NPI addresses each of these components of noise impact. The following subsections show the process of determining the project noise trigger level in accordance with the NPI.

5.1.1 Noise Sensitive Receivers

The project site is located at Level 5 of Building K, Westmead Hospital NSW. The nearest noise sensitive receivers are the Hospital Buildings within the Hospital campus. Figure 2 below shows the project site and the nearby noise sensitive receivers, which are mostly Hospital Buildings. Residential buildings are located 200m to the south-east of the proposed development which are mostly acoustically shielded by the high-rise hospital buildings and noise from nearby roads and mechanical plant noise from the Hospitals.

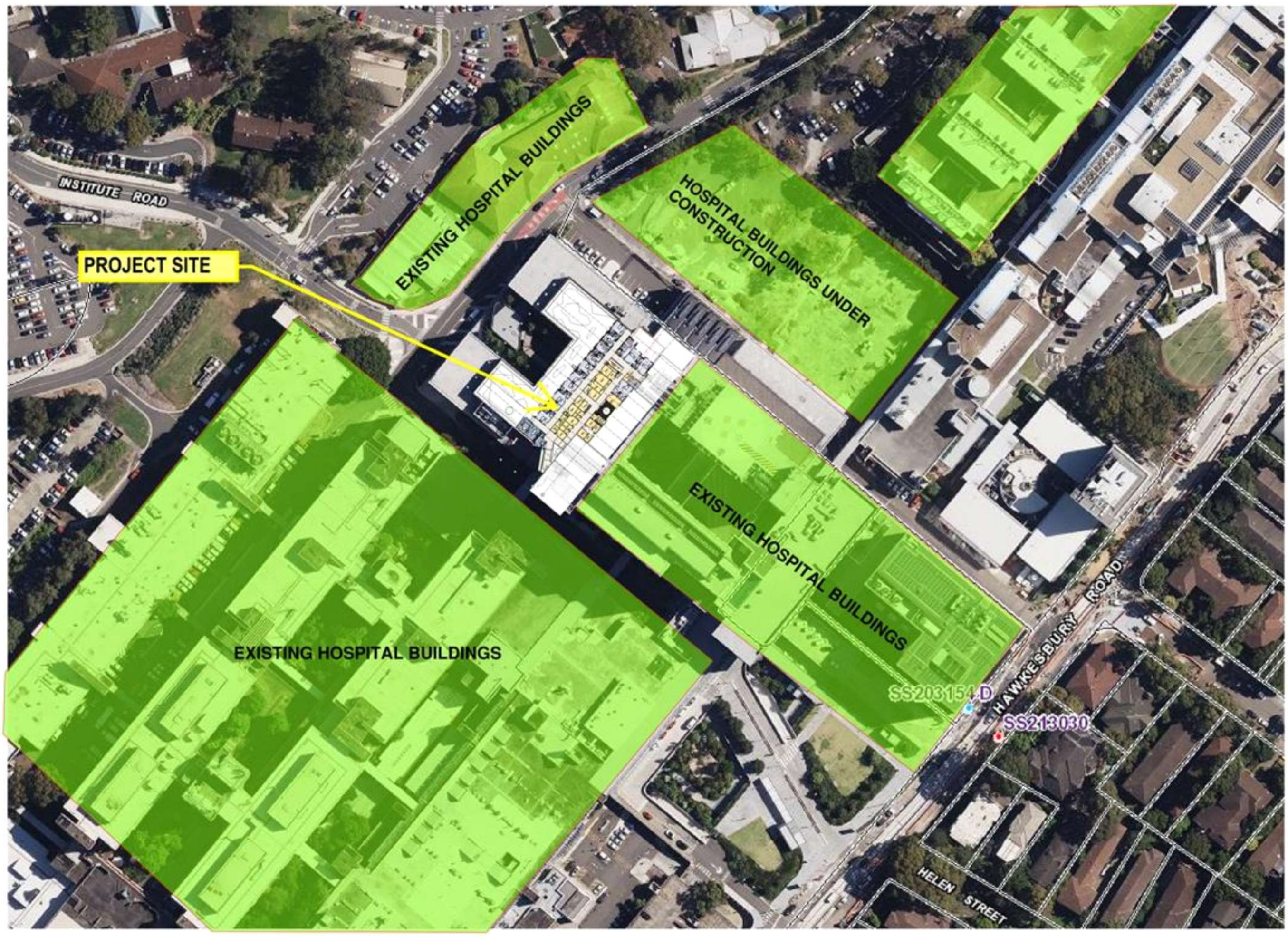


Figure 2 Satellite image showing project site and noise sensitive receivers (Metromap © 2023)

5.1.2 Project Intrusiveness Noise Level

The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source ($L_{Aeq,15min}$) does not exceed the RBL by more than 5 dB, when beyond a minimum threshold (35 dB(A) for the day, 30 dB(A) for the evening and night). This intrusiveness noise level seeks to limit the degree of change a new noise source introduces to an existing environment. The outcome of this approach aims to ensure that the intrusiveness noise level is being met for at least 90% of the time-periods over which annoyance reactions can occur (taken to be periods of 15 minutes). Project intrusiveness noise level is defined as follows:

Project intrusiveness noise level ($L_{Aeq,15min}$) = RBL + 5 dB

Based on the measured RBL presented in *NA230258 Westmead Hospital Schematic Design Report* and the NPI, the project intrusiveness noise levels are established in Table 2.

Table 2 Project intrusiveness noise levels

	Rating Background Level RBL, dB(A)			Project Intrusiveness Noise Levels, $L_{Aeq,15min}$ dB(A)		
	Day	Evening	Night	Day	Evening	Night
At Hospital Buildings (Commercial Buildings)	58	58	58	-	-	-
*This is based on NPI recommended assumed RBLs, the measured levels are affected by operation of mechanical plant equipment and fans.						

5.1.3 Project Amenity Noise Level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPI, where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance.

The recommended amenity noise levels (Table 2.2 of the NPI) represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location. To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows:

Project amenity noise level $L_{Aeq,15min}$ = Recommended amenity noise level – 5 dB(A) + 3 dB(A)

The recommended amenity noise level should be established from Table 2.2 of the NPI based on the noise sensitive receivers' category, determined based on Table 2.3 of the NPI.

As the NPI states, the approach of deriving the project amenity noise level from the recommended amenity noise level minus 5 dB is based on a receiver not being impacted by more than three to four individual industrial noise sources. To standardise the time periods for the intrusiveness and amenity noise levels, NPI assumes that the Amenity $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq,period}$ + 3 decibels (dB).

The NPI recommended Amenity Noise Level and Project Amenity Noise Level for this project are presented in Table 3 below.

Table 3 Project amenity noise levels

Noise Sensitive Receiver	Recommended Amenity Noise Level, LAeq dB(A)			Project Amenity Noise Levels, LAeq,15min dB(A)		
	Day	Evening	Night	Day	Evening	Night
At Hospital (Commercial Buildings)	50 (External) 35 (Internal - noisiest 1 hour)			48 (External) 33 (Internal – Noisiest 1 hour)		

5.1.4 Project Noise Trigger Level

The project noise trigger level is the lower (that is, the more stringent) value of the project intrusiveness noise level and the project amenity noise level determined in accordance with the NPI. The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited, and amenity is protected and that no single industry can unacceptably change the noise level of an area. It is noted that Intrusive noise levels are only applied to residential receivers (residences). For other receiver types identified in Table 2.2 of the NPI, only the amenity levels apply. The project noise trigger levels for this project are established in accordance with the NPI and are shown below in Table 4.

Table 4 Project noise trigger levels

Noise Sensitive Receiver	**Project Intrusiveness Noise Level, $L_{Aeq,15min}$ dB(A)**			**Project Amenity Noise Level, $L_{Aeq,15min}$ dB(A)**			**Project Noise Trigger Level, $L_{Aeq,15min}$ dB(A)**		
	Day	**Evening**	**Night**	**Day**	**Evening**	**Night**	**Day**	**Evening**	**Night**
At Hospital (Commercial Buildings)	-			48 (External) 33 – (Internal – Noisiest 1 Hour)			48 (External) 33 – (Internal – Noisiest 1 Hour)		

5.1.5 Correction for Modifying Factors

Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, a correction should be applied as per the NPI, to the measured or predicted noise levels at the receiver before comparison with the project noise trigger levels. The maximum correction of 10 dB(A) to be applied to the predicted or the measured level where two or more modifying factors are present. NPI recommended correction factors (Table C1 of the NPI) are shown in Table 5.

Table 5 Modifying factor corrections for noise characteristics

Factors	**Corrections[1]**	**Notes**
Tonal Noise	5 dB[2,3]	[1] Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion. [2] Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz. [3] Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard
Low-Frequency Noise	2 or 5 dB[2]	
Intermittent Noise	5 dB	
Duration	0 to 20 dB(A)	
Maximum Adjustment	Maximum correction of 10 dB(A)[2] (excluding duration correction).	

As per the NPI, correction for duration is applied where a single-event noise is continuous for a period of less than two and a half hours in any assessment period. The allowable exceedance of the $L_{Aeq,15min}$ equivalent noise criterion is provided in Table C3 of the NPI for the duration of the event. This adjustment is designed to account for unusual and one-off events and does not apply to regular and/or routine high-noise level events. The adjustments for duration are to be applied to the criterion.

5.1.6 Sleep Disturbance Criteria

The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. NPI recommends, where the subject development/premises night-time noise levels at a residential location exceed:

$L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or

L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

that a detailed maximum noise level event assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period. Based on the NPI, the sleep disturbance criteria for the proposed development are determined as shown in Table 6.

Table 6 Sleep disturbance criteria

Noise Sensitive Receiver	Rating Background Level (RBL) at Night, L_{A90} dB(A)	NPI Recommended Sleep Disturbance Criteria, dB(A)	
		$L_{Aeq,15min}$ (40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater)	L_{AFmax} (52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater)
At Hospital Buildings (Wards)	58	63	73

In addition to the above, NSW Road Noise Policy (RNP) noted that the research on sleep disturbance to date concluded that:

Maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep

One or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

5.2 Operational Noise Impacts Assessment

5.2.1 Control of Building Services Noise (Noise Emission to Outdoor)

Compliance with NSW EPA Noise Policy for Industry 2017 is a legislative requirement in the State of New South Wales. The Policy prescribes procedures for determining the statutory environmental noise limits that apply at noise sensitive locations (such as residential areas) due to noise due to commercial, industrial and trade operations.

Current understanding of mechanical plant equipment installed within existing building or at rooftop is not scheduled to be modified, with no predicted change to existing noise emission profile at nearby noise sensitive receivers.

Mechanical plant equipment may change during successive stages of the project. Noise emission impacts and profile to be re-assessed during later reporting stages.

6 Helicopter Noise Intrusion Assessment and Recommendations

6.1 Acoustic Design Criteria

NSW Health – Engineering Services Guidelines 2022 stipulates that Helicopter operations can exhibit similar noise characteristics to fixed wing aircraft pass-bys and generate high levels of short period steady noise levels hovering or idling. However, emergency medical helicopter operations differ from fixed wing aircraft as:

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

Please refer to the information below relating to the number of historical helicopter movements per year. note Wyong is a retrieval only hospital and do not drop offs.

Location of the Helipad in relation to the project site is shown in Figure 3.

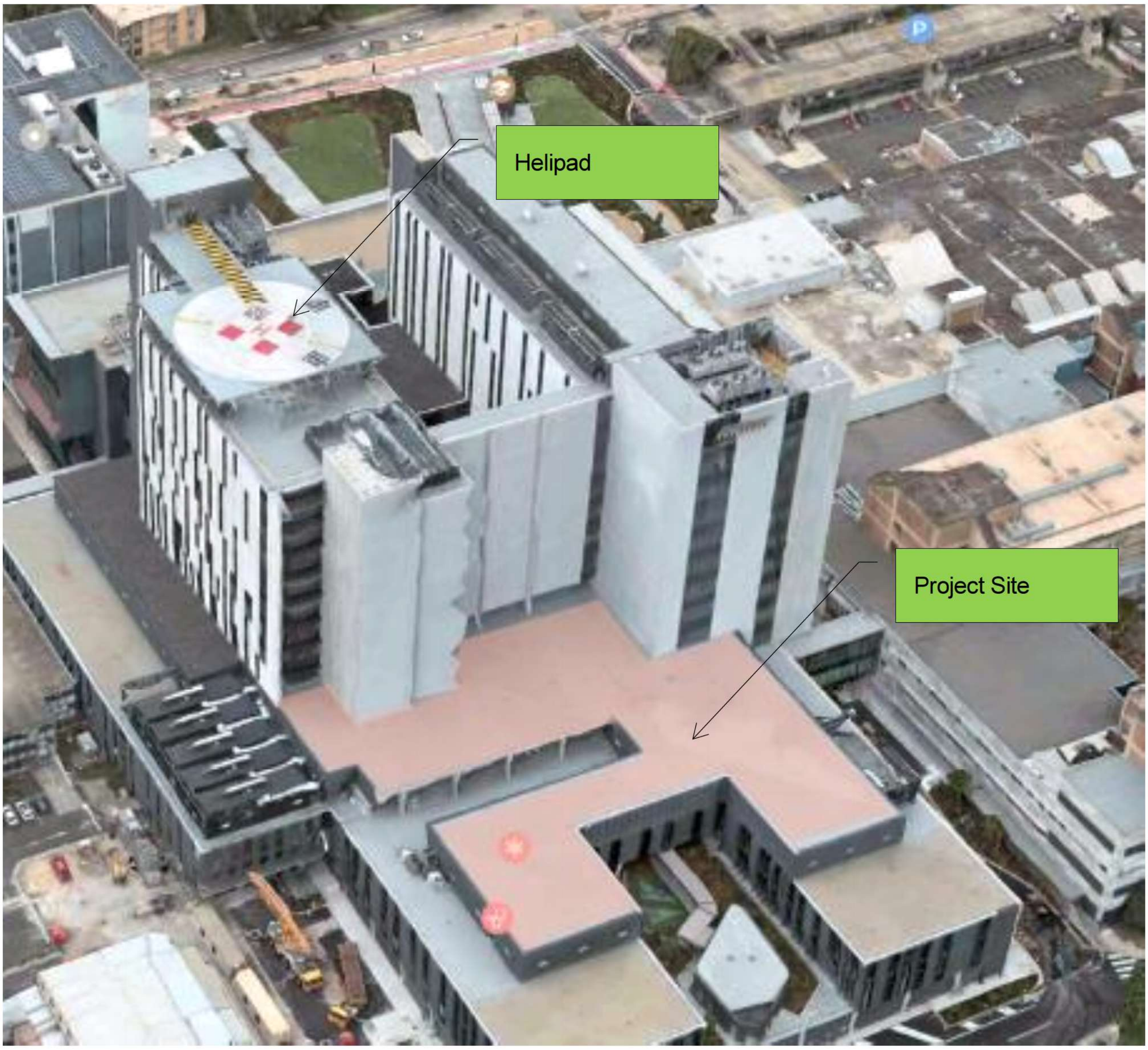


Figure 3 Location of the project site and helipad

Summary of helicopter movements at building K of Westmead Hospital in 2023 are presented in Table 7 below.

Table 7 Helicopter Movements for Westmead Hospital during 2023

Month	Movements	Month	Movements
January 2023	28	July 2023	25
February 2023	30	August 2023	29
March 2023	28	September 2023	38
April 2023	36	October 2023	29
May 2023	23	November 2023	18
June 2023	27		

Frequency of helicopter movements is assumed to continue throughout the lifecycle of the development Table 8 below outlines the internal noise level criteria that should be considered with respect to the new redevelopment.

Table 8 Helicopter noise intrusion criteria

Room	NSW Health Recommended Internal Noise Levels, L_{Amax} dB(A)
Private Offices, Meeting Rooms	70
Open Plan Office	75
Corridors and Lobbies, Reception and Waiting areas	80
Consulting rooms, Interview and Counselling Rooms	65
Single Patient Bedroom	68
Multi Bedroom	68
Cafeteria/Dining	80

6.2 Acoustic Design Advice

Noise intrusion to the building from the external environment has the potential to affect the acoustic amenity within the working environment. The main external noise sources that have been identified in the vicinity of the building are listed below:

- Mechanical Plant/Equipment serving adjacent buildings.
- Helicopter take-off and landing.

Helicopter noise readings have been taken using an unattended noise logger with data correlated to helicopter movement dates and time provided by the client. Table 9 below presents a summary of the measured noise levels that would be used for acoustic design of the proposed palliative care facility.

Table 9 External Noise Measurement Results

Location	Octave – Band Centre Frequencies (Hz) Sound Power Level, dB									Total, dB(A)	Main Noise Contributors
	31.5	63	125	250	500	1000	2000	4000	8000		
North Façade, L_{Aeq} (Measurement Location 11)	70	67	71	69	71	71	59	50	38	73	Mechanical plant noise from Level 4 Mech plant noise from nearby buildings.
South Façade, , L_{Aeq} (Measurement Location 1)	70	69	67	68	70	68	62	56	45	72	
East Façade, , L_{Aeq} (Measurement Location 13)	70	68	66	65	65	62	55	53	38	66	
West Façade, , L_{Aeq} (Measurement Location 7)	71	68	68	65	63	61	56	53	44	66	
All Façade, L_{Amax}	98	98	99	102	100	95	89	83	92	101	Helicopter Noise

6.2.1 External Glazing

The building façade will be designed to control external noise intrusion to meet internal noise levels in accordance with Australian Standards and guidelines. This section documents the external glazing recommendations to achieve the nominated internal noise criteria.

Minimum façade glazing requirements are shown on the markup provided in Figure 4. Table 10 presents the specification of the minimum glass for the external façade.

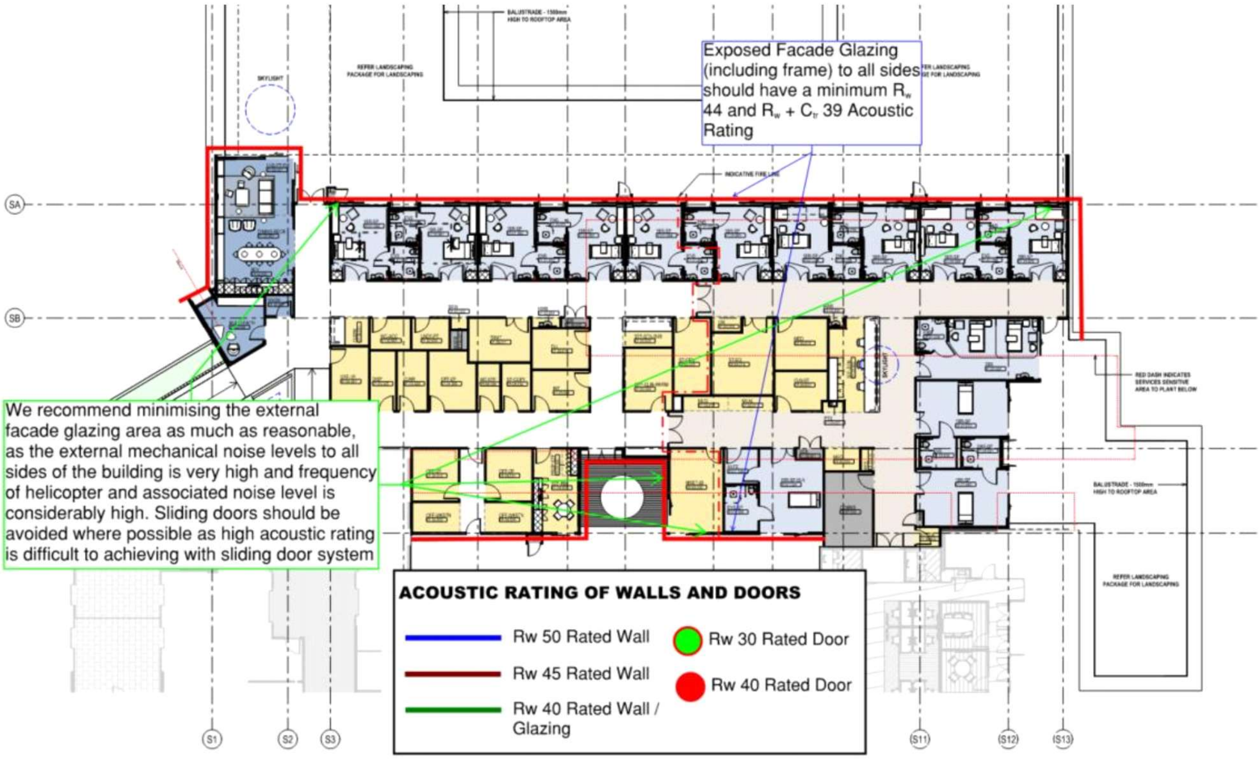


Figure 4 Glazing markup and recommendations

Table 10 Façade Glazing

Room	Glazing Construction	Minimum Acoustic Rating
All Façade		
All Rooms	▪ Double Glazed Unit (Viridian or approved equivalent) comprising of: ▪ 10mm VFloat Glass ▪ 16mm air space ▪ 10.5mm VLam Hush Glass	R_w 44 & $R_w + C_{tr}$ 39

6.2.2 External Walls

Table 11 documents the external wall recommendations to achieve the nominated internal noise criteria.

Table 11 Façade wall types

Room	R_w Rating	Preliminary Recommended Façade Construction
All Facade		
All Rooms	R_w 52 & R_w+Ctr 42	▪ 12mm Cemitel CFC Sheet (23.4 kg/m2) or equivalent cladding on Steel Batten (20mm to 35mm) ▪ 2x16mm Fire/Moisture Rated Plasterboard (minimum 12.5 kg/m2 per layer) ▪ 90mm steel studs at maximum 600mm centres ▪ 90mm Gold Batts R2.5 Insulation within cavity ▪ 2x16mm Fire Rated Plasterboard (minimum 12.5 kg/m2 per layer) Per CSR 5174 or approved equivalent

Room	R_w Rating	Preliminary Recommended Façade Construction
		▪ Masonry/ Corefilled Blockwork Wall (minimum 140mm thicke) ▪ Minimum 40mm cavity ▪ Minimum 92mm steel studs at maximum 600mm centres ▪ 90mm Gold Batts R2.5 Insulation within cavity ▪ 1x13mm Standard plasterboard (or equivalent) Per CSR 5403 or equivalent

Further detailed modelling will be undertaken during the design stages to confirm the suitability of the final façade construction requirements.

6.2.3 External Doors

Table 12 documents the external door assembly recommendations to achieve the nominated internal noise criteria

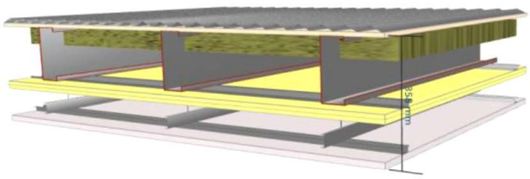
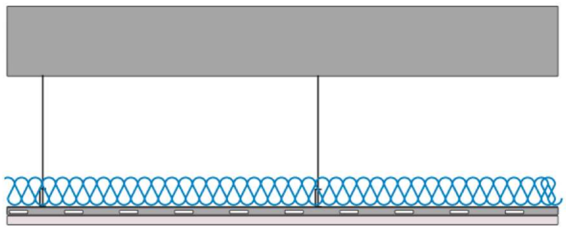
Table 12 Examples of door assemblies

Room	Rw Rating	Door Type	Example
All Facade			
All Rooms	Rw 44	Solid Acoustic Door	Option 1: Pyropanel AS-SPECIAl-A2 (Rw 45) with manufacturer's recommended acoustic seals and installation instructions. Option 2: Doorcraft DAC 45 Acoustic Door A2 (Rw 45) with manufacturer's recommended acoustic seals and installation instructions.
		Glazed Swing Door	Option 1: Darley Aluminium's Klassic View Acoustic Door (8.5 Hush/16/12.5 Hush). Option 2: QRK System Double Glazed Acoustic Door (12.38mm & 10.38mm laminated Glass).
		Glazed Sliding Door	Not Recommended

6.2.4 Roof System

Roof-ceiling assembly should achieve a minimum R_w 57 & R_w+C_{tr} 47 Acoustic rating. Example of roof constructions that are predicted to achieve these requirements are provided in Table 13.

Table 13 Example of roof constructions

Room	Roof system	Example Construction
All	**Option 1: Lightweight Roof** ▪ 0.6 BMT profiled steel. ▪ 1 x 12mm Structural Plywood (marine grade). ▪ Minimum 200mm deep Steel C-Purlin and resilient rail (Rondo 581 or equivalent) ▪ 2 x 70mm Soundscreen Acoustic Insulation with density of 26kg/m3 in the cavity. ▪ 2 x 13mm acoustic rated plasterboard (13 kg/m2 per layer) ▪ Suspended Light Steel Grid with minimum 100mm cavity (Empty cavity). ▪ 1 x 19 mm Mineral fibre ceiling tile – NRC 0.7 and CAC 40.	
	Option 2: Concrete Roof ▪ 200mm Concrete Slab. ▪ Suspended Light Steel Grid with minimum 300mm cavity. ▪ 1 x 19 mm Mineral fibre ceiling tile (NRC 0.7 and CAC 40) on the suspended grid.	

Alternative constructions can be selected but must be approved by the Acoustic Engineer or supplier. Final roof construction is to be reviewed and accepted the client.

Wall to ceiling/roof junctions must be appropriately detailed based on manufacturers specification to not reduce the sound insulation performance due to noise flanking. Junction detailing will be coordinated and reviewed during the documentation phase, including detailing for acoustically rated walls to underside of the roof system.

The building will need to provide appropriate acoustic isolation between adjoining spaces to maintain acoustic privacy and minimise intrusiveness.

7 Operational Vibration Impacts, Assessment and Mitigation Measures

During construction activities, the recommended vibration levels should be complied at all times with DIN 4150 and NSW DEC Assessing Vibration: A Technical Guideline (2006).

If there is any risk of vibration exceedance, a vibration monitoring system should be installed, to warn the Head contractor and the Operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching to the criteria.

7.1 Building Vibration Criteria

7.1.1 Human Comfort

Human response to floor motion is a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly the acceptance criteria for human comfort are difficult to define and quantify.

Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g., office, meeting rooms, residential etc.) and the character of vibration (e.g., continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

Vibration transfer within a building has the potential to adversely affect the occupants. The building structure must be designed to achieve appropriate levels of vibration to minimise such adverse effects.

The concept of using base curves to assess human comfort has been adopted from Australian Standard 2670.2:1990. NB - Please note that this standard was superseded by AS ISO 2631.2:2014, however, it is accepted practice within the Australian market to adopt the multiplying factors as presented in Table 2 Appendix A (2670.2:1990) for building vibration from human comfort.

A base curve marks the threshold of human perception and is defined in one-third octave bands from 1 Hz to 80 Hz. Vibration levels below the base curves typically do not result in adverse comments or complaints from occupants. The vibration criteria for different occupancy types are obtained by multiplying the base curve by a factor. Multiplying factors for different occupation types on the recommendations in AS 2670.2:1990 are listed in Table 14.

Table 14 Multiplying factors for satisfactory magnitudes of building vibration

Room Type	**Multiplying Factor**	
	Continuous or Intermittent Vibration	**Transient Vibration excitation with several occurrences per day**
Critical working areas (for example some hospital operating-theatres, some precision laboratories)	1.0	1.0
Residential	2.0 to 4.0 (Day) 1.4 (Night)	30 to 90 (Day) 1.4 to 20 (Night)
Boardroom/conference, open plan and private offices	4.0	60 to 128
Engineering, Workshop, co-working and collaborative spaces, Plant rooms	8.0	90 to 128

The ASHRAE curves include workshop, office, residential, operating room and VC curves for sensitive equipment. Velocity vibration criteria curves (RMS) defined in one-third octave frequency bands (CPB) range 1 to 80 Hz are shown in Table 15.

Table 15 Human Comfort and Equipment Vibration Criteria from Continuous Vibration

Location	**Assessment Period**	**1 to 80Hz Curve mm/s**
Workshops	Day/ Night Period	0.813
Office Areas, Consulting, examination, treatment, procedures, interview, counselling	Day/ Night Period	0.406
Residential	Day	0.203
	Night	0.144
Hospital operating theatres rooms and critical work areas	Day/ Night Period	0.102
Single bed ward, Multiple bed ward, General intensive care wards and the like	Day/ Night Period	0.140

Guidelines for human comfort with respect to vibration within a building are also provided by *NSW Environmental Noise Management – Assessing Vibration: a technical guide (February 2006)*. This technical guideline provides acceptable RMS acceleration and velocity for continuous, impulsive and intermittent vibration. Velocity and acceleration limits are presented in Table 16.

Table 16 Velocity and acceleration criteria for exposure to continuous and impulsive vibration

Location	**Assessment Period**	**RMS velocity (mm/s)**		**RMS acceleration (m/s2)**		**Peak velocity (mm/s)**	
Continuous Vibration							
		Preferred	Maximum	Preferred	Maximum	Preferred	Maximum
Workshop	Day/Night Period	0.80	1.6	0.040	0.080	1.1	2.2
Offices	Day/Night Period	0.40	0.80	0.020	0.040	0.56	1.1
Critical Areas, include hospital operating theatres and precision laboratories where sensitive operations are occurring	Day/Night Period	0.10	0.20	0.0050	0.010	0.14	0.28
Residences	Day	0.20	0.40	0.010	0.020	0.28	0.56
	Night	0.14	0.28	0.007	0.014	0.20	0.40
Impulsive Vibration							
Workshop	Day / Night Period	13	26	0.64	1.28	18.0	36.0
Offices	Day / Night Period	13	26	0.64	1.28	18.0	36.0
Critical Areas, include hospital operating theatres and precision laboratories where sensitive operations are occurring	Day / Night Period	0.10	0.2	0.0050	0.010	0.14	0.28
Residences	Day	6.0	12.0	0.30	0.60	8.6	17.0
	Night	2.0	4.0	0.10	0.20	2.8	5.6

7.1.2 Vibration Dose Values (VDV)

The vibration dose value (VDV) is fully described in British Standard BS 6472:2008 Guide to Evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting.

Table 17 below presents the vibration criteria for human comfort, in terms of preferred and maximum vibration dose values as described in BS 6472 and provided by *NSW Environmental Noise Management – Assessing Vibration: a technical guide (February 2006)*. The VDV level can be directly related to vibration discomfort experienced by a person. VDV accumulates the vibration energy received over the daytime and night-time periods.

Table 17 Maximum vibration dose values for intermittent vibration

Place	Vibration Dose Values ($m/s^{1.75}$)			
	Daytime (7am – 10pm)		Night-time (10pm – 7am)	
	Preferred	Maximum	Preferred	Maximum
Critical Areas, hospital operating theatres and precision laboratories where operations are occurring	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices	0.40	0.80	0.40	0.80
AAAC Guideline for Healthcare Facilities: Single bed ward (including Mental Health, Parent Accommodation), Multiple bed ward, General intensive care wards, Neonatal or paediatric ICUs, and the like	-	0.20	-	0.10
AAAC Guideline for Healthcare Facilities: Consulting, examination, treatment, procedures, interview, counselling etc.	-	0.40	-	0.40
AAAC Guideline for Healthcare Facilities: Boardroom/conference, open plan and private offices, etc.	-	0.80	-	0.80

7.1.3 Structure-Borne Noise

Table 18 presents the structure-borne noise criteria for noise sensitive receivers

Table 18 Structure-Borne Noise Criteria for Sensitive Receivers

Type of occupancy	Time Period	AAAC Structure -borne noise criteria, dB
Sleeping areas	Night, 10pm to 7am	35 $L_{Amax,s}$

The theoretical/empirical assessment indicates that the structure-borne noise levels predicted within the new development are above the established LAmax,s criteria and the risk of structure -borne noise is high.

7.1.4 Vibration and Structure-Borne Noise Summary

The structure-borne noise and vibration assessment indicates that both the external vibration and structure-borne noise levels does not meet the established criteria at some locations where sleeping areas will be located, so there is a risk of vibration intrusion due to the existing mechanical plant in Level 4. Therefore, we recommend additional structural isolation measures to mitigate external vibration ingress.

7.2 Structure-Borne Noise and Vibration Assessment and Design Recommendations

Existing building services generate noise and vibration and can be transmitted through the structure from Level 4 to Level 5 development. Considerable resonance effects may take place in the higher storeys. Slabs and walls are frequently excited to near-resonance amplitudes. The fundamental frequency of these elements lies between 10 and 30 Hz, whereas the horizontal fundamental frequencies of entire structures often are between 5 and 10 Hz. Floors with a natural frequency in the range from 6 to 15 Hz are particularly sensitive to this excitation.

We understand that the new facility would be sitting above the existing plant room. To minimise structure-borne noise and vibration into the new structure, a base isolation system has become a practical strategy for vibration isolation. We recommend decoupling the existing concrete columns or other structural connection from the new structure with an elastomeric point bearing isolation system such as polyurethane or natural rubber; or alternatively a concrete/lightweight floating floor implementing steel spring isolators between both structures.

Basically, the isolation system introduces a layer of low lateral stiffness between the building structure and the existing columns or concrete floor. These types of systems are also very effective solutions in reducing the perturbancy frequencies generated by building services such as generators, chillers, pumps, AHUs etc. The elastic properties of the vibration isolation elements are therefore of crucial significance to determine the effectiveness of vibration isolation.

The isolation system shall be sized to adequately support the weight of the new building structure at each grid location to avoid lateral movements to achieve desired bearing pressures. The choice of the type of system will require a careful study during the design detail stages. The excitation frequency must be well separated from the natural frequencies of the structure to avoid unwanted resonances and vibration amplifications.

The static stiffness of the point bearing is significant to ascertain the deformation under static load AND the dynamic stiffness is a crucial parameter to determine the natural frequency of an oscillatory system. The natural frequency of an elastomer compressed is dependent upon Young's Modulus (E), its shape and size such as thickness, area and dynamic stiffness (Kdyn). Consequently, increasing the thickness and reducing the size of the proposed pad, the natural frequency decreases, until the desired degree of isolation is achieved. Based on the simple degree of freedom system (expressed in terms of transmissibility), effective isolation; as a general principle, the ratio (r) of the excitation frequency (f) to the natural frequency of the mass-spring system (f0) should be at least $>\sqrt{2}$ (e.g., $r = f/f0 > \sqrt{2}$). The isolation system must provide a sufficient gap with respect to the excitation frequencies and the natural frequencies of the structure.

It is critical to ensure that the only physical contact with the new building structure is via the elastomeric bearing or steel springs, i.e., there must be no rigid connection between both structures.

The proposed isolation system with elastic point bearings should achieve 8-11Hz natural frequency by suitable choice of material and dimensions, while using steel springs should achieve 3-7Hz natural frequency. These point bearings (refer to Figure 5 for preliminary locations) must be strong and stiff under vertical loads and flexible under lateral forces. The stainless-steel plates are used to better distribute the forces within the point bearings. Additionally, this also increases the performance of the point bearings since the full extent of the shape-factor of the material can be utilized.

In order to achieve the relevant criteria, three preliminary isolation systems are recommended for the project as presented in the following sections.

Figure 5 Potential location of the elastomeric point bearing isolation

7.2.1 Option 1 – HRB HS Sylodyn Elastomeric Sheeting

- 100/150mm thick reinforced concrete floor. To be confirmed in further stages of the project with the Structural Engineer.
- The vibration isolation system should provide a natural frequency of approximately 8 to 10Hz. The steel plate should be decoupled by an elastomeric point bearing, consisting of 1 layer of 50/75mm thick HRB HS Sylodyn Elastomeric sheeting (Getzner).
- Figure 6 and Figure 7 presents two samples of point bearings using HRB HS Sylodyn point bearings to be installed at each support. Additional steel stopper which screwed into the concrete can be designed if necessary for lateral restrictions.
- Preliminary base plate recommendations – 25mm thick. To be confirmed in further stages of the project.

Figure 6 HRB HS Sylodyn Elastomeric Pad

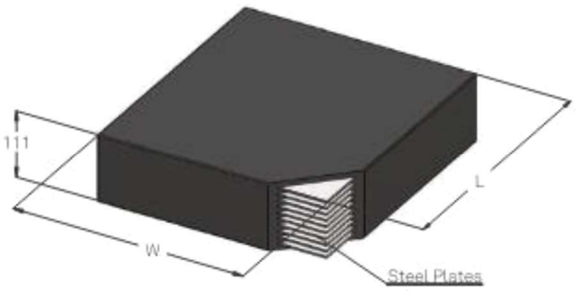
Figure 7 HRB HS Sylodyn Elastomeric Pad

7.2.2 Option 2 – Multi-Plate Rubber Bearings

- 100/150mm thick reinforced concrete floor. To be confirmed in further stages of the project with the Structural Engineer.
- The vibration isolation system should provide a natural frequency of approximately 8 to 10Hz. The steel plate should be decoupled by an elastomeric point bearing, consisting of 1 layer of 111mm thick IRHD 53 natural rubber Multi-Plate Rubber Bearings (MRB, Embelton). Figure 8 presents isometric view and

section details using BBP-NR point bearings to be installed at the building floor supports. Additional steel stopper which screwed into the concrete can be designed if necessary for lateral restrictions.

- Preliminary base plate recommendations – 25mm thick. To be confirmed in further stages of the project.



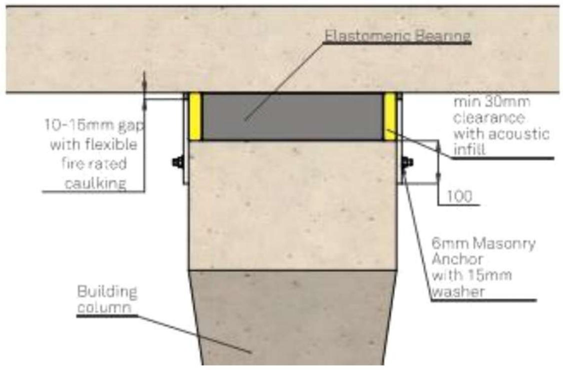


Figure 8 Multi-Plate Rubber Bearings

7.2.3 Option 3 – Lightweight floating floor with steel spring isolators

- Minimum 3 layers of 24mm thick compressed fibre cement flooring.
- Steel spring mounts up to 25mm maximum static deflection and minimum 3.5 to 4Hz of natural frequency including 50mm thick, 48kg/m3 acoustic insulation within the floor cavity.

Section diagram outlined in Figure 9.

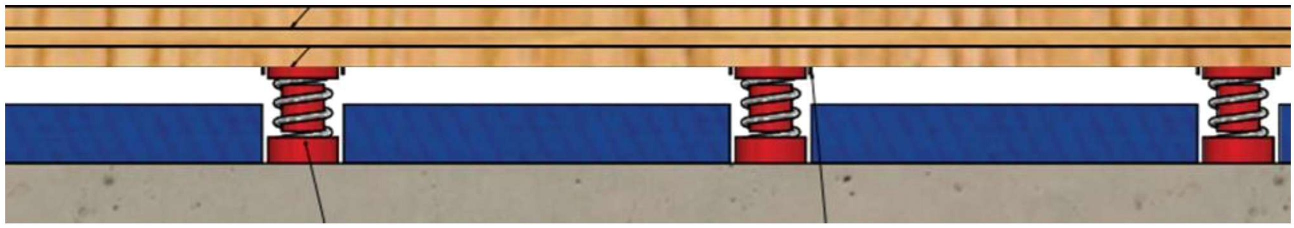


Figure 9 Lightweight floating floor

8 Construction Noise and Vibration Assessment

8.1 Criteria - Interim Construction Noise Guideline

The Interim Construction Noise Guideline (ICNG) (DECC, 2009) guideline recommends standard hours for construction activities as Monday to Friday: 7am to 6pm, Saturday: 8am to 1pm and no work on Sundays or public holidays. These hours are not mandatory and the ICNG acknowledges that the following activities have justification to be undertaken outside the recommended standard construction hours assuming that all reasonable and feasible mitigation measures are implemented to minimise the impacts to the surrounding sensitive land uses:

- the delivery of oversized plant or structures that police or other authorities determine to require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours

- works which maintain noise levels at sensitive receivers to below the noise management levels outside of the recommended standard construction hours.

Construction noise management levels at sensitive residential receivers are provided in Table 19. The construction noise management levels during recommended standard hours represent a noise level that, if exceeded, would require management measures including:

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

The management measures are aimed at reducing noise impacts at the residential receivers. However, it may not be reasonable and feasible to reduce noise levels to below the noise affected management level. The noise affected construction noise management levels during recommended standard hours is not intended as a noise limit but rather a level where noise management is required and as such should not be included as a noise limit in the environmental protection license.

Table 19 Residential construction noise management levels, dBA

Time of day	Noise Management level, $L_{Aeq\ (15\ min)}$	Application Notes
Recommended standard hours	Noise affected: RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. where the predicted or measured $L_{Aeq,15\ min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level the proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected: 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school, or mid-morning or mid-afternoon for works near residences) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected: RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable measures have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Noise management levels for other sensitive land uses are provided in Table 20 and only apply when the properties are in use.

Table 20: Noise management levels for other sensitive land uses

Land Use	Noise management, $L_{Aeq,15\ minute}$
Commercial premises	70 dBA (external)
Hospital Wards and operating theatres	45 dBA (internal)

A summary of the construction noise management levels is provided in Table 21.

Table 21: Proposal construction noise management levels, dBA

Land Use	Noise management, $L_{Aeq,15\ minute}$
Commercial premises - Offices	70 dBA (external)
Hospital Wards and operating theatres	45 dBA (internal)

8.2 Construction Noise Assessment and Recommended Mitigation Measures

It is understood that the project is currently at schematic design stage and there is no contractor engaged or any construction plan developed, therefore assessment of construction noise and vibration is preliminary at this stage. The noise emissions from construction have been assessed at the surrounding potentially affected receivers during the standard construction hours.

Construction activities would generally be carried out during the recommended standard construction working hours. Early morning oversized deliveries may be required on occasion for some of the construction works and may occur outside the recommended construction hours. No work should be scheduled on Sundays or public holidays.

Construction traffic movements would primarily be associated with the transportation of construction machinery and equipment to the proposal site and the transportation of material. Plant and equipment needed for the proposal would be determined during the construction planning phase. Other equipment may be used however it is anticipated that they would produce similar noise emissions.

It is understood that the construction works will be on the Level 5 Building K open roof area (project site). However, the construction activity might risk causing elevated internal noise levels within adjacent functional areas of the building.

The magnitude of off-site noise impact associated with construction will be dependent upon a number of factors:

- The intensity and location of construction activities.
- The type of equipment used.
- Existing background noise levels.
- Intervening terrain and structures.
- The prevailing weather conditions

8.2.1 Airborne Construction Noise Impacts

The equipment noise levels were distance attenuated from the site and the noise levels are shown below. Propagation calculations account for sound intensity losses due to hemispherical spreading, with additional minor losses such as atmospheric absorption, directivity, ground absorption and shielding ignored in the calculations. No construction equipment has been planned at this stage, therefore noise assessment from the following construction equipment is for preliminary planning only.

Table 22 below presents nominated construction plant and equipment noise levels at distance.

Table 22 Construction plant and equipment noise levels at distance

Plant and equipment	Noise level at distance							
	25m	50m	100m	150m	200m	300m	400m	500m
Truck (medium rigid)	64	58	52	48	46	42	40	38
Road truck	69	63	57	53	51	47	45	43
Scissor Lift	59	53	47	43	41	37	35	33

Plant and equipment	Noise level at distance							
	25m	50m	100m	150m	200m	300m	400m	500m
Franna crane	59	53	47	43	41	37	35	33
Bulldozer D9	77	71	65	61	59	55	53	51
Scraper 651	71	65	59	55	53	49	47	45
Excavator (tracked) 35t	71	65	59	55	53	49	47	45
As above + hydraulic hammer	83	77	71	67	65	61	59	57
Grader	74	68	62	58	56	52	50	48
Dump truck	71	65	59	55	53	49	47	45
Compactor	67	61	55	51	49	45	43	41
Roller (large pad foot)	70	64	58	54	52	48	46	44
Water cart	68	62	56	52	50	46	44	42

Where the predicted $L_{Aeq,15\ minute}$ noise level is greater than the noise affected level all feasible and reasonable work practices should be applied, however, it is unlikely that mitigation measures would reduce the predicted noise levels below the management levels. The magnitudes of construction noise levels are dependent on the duration of construction, the type of equipment, location of activities, the surrounding environment's background noise levels and the weather conditions during construction. The predicted noise levels are generally conservative as the construction noise model predicts the worse-case 15-minute scenario and these levels may not represent the actual noise emission experienced by the community throughout the entire construction period.

It is noted that the closest residential land use zone on Hawkesbury Rd is approximately 200m from the proposed site boundary. Based on the straight-line distance calculation from proposed site boundary and closest residential land use zone there are no predicted impacts to residential amenity during any of the designated standard work periods.

8.3 Construction Vibration Impacts

As a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant are listed in the Table 23 below. The minimum distances are quoted for both "cosmetic" damage (refer BS 7385) and human comfort (refer OH&E's Assessing Vibration - a technical guideline). The minimum working distances for cosmetic damage must be complied with at all times, unless otherwise approved by Roads and Maritime or under the environmental license as relevant. DIN 4150 has criteria of particular reference for heritage structures.

Table 23 Recommended buffer distance for control of construction vibration

Plant Item	Rating/ /Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5m	15 to 20m
	< 100 kN (Typically 2-4 tonnes)	6m	20m
	< 200 kN (Typically 4-6 tonnes)	12m	40m
	< 300 kN (Typically 7-13 tonnes)	15m	100m
	> 300 kN (Typically 13-18 tonnes)	20m	100m
	> 300 kN (> 18 tonnes)	25m	100m

Plant Item	Rating/ /Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration guideline)
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2m	7m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7m	23m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22m	73m
Vibratory Pile Driver	Sheet piles	2m to 20m	20m
Pile Boring	≤ 800 mm	2m (nominal)	4m
Jackhammer	Hand held	1m (nominal)	2m

The minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions. Vibration monitoring is recommended to confirm the minimum working distances at specific sites.

Operational aspects of some receivers may be highly sensitive to noise and vibration over and above typical noise and vibration allowances based on annoyance and human comfort. For highly sensitive receivers (eg, high technology facilities with sensitive equipment, recording studios and cinemas), specific assessment is required to ensure satisfactory operation of the facility and determine if any mitigation or management measures are required to minimise the potential impacts. Some guidance where building contents contain sensitive equipment may be found in these additional references:

- Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration, p16
- Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment Proceedings of International Society for Optical Engineering (SPIE), Vol. 1619, San Jose, CA, November 4-6, 1991, pp. 71-85
- ASHRAE Applications Handbook (SI) 2003, Chapter 47 Sound and Vibration Control, pp47.39-47.40
- ISO 8569 1996 Measurement & Evaluation of Shock & Vibration Effects on Sensitive Equipment in buildings

In relation to human comfort (response), the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed (see OEH's Assessing Vibration: a technical guideline). Where the predicted vibration levels exceed the human comfort objectives, procedures are to be followed in order to mitigate the potential impacts at sensitive receivers.

If the predicted ground-borne vibration levels exceed the cosmetic damage objectives, a different construction method with lower source vibration levels must be used where feasible and reasonable otherwise construction works should not proceed unless attended vibration measurements are undertaken at the commencement of the works. If there is any risk of exceedance of the cosmetic damage objective, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the cosmetic damage objective.

8.3.1 Standard Mitigation Measures

The following standard actions and mitigation measures presented in the following Table 24 should be implemented, where applicable.

Table 24 Standard Mitigation Measures (Source NSW RMS Construction Noise and Vibration Guideline)

Action Required	Applies to	Details
Management Control		
Site inductions	Airborne noise. Ground-borne noise & vibration.	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: all project specific and relevant standard noise and vibration mitigation measures relevant licence and approval conditions permissible hours of work any limitations on high noise generating activities. location of nearest sensitive receivers construction employee parking areas designated loading/unloading areas and procedures. site opening/closing times (including deliveries) environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Attended vibration measurements	Ground-borne vibration	Where required attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Source Control		
Construction hours and scheduling.	Airborne noise. Ground-borne noise & vibration.	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours work	Ground-borne noise & vibration. Airborne noise.	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide, work should be carried out in continuous blocks that do not exceed 3 hours each with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis and may not be applicable to all projects.
Equipment selection.	Airborne noise. Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Plan worksites and activities to minimise noise and vibration.	Airborne noise. Ground-borne vibration.	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible.

Action Required	Applies to	Details
		Very noise activities should be scheduled for normal working hours.
Reduced equipment power	Airborne noise. Ground-borne vibration.	Use only the necessary size and power
Non-tonal and ambient sensitive reversing alarms	Airborne noise.	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of goods to construction sites.	Airborne noise.	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.
Path Control		
Shield sensitive receivers from noisy activities.	Airborne noise.	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

8.3.2 Additional Mitigation Measures

It is recommended that the following mitigation measures should be adopted.

- Construction should be undertaken within an enclosed area. A substantial solid acoustic barrier should be implemented around all proposed site work and offices. Examples of suitable barriers are (not limited to): solid construction hoarding, timber lapped and capped fencing, shipping container.
- Construction should be adopted during daytime period in consultation with the client.
- Recommend use of flexible noise barriers with internal absorptive finishes (i.e Echo Barrier H10, Flexshield)
- Minimise voices and reduce the radio/music noise.
- Administrative control for highly sensitive patients in adjacent wards to be implemented in the form of up to and including, notification, respite periods or alternative accommodation.

8.4 Sleep Disturbance

All construction activity is expected to occur during recommended standard hours therefore sleep disturbance impacts at the neighbouring residential receivers are not expected.

8.5 Construction Traffic Impacts

The application notes for the Road Noise Policy state that "for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result, the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds, the relevant day or night noise assessment criterion." This is also considered to be applicable for construction noise therefore if road traffic noise increases from construction is within 2 dB(A) of current levels then the objectives on the Road Noise Policy are achieved.

A significant increase in traffic volumes would be needed in order to increase road traffic noise by 2 dB(A) (a doubling in traffic corresponds to an approximate 3 dB(A) increase). Construction work would generate light and heavy vehicle movements associated with employees, deliveries, transportation of machinery, materials and equipment to work sites.

The increase in vehicle movements would be limited to the period of construction. Noise level increases due to construction traffic would not be significant when compared with the existing vehicle numbers in the study area.

9 Conclusion

ACOR Consultants Pty Ltd has undertaken an acoustic and vibration review of the proposed World Class End of Life Program, to be located at Level 5, Building K, Westmead Hospital, NSW.

Acoustic design review and recommendations are provided to achieve the relevant acoustic and vibration criteria for this project, as per below:

- The design indoor sound levels as per the recommendations of NSW Health – Engineering Services Guidelines 2022.
- NSW Noise Policy for Industry (NPI) 2017.
- NSW DEC Assessing Vibration: A Technical Guideline (2006).

This is a schematic design report, which should be further developed in consultation with the client. It is anticipated that the proposed development will achieve the relevant noise and vibration criteria, provided the design recommendations are implemented.

We trust that the information provided is satisfactory. However, if you have any queries or require further information, please do not hesitate to contact us.

[redacted]

Senior Acoustics Engineer

Glossary of Acoustic Terms

A-weighting	Frequency weighting applied to the level in each stated octave band by a specified amount, in order to better represent the response of the human ear. The letter 'A' will follow a descriptor, indicating the value has been 'A' weighted. An 'A' weighted noise level may also be written as dB(A).
Ctr	The spectrum adaptation term Ctr adjustment factor takes account of low frequency noise.
CAC	Ceiling Attenuation Class. The CAC determines how much cross-talk will occur between one room and another through the ceiling cavity where both rooms have the tested ceiling tile. This is an ideal situation, with no wall head leaks and no services penetrations in the ceiling. Therefore, it defines the ideal, best possible result as tested in a laboratory
dB	Decibel. This is the unit measurement of sound.
dBA	A weighted decibel is the most commonly used descriptor. The A weighting is an adjustment to the raw sound level to approximate what the average human ear can hear, which is less sensitive at very low and very high frequencies.
Dw	The Weighted Level Difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field with no standardisation or normalisation.
DnTw	The Weighted standardised level difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field. The higher the DnTw rating, the better is the acoustic performance of the wall or floor.
DnTw + Ctr	DnTw + Ctr is DnTw with the addition of a low frequency sound correction factor Ctr (always a negative number remember). Rw + Ctr is used because of the increase in low frequency sound sources such as surround sound systems, drums or bass guitars, and of course traffic or aircraft noise. Two walls can have the same DnTw rating, but have different resistance to low frequency sound, thus a different DnTw + Ctr.
Lw or SWL	Sound power level. This is the total radiated sound energy.
Lp or SPL	Sound pressure level. This is the measurable sound level at a given distance from an item.
Lmax	The RMS maximum noise level of a measurement
L10	90th percentile sound level of a measurement. Often called the average maximum noise level
Leq	The energy average noise level of a measurement.
L90	10th percentile sound level of a measurement. Often called the average background noise level

Leq(T)	The time (T) equivalent energy noise level. The time interval is often in blocks of 10 or 15 minutes for short term measurements, or hours for long-term measurements. Common increments for long term measurements are 1 hour, day, night, 18 hours and 24 hours.
Leq(8h)	The 8 hour equivalent energy noise level. Primarily used for occupational noise assessments
LCpeak	The C weighted peak noise level. Primarily used for occupational noise assessments
Ln,w	The Weighted Normalized Impact Sound Pressure Level. This is a single number rating describing the impact sound performance of a floor ceiling assembly as measured in a laboratory. Assessed in accordance with AS/NZS ISO 717.2. The lower the Ln,w rating, the better is the impact sound isolation performance of a floor-ceiling assembly
L'n'Tw	The weighted standardized impact sound pressure level. This is a single number rating describing the impact sound performance of a floor ceiling assembly as measured in a filed. Assessed in accordance with AS/NZS ISO 717.2. The lower the L'nT,w rating, the better is the impact sound isolation performance of a floor-ceiling assembly
Rw	The Weighted Sound Reduction Index. This is the single number rating describing the ability of a building element to reduce noise as measured in a laboratory. Assessed in accordance with AS/NZS ISO 717.1. The higher the Rw rating, the better is the acoustic performance of the wall or floor.
Rw + Ctr	Rw + Ctr is Rw with the addition of a low frequency sound correction factor Ctr (always a negative number remember). Rw + Ctr is used because of the increase in low frequency sound sources such as surround sound systems, drums or bass guitars, and of course traffic or aircraft noise. Two walls can have the same Rw rating, but have different resistance to low frequency sound, thus a different Rw + Ctr.
A-weighting	Frequency weighting applied to the level in each stated octave band by a specified amount, in order to better represent the response of the human ear. The letter 'A' will follow a descriptor, indicating the value has been 'A' weighted. An 'A' weighted noise level may also be written as dB(A).
Ctr	The spectrum adaptation term Ctr adjustment factor takes account of low frequency noise.
CAC	Ceiling Attenuation Class. The CAC determines how much cross-talk will occur between one room and another through the ceiling cavity where both rooms have the tested ceiling tile. This is an ideal situation, with no wall head leaks and no services penetrations in the ceiling. Therefore, it defines the ideal, best possible result as tested in a laboratory
dB	Decibel. This is the unit measurement of sound.
dBA	A weighted decibel is the most commonly used descriptor. The A weighting is an adjustment to the raw sound level to approximate what the average human ear can hear, which is less sensitive at very low and very high frequencies.
Dw	The Weighted Level Difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field with no standardisation or normalisation.

DnTw	The Weighted standardised level difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field. The higher the DnTw rating, the better is the acoustic performance of the wall or floor.
DnTw + Ctr	DnTw + Ctr is DnTw with the addition of a low frequency sound correction factor Ctr (always a negative number remember). Rw + Ctr is used because of the increase in low frequency sound sources such as surround sound systems, drums or bass guitars, and of course traffic or aircraft noise. Two walls can have the same DnTw rating, but have different resistance to low frequency sound, thus a different DnTw + Ctr.
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Leq(T)	The time (T) equivalent energy noise level. The time interval is often in blocks of 10 or 15 minutes for short term measurements, or hours for long-term measurements. Common increments for long term measurements are 1 hour, day, night, 18 hours and 24 hours.
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LCpeak	The C weighted peak noise level. Primarily used for occupational noise assessments
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L'n'Tw	The weighted standardized impact sound pressure level. This is a single number rating describing the impact sound performance of a floor ceiling assembly as measured in a filed. Assessed in accordance with AS/NZS ISO 717.2. The lower the L'nT,w rating, the better is the impact sound isolation performance of a floor-ceiling assembly
Rw	The Weighted Sound Reduction Index. This is the single number rating describing the ability of a building element to reduce noise as measured in a laboratory. Assessed in accordance with AS/NZS ISO 717.1. The higher the Rw rating, the better is the acoustic performance of the wall or floor.

Rw + Ctr	Rw + Ctr is Rw with the addition of a low frequency sound correction factor Ctr (always a negative number remember). Rw + Ctr is used because of the increase in low frequency sound sources such as surround sound systems, drums or bass guitars, and of course traffic or aircraft noise. Two walls can have the same Rw rating, but have different resistance to low frequency sound, thus a different Rw + Ctr.