SJOG Richmond Hospital

Acoustics Report

Assessment of Operational Acoustic Impact

Prepared for: Silver Thomas Hanley (Aus) Pty Ltd
Attention: Brent Railton
Date: 16th September 2021
Prepared by: David Spargo
Ref: 43762

Stantec Australia Pty Ltd
Level 6, Building B, 207 Pacific Highway, St Leonards NSW 2065
Tel: +61 2 8484 7000 Web: www.stantec.com

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Revision

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001	27/10/2019	Draft for Comments	DSP	ORFG
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003	01/10/2020	SSDA Issue	DSP	ORFG
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006	2/12/2020	SSDA Issue update	DSP	ORFG
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008	16/09/2021	SSDA Issue update – background noise levels	DSP	ORFG

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1. Introduction

The purpose of this report is to: assess the potential impact on the surrounding environmental due to noise associated with the operation of the proposed redevelopment of St John of God Richmond Hospital, noise and vibration for both the enabling and the main works (construction), and identify any environmental noise sources that could trigger statutory requirements for controlling intrusive environmental noise, such as rail road or air traffic, in building design elements that could impact the development.

Under NSW State Environmental Planning Policy (State and Regional Development) 2011 (SEPP), the development is deemed a State Significant Development and therefore requires approval by the NSW Environmental Protection Agency.

This report has been prepared by Stantec Australia on behalf of the St John of God Health and in accordance with Statutory requirements…
Accordingly, the following issues are discussed:

- Project overview which summarises extent of the redevelopment works and site layout.
- Unattended acoustic survey conducted to obtain existing ambient noise levels and subsequently derived the external noise level criteria.
- Operational acoustic criteria, which are based on regulatory requirements and guidelines typically used for acoustic assessments.
- Operational acoustic assessment which includes, when required, conceptual treatment.
- Conclusions discussing the outcomes from the acoustic assessments; as well as the acoustic feasibility of the project.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field.

High level design has been used for this assessment. Details such as selection of plant and equipment is not available at this stage, so all estimates noise levels used in this report are typical only.

Therefore, this report shall not be relied upon as providing any warranties or guarantees.

2. Background Information

2.1 Information Sources

This assessment was based on the following information sources:

- Document - Request for Proposal for the provision of Consultant Services for the Redevelopment of SJG Richmond Hospital 14 June 2019
- Noise data - collected on site using two noise loggers and a Type 1 handheld sound level meter.

2.2 Reference Documents

The acoustic assessment is also based on the following reference documents:

- Hawkesbury Development Control Plan 2002.
- NSW Protection of the Environment Operations Act 1997 (POEO Act)
- NSW State Environmental Planning Policy (Infrastructure) 2011 (SEPP)
- NSW Noise Policy for Industry (NSW NPI), issued on October 2017 by the NSW Environmental Protection Authority (NSW EPA)
- NSW Road Noise Policy (NSW RNP), issued March 2011 and published by the Department of Environment, Climate Change and Water NSW, now part of the NSW EPA
- NSW Interim Construction Noise Guideline (NSW INCG), issued July 2009 and published by the Department of Environment and Climate Change NSW (DECC), now part of the NSW EPA
- NSW Health Infrastructure - Engineering Services Guidelines (GL2016_020 dated 26 August 2016), including Design Guidance note no. 13 rev A July 2017 issued 19/07/2017 with Section 13 Acoustics July 2017 update
- Australian Standard, AS 2436-1981, “Guide to Noise Control on Construction, Maintenance and Demolition Sites”
- Australian Standard, AS 2021-2000 Acoustics - Aircraft noise intrusion - Building siting and construction.
- Air Services Australia, “Environmental principles and procedures for minimizing the impact of aircraft noise”.
- “Fly neighborly guide”, produced by the Helicopter Association International.
- Development Near Rail Corridors and Busy Roads – Interim Guideline (DNRCBR-IG), by the NSW Department of Planning which is now part of the NSW Department of Planning & Environment (issued December 2008)
- Assessing Vibration – A Technical Guideline (NSW AV-TG), issued February 2006 by the Department of Environment and Conservation NSW, now part of the NSW EPA

3. Project Overview

3.1 Proposed Redevelopment

This Enabling Works stage for the redevelopment of St John of God Richmond Hospital comprises numerous stages as described in the SJOG RFP 14 June 2019. Stage that are likely to create construction noise are:

- Stage 1 – Minor refurbishments
- Stage 2 – Demolition of Existing Buildings Phase 1.
- Stage 3 – Construction Phase 1.
- Stage 4 – Commissioning Phase 1.
- Stage 5 – Refurbishment Xavier Building and Belmont House
- Stage 6 – Refurbishment Administration and Reception building
- Stage 7 – Demolition Phase 2
- Stage 8 – Refurbishment old gym building

At this early stage of planning, no specific details for noise sources exist.

3.2 Site Description

The existing hospital premises are located at 177 Grose Vale Rd, North Richmond NSW 2753. It is set in a rural landscape surrounded by grazing land. The hospital sits atop Richmond Hill, overlooking Clarks Island in the Hawkesbury River to the southeast, North Richmond to the northeast, Grose Wold to the southwest and Grose Vale to the northwest. The nearest public roads are Grose Vale Road, which at its closest point is 500 m away to the north, and Grose River Road to the northwest of the property. There are neighbouring properties on the northeastern and southwestern sides, which also contain the nearest residences.

The proposed new building, which is part of this redevelopment, will be located approximately on the footprint of existing buildings currently occupying the southwestern side of the property. These buildings will be demolished to make way for the new building.

The acoustic issues relating to the operation after redevelopment are as follows:

- Estimates of noise emissions from existing buildings.
- Estimates of noise emissions from new buildings.
- Estimates of noise emissions from mechanical plant and emergency electrical systems from the development to the surrounding receivers.

It has also been noted that ambient levels are relatively quiet and similar on all sides of the hospital site. Residential receivers on all sides are subject to similar ambient conditions.

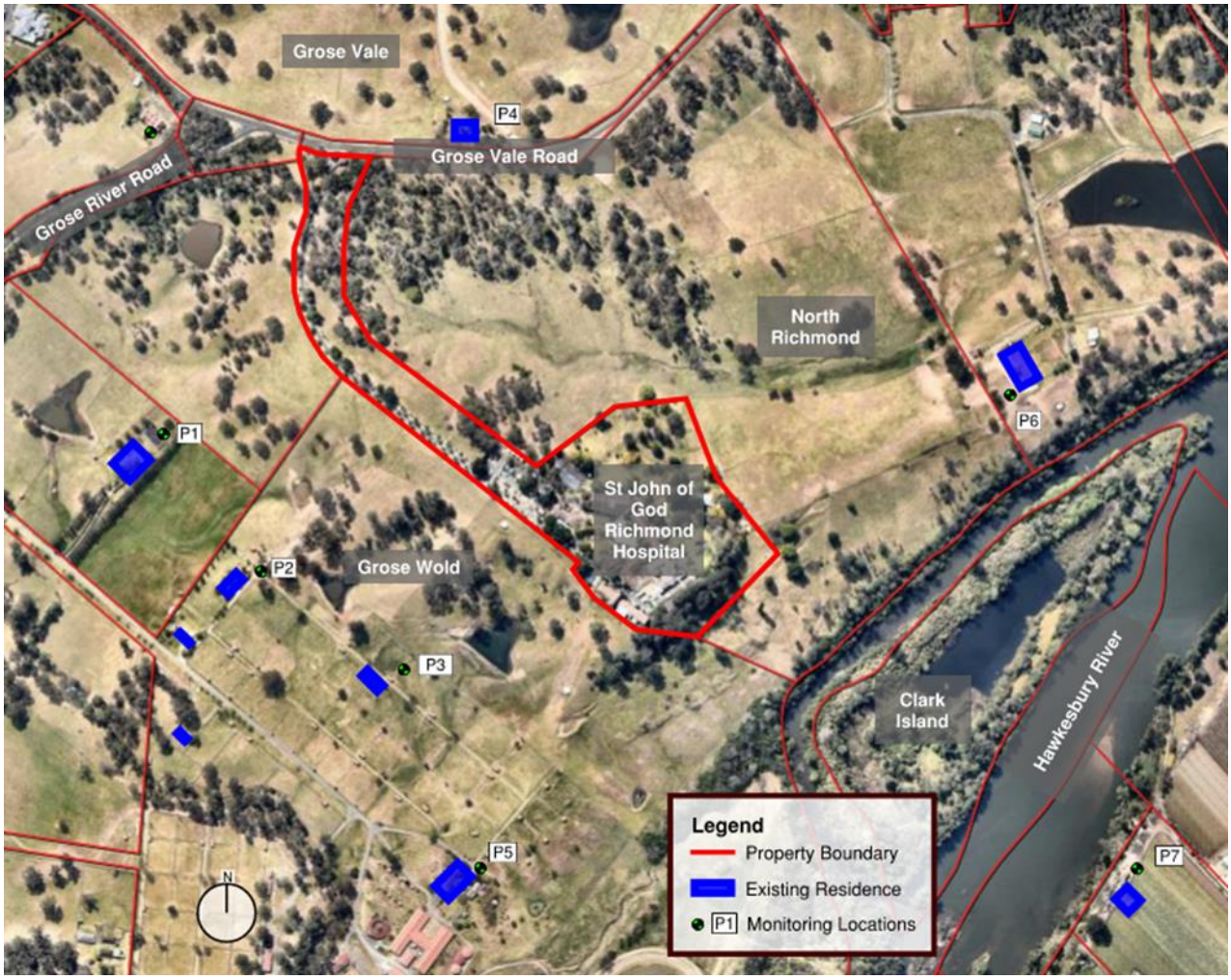

Figure 1 Site location overview showing site boundary and nearby residences, and potential noise monitoring locations. Map source: Nearmap.com

4. Acoustic Survey

Background noise for the project is characterised in two ways. First, the noise around the existing site is surveyed to determine the background plus operational noise within the hospital grounds at its current level. Then, the existing acoustic environment, excluding the operation of the hospital, is surveyed to allow a comparison of the impact of the operation on the environment and properties surrounding the site.

Typically, the latter of these two surveys is conducted using long-term noise monitoring at neighbouring residences in accordance with the NSW Noise Policy for Industry (NSW NPI) '*…to accurately identify the existing acoustic environment confirming that the development will not result in unreasonable acoustic impacts for construction and operation."* Access to neighbouring properties was not possible, however, The NSW NPI provides a minimum background noise levels for rural areas to be used in such cases for assessment.

This section describes the current background noise on the site. Section 5 describes the operational noise impact on neighbouring residences.

Figure 2 Background noise measurement locations. Loggers indicated L1, L2, Short-term measurements P1 & P2. Map source: Nearmap.com

4.1 Existing Noise Environment

The existing background noise on the site is typical for a rural area and characteristically dominated by natural sounds. It can be seen from the decreasing noise levels in the night period and the night ambient noise levels defined by the natural

environment and infrequent human activity. During the day, within the hospital grounds, low level mechanical noise from the hospital's services is the dominant source of noise.
The NSW EPA Noise Policy for Industry (NPI, Environment Protection Authority 2017) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods.
The INP defines these periods as follows:

- Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays

Noise monitoring locations are illustrated in Figure 2.

4.2 Instrumentation

The equipment used for the noise survey was the following:

- Hand-held sound spectrum analyser - Brüel & Kjær 2250 S/N 3027679
- Environmental Noise Logger - Calsella CEL-63X S/N 1488204 indicated as L1 in Figure 2
- Environmental Noise Logger – B&K 2250 S/N 300107 indicated as L2 in Figure 2
- Calibrator - Brüel & Kjær, S/N: 2709826

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

4.3 Attended Noise Survey Result

Attended noise measurements of 15-minute duration were conducted on site to characterise the acoustic environment for noise intrusion into the development and to determine any noise impact on the surrounding receivers. The measurement results were used in conjunction with the Unattended measurement data to calibrate and determine variations in different spots around the site. A summary of the attended noise measurements taken at the site are shown in Table 1 refer to Figure 2 for measurement locations.

Table 1 Summary of short-term measurements

Measurement Location	Date/Start Time	$L_{Aeq,T}$ dB(A)	$L_{A90,T}$ dB(A)	Background Noise Description
P1	24th September 2019 12:15 PM	49	47	Ambient & Mechanical Noise
P2	24th September 2019 12:48 PM	50	35	Ambient & Mechanical Noise
P1	3rd October 2019 11:08 AM	45	41	Ambient & Mechanical Noise
P2	3rd October 2019 11:36 AM	45	35	Ambient & Mechanical Noise

4.4 Unattended Noise Survey Results

Unattended noise measurements of existing ambient noise levels were conducted between 24th Sept 2019 and 3rd Oct 2019. The measurements were undertaken using a Calsella CEL-63X and B&K 2250 Environmental Noise Loggers indicated in Figure 2 as L1 and L2 respectively.
The loggers were set to measure continuous measurements at 15-minute intervals. The instruments were calibrated prior to and after the survey using a noise calibrator which emitted a calibration tone of 94dB(A) at 1 KHz. No significant drift was noted during the calibration procedure.
Additionally, in order to confirm that the measurement data was obtained during favourable weather conditions, weather data such as rainfall and wind speed was obtained from the nearest meteorological station which is located at Richmond RAAF Base (Station ID: 067105). Consequently, measured noise information was excluded if:

- Rain was observed during a 15-minute measurement period; and/or;
- Wind speed at 1.5 m above ground exceeded 5 metres/second.

Please note the measured noise data is defined in terms of equivalent continuous (L_{Aeq}) noise levels and rated background (L_{A90}) noise levels. For definition of these noise parameters, please refer to the Glossary section at the end of this report.

Table 2 Summary of unattended noise measurements

Location	Rating Background Noise (RBL) Level L_{A90}			Equivalent Continuous Noise Level L_{Aeq}		
	Day	Evening	Night	Day	Evening	Night
L1	36	33	30	49	41	45
L2	35	33	30	47	45	43

Figure 3 and Figure 4 show visual representations of the measured noise levels during the unattended noise survey for Logger 1 and Logger 2 respectively. Loggers were positioned within the Hospital grounds to determine the existing noise environment for use in designing the new building and to determine the existing ambient environment at sensitive receivers.

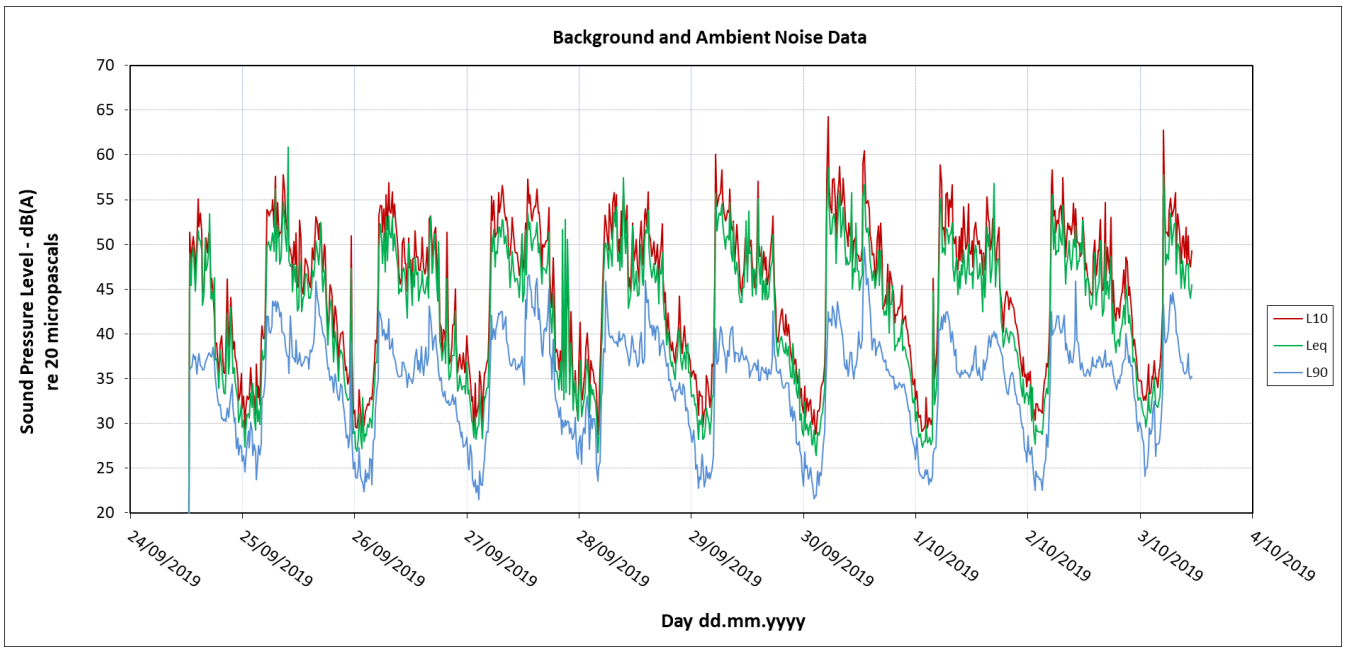

Figure 3 Long-term noise monitoring results at location L1- background noise measurement

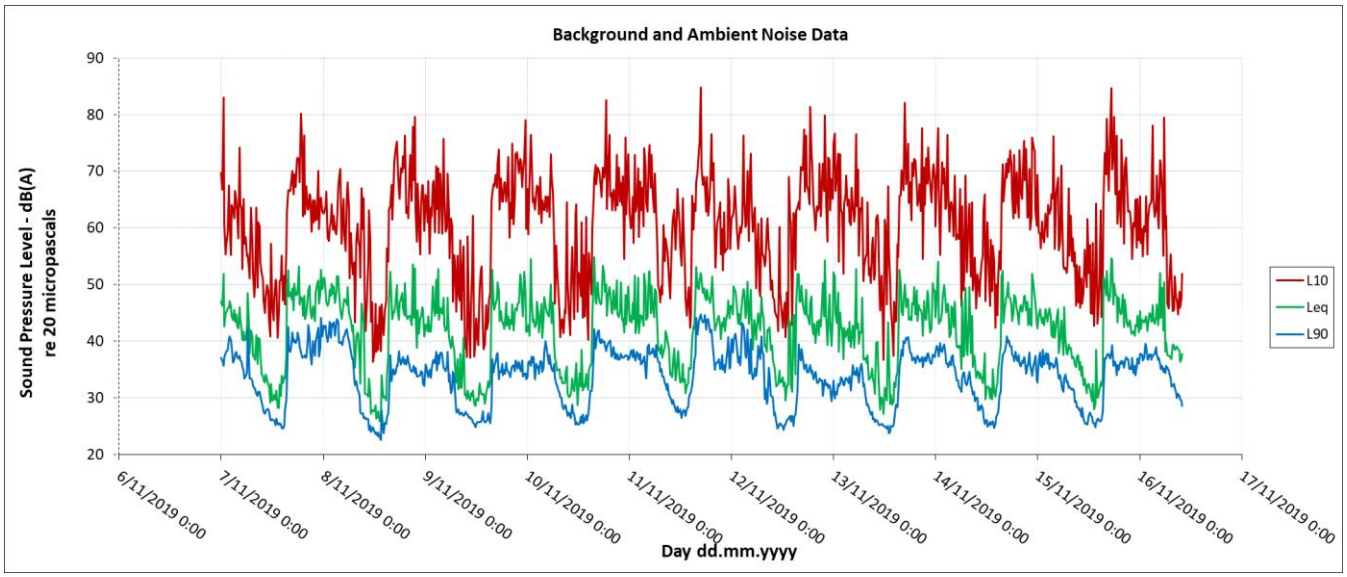

Figure 4 Long-term noise monitoring results at location L2- background noise measurement

5. Operational Acoustic Criteria

5.1 Hawkesbury Development Control Plan 2002

The Hawkesbury Development Control Plan 2002 does not state any specific criteria for the proposed hospital redevelopment or equivalent project category in terms of acoustic impact to the surrounding environment. It simple refers other documents referenced in this report.

5.2 The NSW Noise Policy for Industry (NSW NPI)

The NSW Noise Policy for Industry provides a minimum background noise levels for rural areas.

The external noise level criteria for steady state noise sources such as mechanical plant items have been derived in accordance with the guidelines discussed in the NSW NPI.

The criteria are based on the NSW NPI minimum background noise levels for rural areas. The criteria consider two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Noise Level).
- Maintaining noise level amenity for particular land uses (Amenity Noise Level).

Once both criteria are established the most stringent for each assessment period (day, evening, night) is adopted as the project noise trigger level (PNTL). The PNTL is a level that, if exceeded, would indicate a potential noise impact on the community, and so 'trigger' a management response.

5.2.1 Existing Background Noise

Minimum background noise levels for rural areas are provided in the NSW NPI. These minimum values are used to determine the representative background noise level for each day/evening/night period, called the assessment background noise level (ABL), and the overall day/evening/night level for the period, called the rating background noise level (RBL). These data are shown in Table 3. The RBLs are used for determining the project intrusiveness level.

Table 3 Assumed Minimum Background Noise levels (ABL) and Rating Background Noise Levels (RBL) for receiver category – rural residential

Time of day	Minimum Assumed Assessment background level (ABL) (dB[A])	Rating background noise level (RBL) (dB[A])
Daytime 7am – 6pm	35	35
Evening 6pm – 10pm	30	30
Night 10pm – 7am	30	30

The assessment RBL can now be determined by comparing the calculated RBL against the minimum assumed RBL. The Minimum assumed RBL is given in the NSW NPI and prescribes using the higher of the two values of each day/evening/night period as the assessment RBL, summaries in Table 4. The assessment RBL is used to determine the intrusiveness noise level.

Table 4 Determining Assessment Rating Background Noise Levels

ABL Data	**Day** dB(A)	**Evening** dB(A)	**Night** dB(A)
Minimum Assumed RBL	35	30	30
Assessment RBL	**35**	**30**	**30**

5.2.2 Intrusiveness Noise Level

The NSW EPA NPI states:

"The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15minute period, does not exceed the background noise level by more than 5 dB when beyond a minimum threshold."

The Intrusiveness Noise Level can be summarised as $L_{Aeq,\ 15\ minute} \leq$ RBL background noise level + 5 dB(A).

Table 5 NSW NPI Intrusiveness Noise Level

Period	Noise Descriptor – dB(A)	Intrusiveness Noise Level Criteria – dB(A)
Daytime 7am – 6pm	$L_{Aeq,15min} \leq$ RBL + 5	40
Evening 6pm – 10pm	$L_{Aeq,15min} \leq$ RBL + 5	35
Night 10pm – 7am	$L_{Aeq,15min} \leq$ RBL + 5	35

Logger 2 was chosen to represent background noise level as it was located away from any existing Hospital Mechanical Equipment and represented a true background for the area.

5.2.3 Amenity Noise Level

The NSW NPI states:

"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 (from NSW 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 relevant portions of Table 2.2 from the NSW NPI are reproduced in Table 6 of this report. Please note that based on the definitions of residential receivers as discussed in Section 2.4 of the NSW NPI, the affected residential locations identified in section 3.2 of this report are classified as Rural, Residential.

Table 6 Recommended L_{Aeq} noise level from Industrial noise sources, dB(A)

Receiver	Noise Amenity Area	Time of Day	L_{Aeq}, dB(A) Recommended Amenity Noise Level,
Residential	Rural	Day	50
		Evening	45
		Night	40
Hospital wards: Internal External	All	Noisiest 1-hour period when in use	 35 50

5.2.4 Annoying Noise Correction Factors

Some types of noises can be more annoying than others. The NSW NPI states:

"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level. On the other hand, some sources may cause less annoyance where only a single event occurs for a limited duration."

To account for the potentially annoying character of the noise, an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect. In Chapter 4 of the NSW NPI, Table 4.1 (reproduced in Table 7 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Please note that duration modifying factors can be applied to plant items which only operate occasionally for events such as maintenance operations. An example of such plant items are stand-by emergency generators. According to the NSW INP, the modifying factors can be subtracted from the predicted noise levels generated by such plant items prior to comparison with the NSW INP criteria. The duration modifying factors are listed in Table 8.

Table 7 Modifying factor corrections as per the NSW INP

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method (ISO1996.2-2007 – Annex D).	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. Note: Narrow-band analysis using the reference method in ISO1996-2:2007, Annex C may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.
Low-Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10– 160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15 dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a -2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.
Intermittent noise	Subjectively assessed but should be assisted with measurement to gauge the	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.	5 dB	Adjustment to be applied for night-time only.

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
	extent of change in noise level.			
Duration	Single-event noise duration may range from 1.5 min to 2.5 h.	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated.	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Notes:

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.

Table 8 Modifying factors for duration

Allowable duration of noise (one event in any 24-hour period)	Allowable exceedance of LAeq,15min equivalent project noise trigger level at receptor for the period of the noise event, dB(A) Daytime and Evening (7 am to 10 pm)	Night-time (10 pm to 7 am)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

5.2.5 Project Noise Trigger Levels

The project noise trigger levels (PTNL) are derived from the lowest value of the intrusiveness and amenity criteria after converting to $L_{Aeq,\ 15min}$, dB(A) equivalent level. The project noise trigger levels are summarised in Table 9 below. As previously discussed, these project noise trigger levels are applicable for steady state noise sources such as mechanical plant items.

Table 9 project noise trigger levels (PNTL), dB(A)

Period	Descriptor	PNTL
Residential Receivers		
Day	$L_{Aeq,\ period}$	**40**
Evening	$L_{Aeq,\ 15\ min}$	**35**
Night	$L_{Aeq,\ period}$	**35**

5.3 The State Environmental Planning Policy (Infrastructure) 2007

5.3.1 Noise and Vibration from Road and Rail Corridors

The State Environmental Planning Policy (Infrastructure) 2007 (SEPP 2007) requires that the impact of noise and vibration from road and rail corridors should be considered for several types of development which includes hospital buildings.

No rail corridor exists near the assessment site. There is no assessment required.

5.4 Traffic Noise Criteria

Changes in road traffic characteristics, such as types of vehicles and frequency, due to the operation of the redevelopment requires assessment according to NSW Road Noise Policy (2011).
The traffic noise criteria for the proposed road (or residential land use developments) in NSW Road Noise Policy divides land use developments into different categories and lists the respective criteria for each case.
Table 3 Section 2.3.1 in the NSW Road Noise Policy sets out the assessment criteria for residences to be applied to particular types of projects, road category and land use. Relevant to this project is Category 6 under Local roads category, which is summarized in Table 10.

Table 10 NSW Road Noise Policy – Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of Project/Land Use	Day, dB(A) (7:00am to 10:00pm)	Night, dB(A) (10:00pm to 7:00am)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq\ (1\ hr)}$ 55 (external)	$L_{Aeq\ (1\ hr)}$ 50 (external)

In the process for applying the criteria, 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 should be limited to 2dB above that of the corresponding 'no build option'.

5.5 Aircraft Noise Criteria

No further assessment is considered for the current Environmental Acoustic Assessment on the basis that there is no helicopter pad location or helicopter movements and that the site lies well outside all ANEF contours for Richmond Air Base.

5.6 Sleep Disturbance Criteria

Noise generated by mechanical equipment during night-time periods has the potential to disturb sleep at nearby residences. The NSW EPA's NPI and NGLG address the issue of sleep disturbance in general terms. These policies state that a person's sleep can be significantly disrupted by noise. But currently there is no standard method for describing the level of noise that causes sleep disturbance. Since short duration or intermittent noise is known to be more disturbing to sleep than continuous noise of similar acoustic energy, the NSW EPA's NPI suggests that if night-time noise levels from the development 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,

Then a detailed maximum noise level event assessment should be undertaken.
Table 11 summarises the sleep disturbance criteria that are applied to the surrounding residential premises based on data from L2.

Table 11 Sleep Disturbance Criteria for Night-Time Assessment Period

Average Night-time $L_{Aeq,15min}$ (dB)	Night-time RBL (dB)	Night-time RBL (dB) + 5 dB
45	30	35
Average Night-time L_{AFmax} (dB)	Night-time RBL (dB)	Night-time RBL (dB) + 15 dB
74	30	35

The Application notes regarding the NPI published by the EPA suggest that the EPA recognises that the current sleep disturbance criterion of an $L_{A1,1min}$ not exceeding the $L_{A90,15min}$ by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, the EPA will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely to occur, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level $L_{A1,\ 1min}$ that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN, Environment Protection Authority 1999). Other factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise levels will occur.
- Time of day (normally between 10pm and 7am).
- Whether there are times of the day when there is a clear change in the noise environment (such as early morning shoulder periods).

The $L_{A1,\ 1min}$ descriptor represents a maximum noise level measured under fast time response. DECCW will accept analysis based on either $L_{A1,\ 1min}$ or L_{Amax}.

5.7 Vibration Criteria

The NSW Ministry of Health's Engineering Services Guidelines refers to vibration within a healthcare facility as a critical issue impacting both humans and equipment. The document refers the reader to Australian Standards, EPA guidelines and international standards for guidance in assessing vibration.

The NSW EPA has issued a document titled *"Assessing vibration: A technical Guideline"* (NSW AV TG) which is dated February 2006. This document has been produced to assist on the assessment of vibration levels. The criteria relevant for hospitals is described as "Critical Areas" in Table 12 and Table 13. The guideline does not however address vibration induced damage to structures or structure-borne noise effects.

For human comfort, vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

5.7.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can potentially have an impact on human comfort. This impact is influenced by the activity conducted by those affected (i.e. use of the building) and the time when the vibration levels occur.

Maximum allowable magnitudes of vibration levels with respect to human response are shown in Table 12. Please note that the assessment period is defined as follows:

- Daytime extends from 7 am to 10 pm.
- Night-time is from 10 pm to 7 am.

Table 12 Preferred and max weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80 Hz (from EPA Assessing Vibration: a technical guideline February 2006)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Critical areas[2]	Day or night-time	0.0050	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night-time	0.020	0.014	0.040	0.028
Workshops	Day or night-time	0.04	0.029	0.08	0.058
Impulsive vibration					
Critical areas[2]	Day or night-time	0.0050	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.014
Offices, schools, educational institutions and place of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Notes

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above. Stipulation of such criteria is outside the scope of this policy, and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1:2008

5.7.2 Human Comfort – Intermittent Vibration Criteria

For intermittent events, the vibration assessment is based on Vibration Dose Values (VDVs). VDVs are used in order to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 13 Acceptable Vibration Dose Values for Intermittent Vibration (m/s^ 1.75) (from EPA Assessing Vibration: a technical guideline February 2006)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes

1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1:2008

6. Operational Noise Impact Assessment

6.1 Noise Considerations

The following activities have been identified as being likely to generate noise with the potential to impact the surrounding environment. These noise sources include:

- Continuous noise from mechanical plant such as cooling towers, air handler units (AHU), chillers, condenser units and exhaust fans
- Noise associated with back-up electrical system such as emergency diesel generators
- Intermittent noise from typical site operation, such as maintenance activities and patron noise
- Intermittent traffic noise from light weight trucks entering the loading dock delivering various type of goods
- Intermittent traffic noise from car movement entering and exiting the carparks located on site

Equipment selections are yet to be finalised; therefore, an indicative assessment has been conducted for typical equipment.

6.2 Mechanical Plant

6.2.1 Noise Sources

The proposed hospital redevelopment will include typical building services plant and equipment. At this point in the design we have no details on mechanical plant and equipment.

However, under the current proposal, provision has been made to locate mechanical plant in rooftop recesses. These features effectively provide acoustic parapets which serve to mitigate the propagation of noise from those plant areas.

In areas where plant is to be located at ground level, acoustic barries could be implemented should it be deemed necessary. These could consist of solid barriers, such is brick, or acoustic louvers to attenuate noise levels.

Based on these assumptions, modelling indicates that no further mitigation measures will be required and that noise from mechanical plant areas is unlikely to impact nearby residences.

6.3 Assessment to the NSW EPA Noise Policy for Industry (NPI)

Calculation of noise from the site operations was based on the typical worst-case scenario during the assessment periods including day, evening and night-time. Once mechanical equipment has been finalised, an assessment will be conducted to deem required treatment.

6.3.1 Vehicle Movements in the Carpark

The carpark layouts will be changed as part of the Enabling Works Stage of the redevelopment.

6.3.2 Ambulance Operations

The Ambulance Services of NSW has informed Wood and Grieve Engineers that sirens are not used within hospital sites, the only exception being a “short burst” alerting potential motorists of the ambulance’s presence when necessary.

Whilst driving in response to an emergency call out ambulance drivers may use the siren continuously or use it periodically to alert motorists as deem necessary. Whilst returning to the hospital after attending an emergency the siren will only be used in an extreme emergency. Noise levels generated by ambulance activities will be similar to those currently experienced in the area; with residential properties located along local roads likely to remain in a similar situation as they are now.

6.4 Road Traffic Noise

There are only minimal changes to the number of onsite vehicle parking spots resulting from the new building. We expect this to have negligible effect based on the new parking locations and carpark entry changes. We do not anticipate any further impact on residents resulting from traffic changes post development. Therefore, the proposed development is expected to comply with the requirements of the NSW RNP.

6.5 Aircraft Noise

No further assessment has been conducted for thus Environmental Acoustic Assessment on the basis that the site lies well outside all ANEF contour area for Richmond Air Base.

6.6 Helicopter Noise

No further assessment has been conducted for this Environmental Acoustic Assessment on the basis that there is no helicopter landing pad or helicopter movements on the site.

7. Construction Noise and Vibration Criteria

7.1 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the NSW ICNG. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.
However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, the assessment procedures and criteria in Chapter 4 of the NSW ICNG have been considered.
Consequently, the noise management levels (NMLs) for the construction and demolition activities are presented in Table 14.

Table 14 NSW OEH ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & Public Holidays	Noise Affected RBL + 10dB	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 residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: Times identified by the community when they are less sensitive to noise (such as before and after school, for works near schools, or mid-morning or mid-afternoon for works near residences) If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2. of the NSW ICNG

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

- The NMLs are based on the quantitative assessment method as discussed in the NSW ICNG. This has been assumed in this manner since we consider the hospital redevelopment works not as short-term activities (i.e. duration of more than three weeks).
- It is recommended that the working hours to undertake the redevelopment works should be as per the normal construction hours discussed in the NSW ICNG; these are:
  - Monday to Friday: 7 am to 6 pm
  - Saturday: 8 am to 1 pm
  - No work on Sundays or public holidays

- Feasible measures, as discussed in the NSW ICNG, is defined as follows: “A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements”.
- Reasonable measures, as discussed in the NSW ICNG, is defined as follows: “Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure. The regulatory authority may review the information on feasible and reasonable work practices provided by the proponent and compare the practices against those applied on similar projects. The regulatory authority may negotiate additional work practices that it considers may also be feasible and reasonable”.
- For non-residential premises, the NSW ICNG recommends the following NMLs:
  - For commercial premises: 70 dB(A) LAeq (15 minutes) external noise level
  - For places of worship, hospital wards and operating theatres: 45 dB(A) LAeq (15 minutes) internal noise level. Based on the assumption that the existing hospital façade provides a 15 dB(A) noise reduction (which corresponds to typical 10.38 mm thick laminated commercial glazing), then the external NML is estimated as 60 dB(A) LAeq (15 minutes).

7.2 Construction Vibration Criteria

For human comfort, the NSW ICNG recommends the use of the vibration criteria as discussed in the NSW AV-TG. Hence please refer to Section 5.7 for further discussion regarding these criteria.
In addition to these human comfort criteria, we also recommend considering the following vibration criteria which address structural damage.

7.2.1 Structural Damage – Vibration Criteria

Generally structural vibration criteria are defined in order to minimize the risk of cosmetic superficial damage (such as surface cracks). These criteria are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 “Structural vibration in buildings – Effects on structures” and British Standard BS7385-Part 2: 1993 “Evaluation and Measurement for Vibration in Buildings”.
Table 15 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage does not occur.
Table 16 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS 7385-Part 2:1993.

Table 15 Guideline value of vibration velocity (vi) for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		< 10Hz	10 - 50Hz	50 -100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20-40	40-50	40
2	Dwellings and buildings of similar design and/or use	5	5-15	15-20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3-8	8-10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 16 Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

7.2.2 Criteria for Vibration Sensitive Equipment

Vibration criteria for vibration sensitive equipment has been compiled by the American Society of Heating and Refrigeration Engineers (ASHRAE) and published in the *ASHRAE Handbook - HVAC Applications*. Table 17 below summarises these criteria.

Certain hospital equipment has been identified as such vibration sensitive equipment. Hence, in general terms, the applicable criteria for this equipment correspond to the following curves:

- Operating room, for equipment in operating theatres.
- Curves VC-A, VC-B and VC-C for vibration sensitive equipment such as MRIs, CT scanners, etc.

Also please refer to vibration criteria discussed in Section 5.7 which are classified under *Critical Areas.*

Please note that specific criteria for this equipment are likely to be within the margins of the general criteria provided above. Hence it is recommended that hospital staff or the equipment manufacturer should provide specific vibration criteria for each vibration sensitive instrument.

Table 17 Building vibration criteria for vibration measured on building structure (extract from the ASHRAE Handbook)

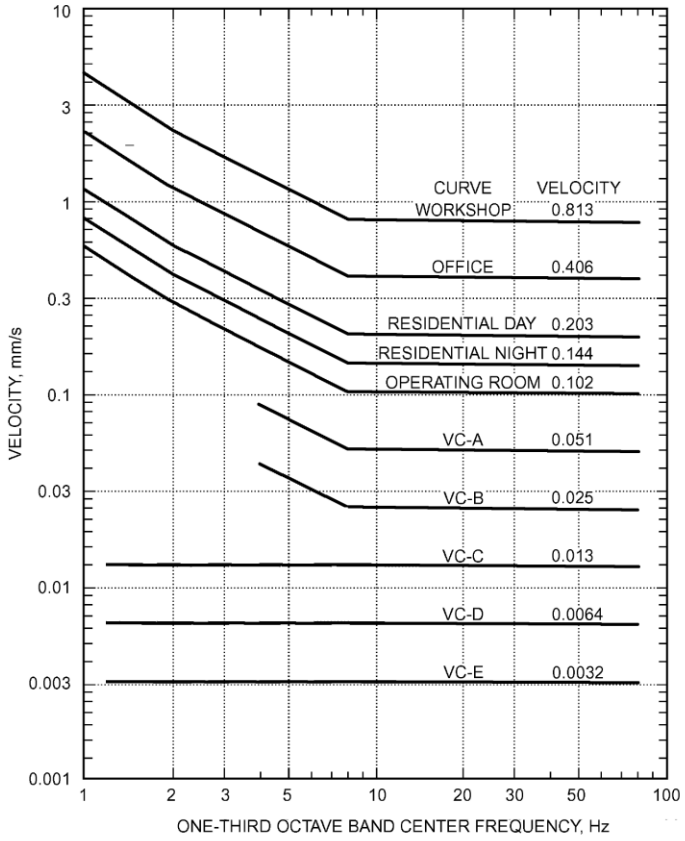

Table 46 Human Comfort and Equipment Vibration Criteria

Human Comfort	Time of Day	8 to 80 Hz Curve,[a] mm/s
Workshops	All	0.813
Office areas	All[b]	0.406
Residential (good environmental standards)	0700-2200[b]	0.203
	2200-0700[b]	0.144
Hospital operating rooms and critical work areas	All	0.102

Equipment Requirements	Curve[a]
Adequate for computer equipment, probe test equipment, and microscopes less than 40×	0.203
Bench microscopes up to 100× magnification; laboratory robots	0.102
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths[c]	0.025
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size[c]	0.013
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems[c]	0.0054
Unisolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems[c]	0.0032

[a]See Figure 37 for corresponding curves.
[b]In areas where individuals are sensitive to vibration, use Residential Day curve.
[c]Classes of microelectronics manufacturing equipment:

8. Acoustic Assessment of Construction Activities

As the St John of God Richmond Hospital redevelopment Enabling Works stage will require construction work to be undertaken while the Hospital is still operating; it is recommended that a detailed Construction Noise and Vibration Management Plan (CNVMP) be developed prior to commencement of construction to ensure the noise and vibration criteria outlined in Section 6 of this report are complied with.

The CNVMP should assess the likely noise and vibration emissions from construction activities occurring on site and recommend reasonable and feasible mitigation measures in order to comply with construction noise and vibration criteria and in doing so, minimizing the impact of construction activities on nearby residents but also on the hospital itself.

The CNVMP will include strategy to manage noise and vibration impact depending on the programmed construction activities such as noise and vibration monitoring and programming of activities generating high noise levels during the non-sensitive period of the day.

9. Conclusion

This report presents the results of a study of operational noise emission for the Enabling Works stage of the proposed redevelopment of the St John of God Richmond Hospital located at 177 Grose Vale Rd, North Richmond NSW 2753. Main Works will be addressed in a separate Report. This report forms a part of the documentation package to be submitted to the public authority (Health Infrastructure) as part of the assessment for the proposed Hospital redevelopment and operation.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed redevelopment have been established.

The establishment of the noise criteria was based on our noise survey which monitored ambient and background noise levels using both handheld sound level meters in the hospital grounds and assumed minimum background noise levels to set noise levels for the most-affected neighbouring receiver in the vicinity of the existing Hospital.

The predicted noise levels presented in this report show that the most stringent noise criterion (night-time criterion) will be met with the implementation of mitigation measures for external mechanical plant, yet to be described. Noise control measures will have to be refined as plant equipment is selected.

Following our investigation, except where explicitly noted, it was found that no significant noise impacts will occur as a result of the proposed Enabling Works Stage of the development should the proposed noise mitigation measures be implemented during the construction stage. Further acoustic treatments may be required during the Main works stage of the development.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the proposed development should not be refused on the grounds of excessive noise generation.

Design with
community in mind

Level 6, Building B
207 Pacific Highway
St Leonards NSW 2065
Tel +61 +61 2 8484 7000

For more information please visit
www.stantec.com

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