Health Infrastructure

UNSW Health Translation Hub

SSDA Acoustic Assessment Report

AC01_v5_SSDA Acoustic Assessment Report

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Job number 278548

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Contents

Appendices

1 Introduction

This report supports a State Significant Development Application (SSDA) for the proposed UNSW Health Translation Hub (UNSW HTH) at the Randwick Hospitals Campus (RHC), which is submitted to the Department of Planning, Industry and Environment (DPIE) pursuant to Part 4 of the *Environmental Planning and Assessment Act 1979* (the Act). Health Infrastructure on behalf of Health Administration Corporation (HAC) is the applicant for the UNSW HTH, which will be delivered with the University of New South Wales (UNSW).

The UNSW HTH forms an extension of the existing and proposed hospital facilities at the RHC, providing a specialist health-related research and education facility on the Campus.

1.1 Background

A partnership agreement has been established between HAC and the UNSW to develop the UNSW HTH. This partnership will also allow UNSW to operate the building as well as manage its design and delivery.

The partnership will bring together educational and medical researchers, clinicians, educators and public health officials to drive excellence, and support the rapid translation of research, innovation and education into improved patient care. It will strengthen the symbiotic relationship between UNSW and the RHC and its research institutes and broader health partners which form part of the Randwick Health and Innovation Precinct (RHIP).

The UNSW HTH will build on the existing affiliation between UNSW and the Sydney Children's Hospital Network (SCHN); Health Infrastructure; and the South Eastern Sydney Local Health District, including Prince of Wales Hospital, The Royal Hospital for Women and Eastern Suburbs Mental Health Services.

1.2 Site description and location

The site is located approximately 6 kilometres (km) from the Sydney Central Business District (CBD), within the Randwick Local Government Area (LGA). It is located approximately 4km from Sydney Airport. Figure 1 provides a regional context map of the site showing its location in relation to the Sydney CBD and surrounding centres.

This block sits in between the existing Randwick Hospitals Campus and the UNSW Kensington Campus, and directly adjacent to the CBD and South East Light Rail service which runs along High Street (Figure 2). The site of the proposed UNSW HTH has an area of 8,897square metres (sqm).

The site has been subject to some site preparation and early works associated with the broader development of the block. Adjacent to the site, along the High Street and Botany Road frontages, runs a 6-metre (m) wide stormwater and sewage easement.

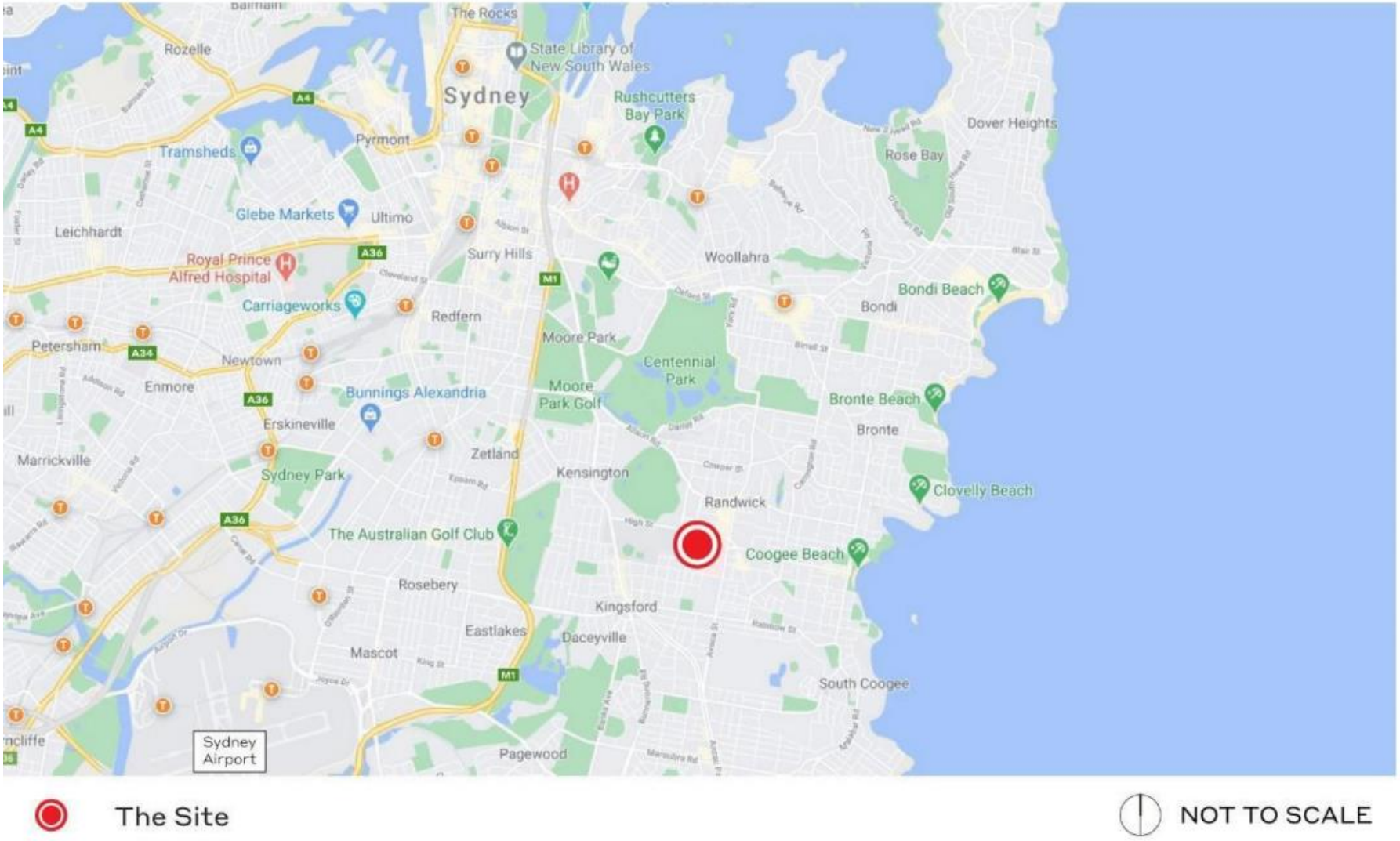

Figure 1: Site context (Source: Google maps and Ethos Urban)

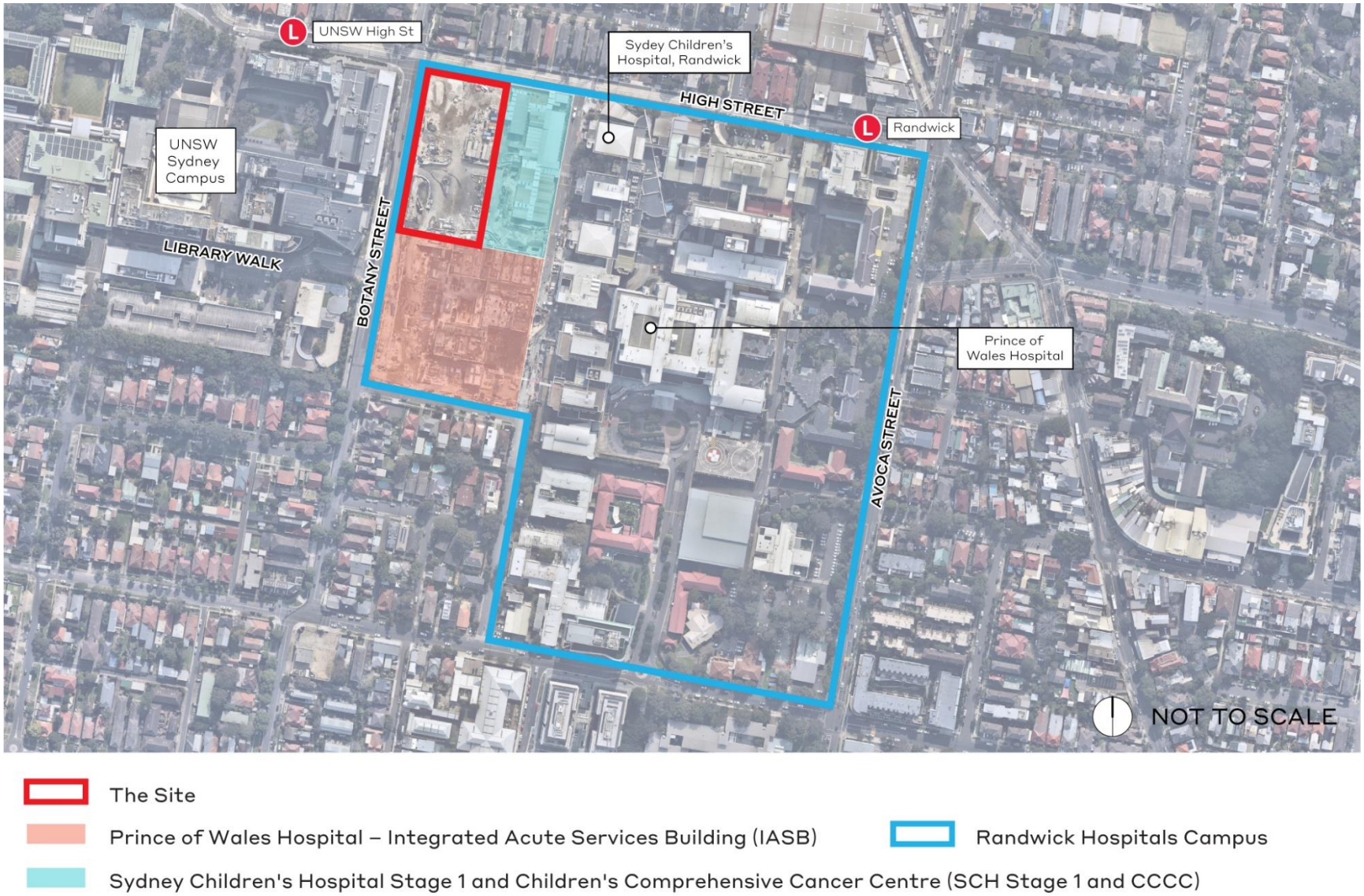

Figure 2: Site aerial (Source: Nearmaps and Ethos Urban)

1.3 Overview of the Proposed Development

The proposal involves the expansion of the existing and proposed hospital facilities at the RHC to provide ancillary health research and education uses. This will be in the form of a single building which will be physically connected (at podium level) to the neighbouring Sydney Children's Hospital Stage 1 and Children's Comprehensive Cancer Centre (SCH Stage 1 and the CCCC) redevelopment.

Specifically, the SSDA seeks approval for:

- Relevant site preparation, excavation and enabling works.
- Construction and use of a new, 15-storey building accommodating research and health education uses, comprising:
    - One basement level; and
    - A total GFA of approximately 35,600sqm, including health-related research, education and administrative floor space.
- Pedestrian link bridges connecting the UNSW Kensington Campus to the RHC, via the Wallace Wurth Building to the UNSW HTH and through to the SCH Stage 1 and the CCCC.
- Landscaping and public domain works, including the creation of over 2,500 sqm of new publicly accessible open space within the eastern portion of the site, sitting between the UNSW HTH and the SCH Stage 1 and the CCCC redevelopment.
- Building signage.
- Stratum subdivision.
- Services and utilities augmentation as required.

1.3.1 Operation and function of the UNSW HTH

The UNSW HTH will be an expansion of the RHC to accommodate new health related education, research, and administrative facilities. It will include:

- Purpose-built spaces for health educators and researchers to work alongside clinicians.
- Floor plates for health translation research focused work with physical connections to the SCH Stage1 and the CCCC and wider Randwick Hospitals Campus.
- Dedicated facilities for the CCCC directly linking the UNSW HTH with the SCH Stage 1 and the CCCC.
- An education hub, including education and training rooms allowing hospital staff to educate and train UNSW medical students.
- Facilities for education, training, research, seminars and industry events.

- Clinical schools for the Women's and Children's Health, Psychiatry and Prince of Wales Hospital.
- Ambulatory care clinics including in neurosciences, public and population health.
- Supporting facilities including retail premises.

1.4 Secretary's Environmental Assessment Requirements

Department of Planning, Industry and Environment has issued Secretary's Environmental Assessment Requirements (SEARs) for the proposed development. Key Issue 10 of the SEARs for application SSD 10822510 sets out the requirements with regards to the assessment of noise and vibration. It also references the following policies relevant to acoustics:

- NSW *Noise Policy for Industry* (NPfI) [1]
- NSW *Interim Construction Noise Guideline* (ICNG) [2]
- NSW *Assessing Vibration: A Technical Guideline* [3]
- Australian Standard 2363:1999 *Acoustics – Measurement of noise from helicopter operations* [4]

The SEARs are listed in Table 1 below. The section of the report where each requirement is addressed and relevant clarifications are also listed.

Table 1: Key Issue 10 of SEARs

Number	Requirement	Mitigation Measure	Comment
1	Includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction.	Section 6	As is common, appropriate detail on the construction methodologies required for detailed quantitative assessment of the project are not yet known at this stage. However, construction Noise Management Levels (NMLs) are determined and a preliminary quantitative assessment has been completed. High level construction noise and vibration management strategies are provided within this report.
2	Details the proposed construction hours and provide details of, and justification for, instances where it is expected that works would be carried out outside standard construction hours	Section 6	-

Number	Requirement	Mitigation Measure	Comment
3	Includes a quantitative assessment of the main sources of operational noise, including consideration of any mechanical services (e.g. air conditioning plant)	Section 4	Regarding mechanical services equipment, appropriate criteria are determined based on relevant legislation. As is common at this stage of a project, relevant mechanical equipment is yet to be fully selected. Preliminary mitigation strategies have been provided in this report.
4	Outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers	Section 4	-
5	Considers sources of external noise intrusion and vibration in proximity to the site (including, road, light rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards	Section 5	-
6	Demonstrates that the assessment has been prepared in accordance with policies and guidelines relevant to the context of the site and the nature of the proposed development.	Section 4 Section 5 Section 6	In reference to AS 2363:1999, information regarding the helicopter movements and detailed information of the façade design are not known in this stage. As is common, further investigation and assessment of helicopter noise will be developed during detailed design.

1.5 Scope of assessment

The following procedure outlines the scope of assessment with respect to the above acoustic aspects and relevant policies and guidelines:

- Examine the proposed development plans to identify acoustic aspects of the construction and operation of the development.
- Identify off-site surrounding noise and vibration sensitive receivers which are to be assessed regarding construction and operational activities.
- Rely upon existing background noise monitoring data from previous DA reports of the proposal to quantify the existing acoustic environment at relevant surrounding receiver locations to set project targets in accordance with relevant policy.
- Where appropriate, carry out a preliminary quantitative acoustic assessment of potential impacts and compare against the relevant noise and vibration targets.

- Identify where further input to the project design development is required, and identify in-principle mitigation or management methods for the control of noise and vibration where required.
- Outline the processes to be adopted for the continued design development of acoustic aspects for the project.
- Provide a summary of mitigation measures (Section 7)

A glossary of the acoustic terminology used in this document is presented in Appendix A.

2 Surrounding land uses

The nearest most potentially affected off-site land uses surrounding the development have been identified in Figure 3. These receivers have been selected as they are considered to be the most noise-affected. It is anticipated that if the acoustic criteria is achieved at these locations, it follows that the criteria will be achieved at all other locations.

Residential receivers are listed in Table 2. The reasonably most-affected non-residential sensitive receivers are listed in Table 3.

Table 2: Residential receivers for UNSW HTH works

Receiver ID	Address	No. of floors	Approximate distance to site [m]
R1	2 Blenheim St, Randwick NSW 2031	4	28
R2	3 Magill St, Randwick NSW 2031	2	150
R3	47 Botany St, Randwick NSW 2031	1	20
R4	34 Botany St, Randwick NSW 2031	1	44
R5	40 Botany St, Kingsford NSW 2032	2	150

Table 3: Reasonably most-affected non-residential sensitive receivers for UNSW HTH works

Receiver ID	Name	Address	No. of floors	Approximate distance to site [m]
Commercial				
C1	High St Society Cafe	1/64 High St, Randwick NSW 2031	3	230
C2	Pizza Hut	129 Botany St, Randwick NSW 2031	1	315
Educational Facilities				
E1	Wallace Wurth Building	61-63 Botany St, Randwick NSW 2031	6	28
E2	Lowy Cancer Research Centre	Cnr High and Botany St, Kensington NSW 2033	6	110
Passive Recreation Area				
PR1	Writtle Park	20 Botany St, Randwick NSW 2031	1	210
Health				
H1	Sydney Children's Hospital, Randwick	High St, Randwick NSW 2031	4	12
H2	Royal Hospital for Women	Barker St, Randwick NSW 2031	4	136

Receiver ID	Name	Address	No. of floors	Approximate distance to site [m]
H3	Wales Medical Centre	66 High St, Randwick NSW 2031	7	220
H4	UNSW Medicine Lifestyle Clinic	38 Botany St, Randwick NSW 2031	1	36
H5	Sydney Children's Hospital,: Children's Comprehensive Cancer Centre	High St, Randwick NSW 2031	9	<10
H6	Prince of Wales Integrated Acute Services Building	Hospital Rd, Randwick NSW 2031	9	<10
Place of Worship				
PW1	Our Lady of the Sacred Heart Catholic Church	193 Avoca St, Randwick NSW 2031	3	340
PW2	East Sydney Community Christian Church	8/10 Soudan St, Randwick NSW 2031	2	400

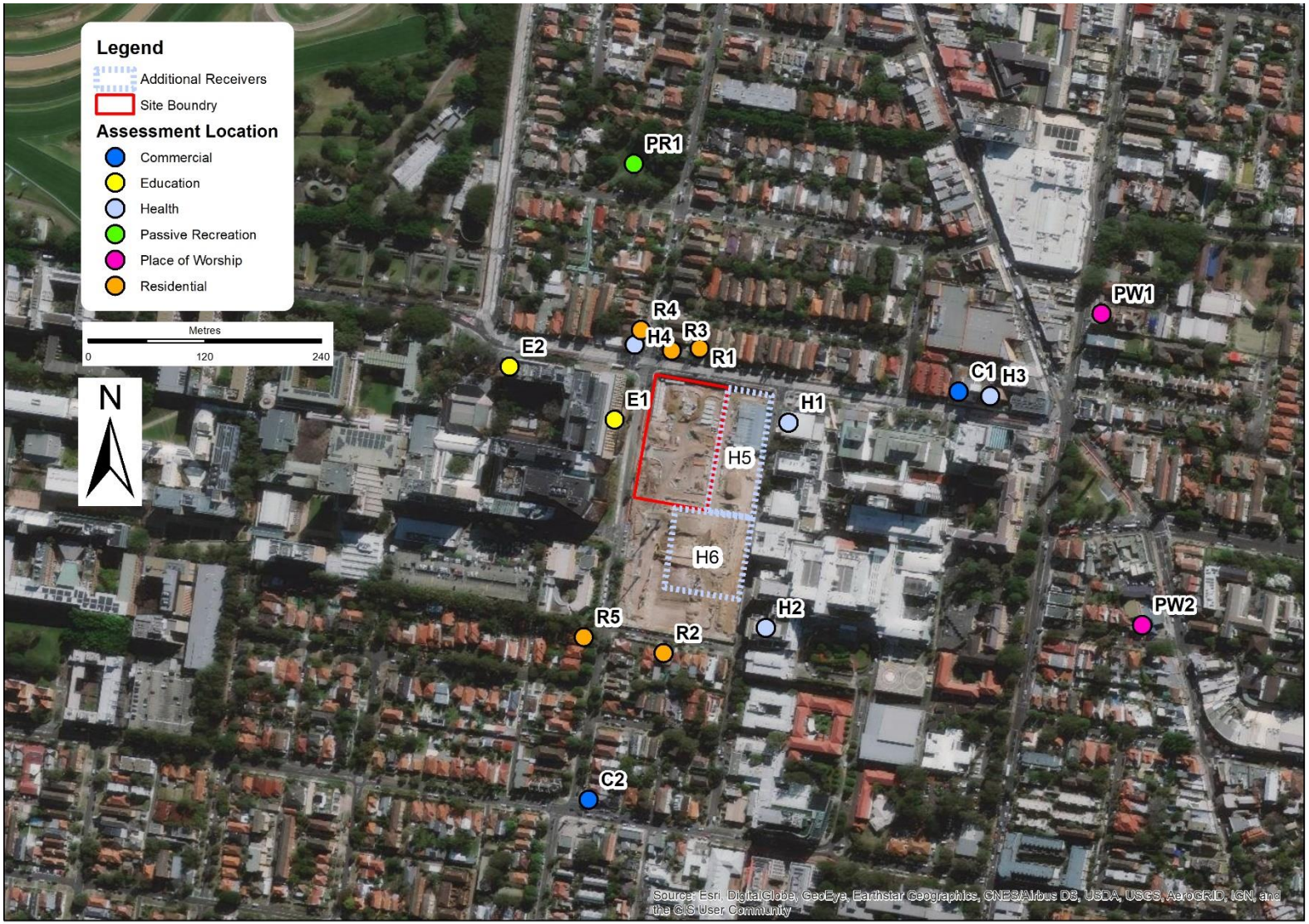

Figure 3 Noise sensitive receiver locations

3 Existing acoustic environment

3.1 Noise levels

A noise survey has been conducted to establish criteria for the assessment of operational and construction noise from the UNSW HTH as well as to establish the levels of environmental noise the site is exposed to.

3.1.1 Long-term noise monitoring

Noise data has been sourced from the noise monitoring results presented in the Noise and Vibration Impact Assessment Report prepared by Acoustic Studio for the Randwick Campus Redevelopment [5]. The noise monitoring was undertaken from 18 October 2017 to 3 November 2017 and 18 July 2018 to 25 July 2018. Although there has been significant development in the surrounding area being the operation of the Light Rail Network it is not envisioned that the external noise environment has been significantly changed. Furthermore, as there is currently significant construction occurring around the proposed site including the IASB building, noise monitoring at this time would not be considered conservative or representative of the ambient noise level. Therefore, Arup considers it reasonable to assume that ambient noise levels have not altered significantly since 2018 and have used this data to derive acoustic criteria for the development.

Table 4 presents the overall single Rating Background Levels (RBL) and representative ambient L_{Aeq} noise levels for each assessment period, determined in accordance with the NPfI.

Table 4: Long-term noise monitoring results

Location	Time period	Rating background noise levels, dBL_{A90}	Ambient dB_{LAeq} noise levels
L1: 12 Blenheim Street	Day	47	59
	Evening	45	53
	Night	43	55
L2: 7 Magill Street	Day	46	55
	Evening	44	51
	Night	43	51

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

3.1.2 Short-term noise measurement results

Short-term measurement data for UNSW HTH was sourced from the attended noise measurements section presented in the Feasibility Acoustic Design Report prepared by Pulse Acoustic Consultancy for the SCH Stage 1 and the CCCC [6].

The attended noise monitoring was undertaken on 16 June 2020 at 3:30pm to 5:30pm and 17 June 2020 at 12:30am to 2:30am.

A summary of the results is presented in the following table.

Table 5: Measured results of the attended noise survey

Measurement Location	**Date and Time**	**Measured Noise Level (dBA)**		**Comments**
		L_{A90} (15-min)[1]	**L_{Aeq} (15min)[2]**	
A1: Hospital Road, Outside Southern Wing of Existing SCH.	Tuesday 16th June 2020 at 3:30pm to 5:30pm	55	61	Construction noise affected, IASB works
	Wednesday 17th June 2020 at 12:30am and 2:30am	51	53	Mechanical noise from existing SCH building, occasional Light Rail
A2: Corner of Hospital Road and High Street, Existing SCH Side	Tuesday 16th June 2020 at 3:30pm to 5:30pm	53	63	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal and distant traffic noise.
	Wednesday 17th June 2020 at 12:30am and 2:30am	52	53	Occasional Light Rail Vehicle, distant traffic movements from Botany, distant mechanical noise from existing SCH building and pedestrian signal
A3: High Street, Southern Boundary of 10 Blenheim Street, Randwick	Tuesday 16th June 2020 at 3:30pm to 5:30pm	52	61	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal, tyre noise over concrete expansion gaps and distant traffic noise from Botany Street.
	Wednesday 17th June 2020 at 12:30am and 2:30am	46	60	Occasional Light Rail Vehicle, distant traffic noise from Botany Street, distant mechanical noise from UNSW Wallace Wurth and existing SCH buildings.

Measurement Location	Date and Time	Measured Noise Level (dBA)		Comments
		L_{A90} (15-min)[1]	L_{Aeq} (15min)[2]	
A4: Corner of High Street and Botany Street, new Hospital precinct side	Wednesday 17th June 2020 at 12:30am and 2:30am	45	57	Occasional vehicle movement along Botany Street, distant mechanical noise from existing SCH building.
A5: Botany Street, outside Entrance to Wallace Wurth Building (C27, UNSW)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	61	68	Frequent traffic movements along Botany Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	48	58	Occasional vehicle movement along Botany Street, distant mechanical noise from existing SCH building.
Location 6: Corner of Magill Street and Botany Street, outside 103 Botany Street, Randwick	Tuesday 16th June 2020 at 3:30pm to 5:30pm	54	65	Frequent traffic movements along Botany Street and Magill Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	45	56	Distant mechanical noise from both UNSW Wallace Wurth and existing SCH buildings
Location 7: Magill Street, northern boundary of 5 Magill Street, Randwick (See Figure 1-4)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	47	56	Moderate traffic movements along Magill Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	44	45	Distant mechanical noise from existing SCH buildings.

Note

The LA90 noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

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

3.1.3 Vibration monitoring

Vibration measurement data for UNSW HTH was sourced from the vibration monitoring results presented in the Feasibility Acoustic Design Report prepared by Pulse Acoustic Consultancy for the SCH Stage 1 and the CCCC [6]. The vibration monitoring was undertaken on 16 June 2020. Measurements were conducted to understand if vibration from light rail would impact onto the SCH S1 and CCCC building. As the UNSW HTH building is a similar distance away

from the light rails as the SCH 1 and CCCC building, results are assumed to be the same. Location of vibration monitoring can be viewed in Figure 4

A summary of the results is presented in the following Table 6 and Table 7.

Table 6: Measured vibration impacts, presented in Vibration Dose Value (VDV) - $mm/s^{1.75}$

Measurement Number	**Light rail vehicle direction**	**Measured vibration dose value (VDV) $mm/s^{1.75}$**
Light Rail Vehicle 1	Towards City	0.006
Light Rail Vehicle 2	Towards City	0.005
Light Rail Vehicle 3	Towards Randwick	0.003
Light Rail Vehicle 4	Towards City	0.007
Light Rail Vehicle 5	Towards Randwick	0.003
Light Rail Vehicle 6	Towards City	0.006
Light Rail Vehicle 7	Towards City	0.007
Light Rail Vehicle 8	Towards Randwick	0.003
Light Rail Vehicle 9	Towards Randwick	0.003
Light Rail Vehicle 10	Towards City	0.005
Light Rail Vehicle 11	Towards Randwick	0.003

Table 7: Measured vibration impacts, presented in Peak Velocity in millimetre / second (mm/s)

Measurement Number	**Light rail vehicle direction**	**Measured peak velocity mm/s**		
		s-axis	**y-axis**	**z-axis**
Light Rail Vehicle 1	Towards City	0.3	0.2	0.3
Light Rail Vehicle 2	Towards City	0.3	0.1	0.3
Light Rail Vehicle 3	Towards Randwick	0.1	0.1	0.1
Light Rail Vehicle 4	Towards City	0.2	0.2	0.3
Light Rail Vehicle 5	Towards Randwick	0.1	0.1	0.2
Light Rail Vehicle 6	Towards City	0.2	0.2	0.3
Light Rail Vehicle 7	Towards City	0.2	0.2	0.3

Measurement Number	Light rail vehicle direction	Measured peak velocity mm/s		
		s-axis	y-axis	z-axis
Light Rail Vehicle 8	Towards Randwick	0.1	0.1	0.1
Light Rail Vehicle 9	Towards Randwick	0.4	0.1	0.1
Light Rail Vehicle 10	Towards City	0.4	0.1	0.3
Light Rail Vehicle 11	Towards Randwick	0.1	0.1	0.2

Table 8: Measured vibration impacts, presented in Peak Velocity in meter / second (m/s)

Measurement Number	Light rail vehicle direction	Measured peak velocity m/s		
		s-axis	y-axis	z-axis
Light Rail Vehicle 1	Towards City	0.0003	0.0002	0.0003
Light Rail Vehicle 2	Towards City	0.0003	0.0001	0.0003
Light Rail Vehicle 3	Towards Randwick	0.0001	0.0001	0.0001
Light Rail Vehicle 4	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 5	Towards Randwick	0.0001	0.0001	0.0002
Light Rail Vehicle 6	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 7	Towards City	0.0002	0.0002	0.0003
Light Rail Vehicle 8	Towards Randwick	0.0001	0.0001	0.0001
Light Rail Vehicle 9	Towards Randwick	0.0004	0.0001	0.0001
Light Rail Vehicle 10	Towards City	0.0004	0.0001	0.0003
Light Rail Vehicle 11	Towards Randwick	0.0001	0.0001	0.0002

Figure 4: Long term noise and vibration monitoring locations

4 Operational noise

4.1 Overview

The primary operational noise sources with the potential to impact upon surrounding noise sensitive uses has been identified as building services (i.e. mechanical, electrical and hydraulic plant and equipment) and vehicular movements on site.

4.2 Criteria

4.2.1 NSW Noise Policy for Industry

Building services and equipment noise under normal operation of the building (ie excluding emergency conditions) is to be assessed in accordance with the NSW Noise Policy for Industry (NPfI) [7].

The NPfI is primarily concerned with controlling intrusive noise impacts in the short-term for residences and maintaining long-term noise level amenity for residences and other land uses.

The NPfI sets out the procedure to determine the project noise trigger levels relevant to an industrial development. The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so 'trigger' a management response.

4.2.1.1 Intrusive noise trigger level

The intrusive noise trigger level is applicable to residential premises only and is summarised as follows:

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

  (where $L_{Aeq,15minute}$ represent the equivalent continuous noise level of the source)

4.2.1.2 Recommended and 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 NPfI where feasible and reasonable. An extract from the policy is given below in Table 9

Table 9: NPfI Recommended Amenity Noise Levels (RANLs)

Receiver	**Noise amenity area**	**Time of Day**	**Recommended amenity noise levels (RANLs) dBL$_{Aeq,}$**
Hospital ward - Internal External	All All	Noisiest 1-hour Noisiest 1-hour	35 50
School classroom - internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dB(A) above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
Place of worship – internal	All	When in use	40
Area specifically reserved for passive recreation (e.g. national park)	All	When in use	50
Active recreation area (e.g. school playground, golf course)	All	When in use	55
Commercial premises	All	When in use	65
Industrial premises	All	When in use	70

Receiver	Noise amenity area	Time of Day	Recommended amenity noise levels (RANLs) $dBL_{Aeq,}$
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dB(A) to recommended noise amenity area

Notes: The RANLs refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.

The NPfI defines day, evening and night time periods as:

- Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
- Evening: the period from 6 pm to 10 pm.
- Night: the remaining period.

(These periods may be varied where appropriate. In the case where existing schools are affected by noise from existing industrial noise sources, the acceptable LAeq noise level may be increased to 40 dB LAeq(1hr)

The RANLs represent the objective for **total** industrial noise at a receiver location, whereas the **project amenity noise level (PANL)** represents the objective for noise from a **single** industrial development at a receiver location.

To ensure that any new industrial source of noise is within the RANLs for an area, the PANL applies for each new source of industrial noise as follows:

- *Project Amenity Noise Level (PANL) = Recommended Amenity Noise Level (RANL) minus 5 dB(A)*

The NPfI also provides the following exceptions to the above method for deriving the project amenity noise level:

1. *In areas with high traffic noise levels.*
2. *In proposed developments in major industrial clusters.*
3. *Where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.*
4. *Where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.*

The area surrounding the site can be categorised as Urban under the NPfI.

Table 10 summarises the RANLs and the PANLs applicable for the project.

Table 10: NPfI RANLs and PANLs for residential recievers

ID	Indicative Noise Amenity Area	Time of day[1]	Recommended Amenity Noise Level (RANL) $L_{Aeq(period)}$	Project Amenity Noise Level (PANL) $L_{Aeq(period)}$
Northern residential receivers	Urban	Day	60	55
		Evening	50	45
		Night	45	40
Southern residential receivers	Urban	Day	60	55
		Evening	50	45
		Night	45	40

Notes:

1. The NPfI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.

4.2.1.3 Sleep disturbance

The NSW NPfI recommends the following screening criteria for the assessment of potential sleep disturbance, for the period between 10 pm and 7 am:

- $L_{Aeq,15min}$ 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

4.2.1.4 NPfI Project specific noise levels

Based on the background and ambient noise monitoring, Table 11 and Table 12 summarises the derived project specific noise levels based on the NPfI.

Table 11: NPfI Project specific noise levels

Receiver	Time Period[1]	Project Specific Noise Levels			
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) [3] $L_{Aeq,15min}$	Project Noise Trigger Levels, $L_{Aeq,15min}$	Sleep Disturbance $L_{Amax(night)}$
Northern residential receivers	Day	52	58	52	N/A2
	Evening	50	48	48	N/A2
	Night	48	48	48	48
Southern residential receivers	Day	51	58	51	N/A2
	Evening	49	48	48	N/A2
	Night	48	44	44	48

Receiver	Time Period[1]	Project Specific Noise Levels			
		Intrusive Noise Trigger Levels $L_{Aeq,15min}$	Project Amenity Noise Level (PANL) [3] $L_{Aeq,15min}$	Project Noise Trigger Levels, $L_{Aeq,15min}$	Sleep Disturbance $L_{Amax(night)}$

Notes:

1. The NPfI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. N/A Not Applicable
3. The NPfI has simplified assessment for the amenity criteria, making a crude assumption regarding the relationship between the $L_{Aeq(15min)}$ and $L_{Aeq(period)}$, applying a +3 dB correction to adjust the Project Amenity Level $L_{Aeq(period)}$ to an $L_{Aeq(15min)}$.

Table 12: NPfI RANLs for non-residental recievers

Receiver ID	Name	Address	Time Period	Recommended amenity noise levels (RANLs) $L_{Aeq,period}$ dBA	Project Noise Trigger Levels,[1] $L_{Aeq,15min}$
Commercial					
C1	High St Society Cafe	1/64 High St, Randwick NSW 2031	When in use	65	60
C2	Pizza Hut	129 Botany St, Randwick NSW 2031	When in use	65	60
Educational Facilities					
E1	Wallace Wurth Building	61-63 Botany St, Randwick NSW 2031	Noisiest 1-hour period when in use	35	40
E2	Lowy Cancer Research Centre	Cnr High and Botany St, Kensington NSW 2033	Noisiest 1-hour period when in use	35	40
Passive Recreation Area					
PR1	Writtle Park	20 Botany St, Randwick NSW 2031	When in use	50	45
Health					
H1	Sydney Children's Hospital, Randwick	High St, Randwick NSW 2031	Noisiest 1-hour	50	45

Receiver ID	Name	Address	Time Period	Recommended amenity noise levels (RANLs) $L_{Aeq,period}$ dBA	Project Noise Trigger Levels,[1] $L_{Aeq,15min}$
H2	Royal Hospital for Women	Barker St, Randwick NSW 2031	Noisiest 1-hour	50	45
H3	Wales Medical Centre	66 High St, Randwick NSW 2031	Noisiest 1-hour	50	45
H4	UNSW Medicine Lifestyle Clinic	38 Botany St, Randwick NSW 2031	Noisiest 1-hour	50	45
H5	Sydney Children's Hospital,: Children's Comprehensive Cancer Centre	High St, Randwick NSW 2031	Noisiest 1-hour	50	45
H6	Prince of Wales Integrated Acute Services Building	Hospital Rd, Randwick NSW 2031	Noisiest 1-hour	50	45
Place of Worship					
PW1	Our Lady of the Sacred Heart Catholic Church	193 Avoca St, Randwick NSW 2031	When in use	40	45
PW2	East Sydney Community Christian Church	8/10 Soudan St, Randwick NSW 2031	When in use	40	45

Note: 1 - External noise levels for Health, Education and Place of Worship receivers have been determined by assuming a 10dB reduction through an open window.

4.2.2 Road traffic noise criteria

Increased traffic generated on the surrounding road network due to the operational activities in UNSW HTH is assessed in accordance with the NSW *Road Noise Policy* (RNP) [8]. The assessment criteria are reproduced in Table 13 and Table 14 below.

Table 13: Road traffic criteria for traffic generating development - residential receivers

Road category	Type of project / land use	Assessment criteria – dBL_{Aeq}	
		Day (7:00am-10:00pm)	Night (10:00pm-7:00am)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 55 (external)	$L_{Aeq,(9\ hour)}$ 50 (external)

Note: These criteria are for assessment against façade corrected noise levels when measured in front of a building façade.

Table 14: Road traffic criteria for traffic generating development – Non-residential receivers

Receiver	**Assessment criteria – dBL$_{Aeq}$**	
	Day (7:00am-10:00pm)	**Night (10:00pm-7:00am)**
Hospital Wards	LAeq,(1 hour) 35 (internal)	LAeq,(1 hour) 35 (internal)
Classrooms	LAeq,(1 hour) 40 (internal) when in use	-
Places of Worship	LAeq,(1 hour) 40 (internal)	LAeq,(1 hour) 40 (internal)
Open Space (Passive use)	LAeq,(15 hour) 55 (external) when in use	-

Note: These criteria are for assessment against façade corrected noise levels when measured in front of a building façade.

Regarding the application of the assessment, the RNP states:

> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

4.3 Operation noise review

4.3.1 Mechanical services

The primary operational noise associated with the UNSW HTH building relates to building services equipment, such as air-conditioning and ventilation systems.

Currently the mechanical strategy for the project is to have distribution of equipment throughout the building with main plant rooms on the Basement level, Level 7 and Level 14. The preliminary equipment includes, but is not limited to:

- Air handling units
- Water cooled chillers
- Exhaust fans
- Cooling towers
- Air source heat pumps
- Generators

During ongoing design of the development, equipment will be selected and provided with noise and vibration attenuation measures as required to meet the Project goals. Noise mitigation treatment will likely be required, including:

- Specification of maximum sound power levels for all items of plant as part of the project documentation;
- Use of attenuators to control fan noise;

- Acoustic louvres to control noise from plantroom ventilation openings to amenity areas;
- Vibration isolators to reduce vibration input to the building structure;
- Acoustic screens around external plant, where required; and,
- Incorporation of sound absorptive treatments in plantroom spaces.

Noise emissions from any external mechanical plant shall be treated such that noise emission complies with NPfI PANL criteria at all surrounding receivers. This may require the use of acoustic louvres, enclosures, barriers or attenuators. Acoustic design and certification of building services equipment is typically recommended to be provided at the construction certificate stage. Assuming mechanical systems are designed in coordination with an acoustic consultant and all appropriate mitigation measures are taken, it is believed the UNSW HTH building is capable of complying with operational noise criteria.

4.3.2 Increased road traffic

JMT Consulting have indicated that future traffic movements generated by the development will be as follows:

Table 15: Future traffic movements generated by the development

	AM peak hour (8am - 9am)	**PM peak hour (5pm - 6pm)**	**Daily**
General Traffic	0	0	0
Logistics Vehicles	10	7	65
Total Vehicles	10	7	65

An increase of more than 2dB requires an increase in traffic movements of more than 60%. Based on the low number of traffic movements presented, the proposed development is not anticipated to significantly increase existing road traffic noise levels during operation.

5 Impacts upon development

5.1 Road traffic and light rail noise

5.1.1 Criteria

The *NSW State Environmental Planning Policy (Infrastructure) 2007* (known as 'ISEPP') [9] and the supplementary guideline, Department of Planning, Industry and Environment's publication *Development near Rail Corridors and Busy Roads – Interim Guideline* [10] provides guidance concerning the assessment of road and rail traffic noise.

The ISEPP came into force in NSW on 1 January 2008 to facilitate the effective delivery of infrastructure across the State. Relevant to the acoustic assessment are the following clauses:

> *87 Impact of rail noise or vibration on non-rail development*
>
> (1) *This clause applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by road noise or vibration:*
>
> *a) Residential accommodation,*
>
> *b) a place of public worship,*
>
> *c) a hospital,*
>
> *d) an educational establishment or child care centre.*
>
> *102 Impact of road noise or vibration on non-road development*
>
> (2) *This clause applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles (based on the traffic volume data published on the website of the RMS) and that the consent authority considers is likely to be adversely affected by road noise or vibration:*
>
> *e) a building for residential use,*
>
> *f) a place of public worship,*
>
> *g) a hospital,*
>
> *h) an educational establishment or child care centre.*

The NSW Department of Planning *Development in Rail Corridors and Busy Roads – Interim Guideline* (December 2008) [10] supplements the ISEPP [9]. While the ISEPP [9] applies only to roads with an AADT greater than 20,000

vehicles, the guideline is also recommended for other road traffic noise affected sites.

The Guideline clarifies the time period of measurement and assessment. Section 3.4 '*What Noise and Vibration Concepts are Relevant*' and Table 3.1 of Section 3.6.1 confirms that noise assessment is based over the following time periods:

- Daytime 7:00am – 10:00pm $L_{Aeq(15hr)}$
- Night-time 10:00pm – 7:00am $L_{Aeq(9hr)}$

The noise criteria nominated in the ISEPP apply to internal noise levels with windows and doors closed.

Table 16 presents the ISEPP internal noise criteria for non-residential buildings.

Table 16: Road traffic intrusion noise criteria

Non-residential building	**Airborne noise level[1]**	**Ground-borne rail noise[2]**
Educational Institutions	40	40

Note:

1 – airborne noise is calculated as $L_{eq(9h)}$ (10:00pm-7:00am) (night) and $L_{eq(15h)}$ (7:00am-10:00pm) (Day).

2 – $L_{Amax\ (slow)}$ for 95% of rail pass-by events

5.1.2 Noise intrusion assessment

At this stage, detailed noise intrusion calculations have not been carried out subject to insufficient architectural detail. Notwithstanding, the measured noise levels in the area are moderate and internal criteria can be readily achieved with a sealed façade.

The acoustic requirements and specification of the façade will be determined during the Detailed Design phase.

5.2 Light rail vibration

5.2.1 Criteria

The NSW EPA's *Assessing Vibration – A Technical Guideline* [11] provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472-1:2008 [12].

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV considers both the magnitude of vibration events and the number of instances of the vibration event. Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as 'impulsive' sources for the purposes of assessment.

As noted in the Guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration Table 17 and Table 18 respectively.

Table 17: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Critical areas1	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical areas1	Day- or Night-time	0.005	0.0036	0.01	0.0072
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.64	0.46	1.28	0.92

1 - Criteria for sensitive areas are only indicative, and have been provided as guidance to acceptable vibration levels for the use of sensitive equipment, eg. camera equipment at Fox Studios.

Table 18: Acceptable vibration dose values for intermittent vibration (m/s1.75)

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	**Maximum Value**	**Preferred Value**	**Maximum Value**
Critical areas[1]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

1 - Criteria for sensitive areas are only indicative, and there may be a need to assess intermittent vibration against impulsive or continuous criteria.

5.2.2 Vibration assessment

The CBD and South East Light Rail corridor passes through High Street, nearby to the proposed development. Potential vibration impacts have been considered and we make the following comments.

The design of the light rail network includes vibration control measures to achieve specific vibration limits at the nearest residential receivers along High Street. Satisfying these limits will also ensure the vibration limits at UNSW HTH are also achieved.

Measured vibration results displayed in Table 8 are well below the limits set out in the above Table 17 and Table 18 and therefore is not anticipated to impact this project.

6 Construction

This assessment should be used to inform the proposed work practices and management measures contained in the preliminary Construction Management Plan (CMP) provided by Buildcorp. The preliminary CMP will be further developed as the construction methodologies and processes are confirmed during the design development process.

6.1.1 Construction staging and activities

The staging would involve a sequence of works commencing in 2024 with an anticipated completion of late 2026. Table 19 summarises the main construction activities.

Table 19: Anticipated construction activities to be carried out during main works

No	Stage	Key steps
1	Site Establishment	• Secure construction site perimeter with A class hoarding. B class to be installed adjacent to work zone • Site accommodation to be established east of the building

2	Excavation	• All excavation work will take place using large excavation plant and equipment
		• Rock excavation
		  ○ Softer rock removed using ripping techniques
		  ○ Harder rock being saw cut and removed where feasible

3	Foundation / Sub-structure Phase	• Piles and structural footings will be engineered and constructed in such a way as to mitigate the risk of noise and vibration wherever possible. The works will be occurring concurrently with the detailed excavation phase
4	Structure Phase	• This phase will consist of traditional concrete column and suspended post tensioned concrete slab construction to the lower levels of the building. The upper levels will be constructed from timber. A concrete lift and stair core will service all levels. • Construction of the structure shall be via the use of the sites tower cranes, workers and materials hoist and concrete pumps
5	Pedestrian link bridge	• The structure of the link bridge between the SCH Stage 1 and the CCCC and UNSW HTH will be prefabricated and craned into position prior to the completion of the new SCH Stage 1 and the CCCC
6	Façade and building envelope phase	• The façade will consist of a prefabricated curtain wall system. The prefab components will be transported to site and where possible lifted directly from the truck in the work zone and placed on the applicable floor ready for installation. • Construction of the façade and envelope shall be via the use of the sites tower crane.

No	Stage	Key steps
7	Internal fit out and finishes phase	• Construction of the internal fitout & finishes shall be via the use of the sites tower crane accompanied by a forklift. Material deliveries will utilise the work zone in Botany St where materials will be lifted directly from the delivery vehicles and loaded to the applicable floors via loading platforms. Along with smaller material deliveries through the loading dock in the basement utilising the builders lift.
8	Connection of services	• Connections shall be undertaken via the use of small scale and specific excavation equipment where necessary.
9	Landscaping and external works phase	• Upon completion of all construction and removal of the site material handling equipment (tower crane, scaffold etc), the Public Domain, landscape and external works surrounding the built form will commence to complete its integration with the property boundary line and streetscape. • Works shall be undertaken via the use of small-scale plant and construction equipment for material handling purposes now that the main handling equipment have been removed.

6.1.2 Indicative schedule

The indicative construction schedule associated with the SSD application is outlined in Table 20

Table 20: Indicative construction schedule

Project Milestone	Planned Completion Date
Site Establishment	Early of 2024
Construction Completion	Late 2026
Operational	Late 2026

6.1.3 Construction Hours

Construction between Monday to Friday is to be carried out during the ICNG recommended standard construction hours.

Extended construction hours on Saturday are proposed for the undertaking of typical construction activities in order to provide opportunity for the most efficient construction program as well as mitigating traffic impacts.

Table 21: Proposed Construction Hours

Day	Standard construction hours	Proposed construction hours
Monday to Friday	7 am to 6 pm	7 am to 6 pm
Saturday	8 am to 1 pm	8 am to 5 pm
Sunday and public holiday	No work	No work

6.2 Construction noise criteria

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction noise management levels

above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG provides two methods for assessing construction noise, varying typically based on the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of noise management levels and prediction of construction noise levels. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

This development is expected to warrant a quantitative assessment.

6.2.1 Construction Noise Management levels

The ICNG sets out management levels for noise at noise sensitive receivers, and how they are to be applied. These noise management levels (NMLs) for residential receivers and other sensitive receivers are reproduced in Table 22 and in Table 23 respectively.

Table 22: Construction NMLs at residential receivers

Time of day	**NML 1** $L_{Aeq\ (15\ min)}$	**How to apply**
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details and avenues to raise concerns with the project team within the specified time frame and via the appropriate channels e.g. flyer, doorknock.

Time of day	NML 1 $L_{Aeq\ (15\ min)}$	How to apply
	Highly noise affected 75dB(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, taking into account: • Times identified by sensitive recievers such as the community, UNSW and RHC 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 senseitive receivers are 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 5dB(A) above the noise affected level, the proponent should negotiate with the community.[2]

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

2 – Reccommended community engagement is outlined in Section 6.5.1

Table 23: Construction NMLs at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

1 - Noise management levels apply when receiver areas are in use only.

For work within standard construction hours, if after implementing all 'feasible and reasonable' noise levels the site still exceeds the noise affected level, the ICNG does not require any further action – since there is no further scope for noise mitigation.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community. While there is no 'highly-noise affected level' outlined in the ICNG for out-of-hours work, this report adopts the terminology where the construction noise level is 5 dB above the noise affected level.

6.2.2 Project construction noise targets

Based on the measured background noise levels presented in Table 4 and the criteria methodology presented above, Table 24 outlines the construction noise management levels applicable to demolition, excavation and construction.

Table 24: Construction NMLs for residential receivers

ID	Time Period	NML Description	NML, $dBL_{Aeq\ 15minute}$
Northern residential receivers	During recommended standard hours[2]	Noise affected	57
		Highly noise affected	75
	Outside recommended standard hours[3]	Noise affected	50
		Highly noise affected	55
Southern residential receivers	During recommended standard hours[2]	Noise affected	56
		Highly noise affected	75
	Outside recommended standard hours[3]	Noise affected	49
		Highly noise affected	54

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

2 - Monday to Friday 7 am to 6pm; Saturday 8am to 1pm; Sunday and Public Holidays no work

3 - Noise management level based on evening period (i.e. 6 pm to 10 pm) background noise level

Table 25: Construction NMLs for non-residential receivers

Receiver ID	Name	Address	NML[1], $dBL_{Aeq\ 15minute}$
Commercial			
C1	High St Society Cafe	1/64 High St, Randwick NSW 2031	70
C2	Pizza Hut	129 Botany St, Randwick NSW 2031	70
Educational Facilities			
E1	Wallace Wurth Building	61-63 Botany St, Randwick NSW 2031	45 (Internal)
E2	Lowy Cancer Research Centre	Cnr High and Botany St, Kensington NSW 2033	45 (Internal)

Receiver ID	Name	Address	NML[1], $dBL_{Aeq\ 15minute}$
Passive Recreation Area			
PR1	Writtle Park	20 Botany St, Randwick NSW 2031	60
Health			
H1	Sydney Children's Hospital, Randwick	High St, Randwick NSW 2031	45 (Internal)
H2	Royal Hospital for Women	Barker St, Randwick NSW 2031	45 (Internal)
H3	Wales Medical Centre	66 High St, Randwick NSW 2031	45 (Internal)
H4	UNSW Medicine Lifestyle Clinic	38 Botany St, Randwick NSW 2031	45 (Internal)
H5	SCH Stage 1 and the CCCC	Corner of Botany and High St, Randwick NSW 2031	45 (Internal)
H6	Prince of Wales Integrated Acute Services Building	Hospital Rd, Randwick NSW 2031	45 (Internal)
Place of Worship			
PW1	Our Lady of the Sacred Heart Catholic Church	193 Avoca St, Randwick NSW 2031	45 (Internal)
PW2	East Sydney Community Christian Church	8/10 Soudan St, Randwick NSW 2031	45 (Internal)

Note:
1 – When in use.

6.2.3 Construction traffic noise criteria

Increased traffic generated on the surrounding road network due to construction activities in UNSW HTH on the surrounding road is assessed in accordance with the NSW *Road Noise Policy* (RNP) [8]. Please refer to the criteria in Section 4.2.2.

6.3 Construction vibration criteria

6.3.1 Disturbance to building occupants

Refer to Section 5.2.

6.3.2 Vibration sensitive equipment or receivers

Some high technology manufacturing facilities, hospitals and laboratories use equipment and processes that are highly sensitive to vibration, such as high magnification microscopy (including optical and electron microscopes) and high resolution imaging equipment (e.g. MRI). Buildings housing sensitive computer or telecommunications equipment may also require assessment against stricter criteria than those nominated for building damage.

While the acceptable vibration levels for such equipment are recommended to be obtained from the instrument manufacturers, generic criteria such as the ASHRAE Vibration Criteria for Vibration Sensitive Equipment (VC-curves) can be adopted for planning purposes.

Regarding existing hospital buildings/facilities surrounding the UNSW HTH site, an investigation of all vibration sensitive equipment should take place during development of the detailed Construction Noise and Vibration Management Plan.

6.3.3 Structural damage

6.3.3.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 [13] and/or German Standard DIN4150-3 [14]. British Standard 7385 Part 1: 1990, defines different levels of structural damage as:

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

Table 1 of British Standard 7385 Part 2 (1993) sets limits for the protection against cosmetic damage, however the following guidance on minor and major damage is provided in Section 7.4.2 of the Standard:

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

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

- *cracks form in plastered surfaces of walls;*
- *existing cracks in the building are enlarged;*
- *partitions become detached from loadbearing walls or floors.*

These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures.

6.3.3.2 British standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 26 sets out the BS7385-2 criteria for cosmetic, minor and major damage.

Table 26: BS7385-2 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s[1]		
			4 Hz to 15 Hz	15 Hz to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor[2]	100		
		Major[2]	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Note:

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

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

3 - All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

6.3.3.3 German standard DIN 4150

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure'* [14] are generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings. For the subject site, surrounding buildings are not deemed structurally sensitive and therefore the British Standard is considered appropriate for vibration management.

6.3.4 Buried services

It is not expected that the proposed works will impact upon buried services, however the following is provided for guidance. DIN 4150-2:1999 sets out guideline values for vibration effects on buried pipework (see Table 27).

Table 27: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note:

For gas and water supply pipes within 2m of buildings, the levels given in DIN4150-3 [14] should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 m of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/s the ground vibration is required to be monitored.

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

6.4 Construction noise and vibration assessment

Appropriate detail on the construction methodologies required for quantitative assessment of the project are not yet known. A preliminary assessment has been carried out based on construction staging in Section 6.1.1 and typical equipment to be used. A preliminary assessment has been conducted to inform the mitigation measures to be put in place.

The noise assessment aims to provide a 'realistic worst-case' noise impact assessment based on construction works within any 15-minute period. The predictions assume activities are located at the closest point of the works zone to the nearest sensitive receivers.

The predictions assume activities are located at the closest point of the works zone to the nearest sensitive receivers. In reality, the potential construction noise impacts at any particular location will vary depending on factors including:

- The position of the works within the site and distance to the nearest sensitive receiver
- The overall duration of the works
- The cumulative operation of works

An analysis of potential cumulative impacts due to works being undertaken concurrently within the project has not been included. As the predictions are based on worst-case nearest distances, the influence of cumulative works is not expected to be significantly higher than the levels predicted.

Where the predicted noise level is greater than the noise management levels all feasible and reasonable work practices should be applied, however it is unlikely mitigation measures would reduce the received noise levels below the noise management levels, this is further discussed in Section 6.5. Where activity is predicted to exceed the 'highly noise affected' levels of 75 $dBL_{Aeq(15minute)}$, it is recommended that respite periods should be considered during these phases.

It should be noted that this is a preliminary assessment, and as such the following assumptions have been applied:

- Three (3) types of equipment have been assumed for each stage
- One unit of each type of equipment has been assumed to operate concurrently and continuously over a full 15-minute period (a typical worst-case assumption).

Assumed construction equipment and activites to be used are provided in Table 28.

Refer to Appendix B for the sound power levels of construction equipment.

Predicted noise levels for the construction of the project are tabulated in Table 29 and Table 30.

Table 28: Plant used to calculate construction noise predictions

Plant Item	Sound Power Level, dB(A)	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	Stage 9
		Site Establishment	Excavation	Foundation/ substructure	Structure	Pedestrian link	Façade and building enevelope	Internal fitout and finishes	Connection of services	Landscaping and external works
		Total SWL of construction activity at each stage, dB(A)								
		113	115	115	115	115	115	115	111	112
Forklift	106	1						1	1	
Concrete pump	106			1		1				
Truck	107		1	1	1	1	1	1	1	1
Crane (Mobile)	113				1	1	1	1		
Concrete pump truck	113			1						
Bulldozer	114		1							
Excavator (40t)	106	1	1		1				1	
Hand Tools (Electric)	110	1					1	1		
Roller	109									1

Note:

1 – Plant will be operational for 100% in a 15minute period

Table 29: Predicted noise levels at nearest affected residential receiver (Exceedance – above NML, Highly intrusive - >75dB)

ID	Distance from site (m)	Period	Criteria		Predicted Noise Levels ($dBL_{Aeq15minute}$)								
					Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	Stage 9
			Noise Affected	Highly Noise Affected	Site Establishment	Excavation	Foundation/substructure	Structure	Pedestrian link bridge	Façade and building envelope	Internal fit outs and finishes	Connection of services	Landscaping and external works
R1	28	Standard Hours	57	75	83	85	85	85	85	85	85	81	82
		OOHW	50	55	83	85	85	85	85	85	85	81	82
R2	150	Standard Hours	56	75	69	71	71	71	71	71	71	67	68
		OOHW	50	55	69	71	71	71	71	71	71	67	68
R3	20	Standard Hours	57	75	86	88	88	88	88	88	88	84	85
		OOHW	50	55	86	88	88	88	88	88	88	84	85
R4	44	Standard Hours	57	75	79	81	81	81	81	81	81	77	78
		OOHW	50	55	79	81	81	81	81	81	81	77	78
R5	150	Standard Hours	56	75	69	71	71	71	71	71	71	67	68
		OOHW	50	55	69	71	71	71	71	71	71	67	68

Note:

1 – The results are highlighted according to the level of exceedance above the NML according to ICNG criteria

Table 30: Predicted noise levels at nearest affected non-residential receivers (Exceedance – above NML, Highly intrusive - >75dB)

ID	Distance from site (m)	Criteria NML	Predicted Noise Levels($dBL_{Aeq15minute}$)								
			Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8	Stage 9
			Site Establishment	Excavation	Foundation/substructure	Structure	Pedestrian link bridge	Façade and building envelope	Internal fit outs and finishes	Connection of services	Landscaping and external works
C1	230	70	65	67	67	67	67	67	67	63	64
C2	315	70	63	64	64	64	64	64	64	60	61
E1	28	55[3]	83	85	85	85	85	85	85	81	82
E2	110	55[3]	71	73	73	73	73	73	73	69	70
PR1	210	60	66	68	68	68	68	68	68	64	65
H1	12	55[3]	90	92	92	92	92	92	92	90	89
H2	136	55[3]	69	71	71	71	71	71	71	68	68
H3	220	55[3]	65	67	67	67	67	67	67	67	64
H4	36	55[3]	81	83	83	83	83	83	83	79	80
H5	10	55[3]	92	94	94	94	94	94	94	90	91
H6	10	55[3]	92	94	94	94	94	94	94	90	91
PW1	340	55[3]	61	63	63	63	63	63	63	59	60
PW2	400	55[3]	60	62	62	62	62	62	62	58	59

Note: 1 – The results are highlighted according to the level of exceedance above the NML according to ICNG criteria

2 - A 10dB correction was applied to the convert internal criteria to convert to external criteria assuming minimum reduction through a window.

6.5 Construction noise and vibration management plan

For all construction works, the contractor would be expected to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise and vibration sensitive receiver locations
- Areas of potential impact
- Mitigation strategy
- Monitoring methodology
- Community engagement strategy.

General guidance on the control of construction noise and vibration impacts relevant to this study are discussed in the following sections. A summary of all mitigation and management measures is presented in Table 31.

6.5.1 General

In general, practices to reduce construction noise impacts will be required, and may include;

- Adherence to the standard approved working hours as outlined in the Project Approval.
- Manage noise from construction work that might be undertaken outside the recommended standard hours
- The location of stationary plant (concrete pumps, air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using site sheds and other temporary structures or screens/hoarding to limit noise exposure where possible.
- Sealing of openings in the building (temporary or permanent) prior to commencement of internal works to limit noise emission.
- The appropriate choice of low-noise construction equipment and/or methods
- The use of audible movement alarms of a type that would minimise noise impacts on surrounding noise sensitive receivers must be implemented.
- Modifications to construction equipment or the construction methodology or program. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.
- Carry out consultation with the community during construction including, but not limited to, advance notification of planned activities and expected disruption/effects and construction noise complaints handling procedures.

6.5.2 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Appoint a named member of staff who will act as the Responsible Person with respect to noise and vibration
- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.

6.5.3 Vibration – minimum working distances

Recommended minimum working distances for vibration intensive plant, which are based on international standards and guidance and reproduced in Table 31 for reference. With regards to the proposed development works, vibration is not expected to impact upon surrounding development.

Table 31: Recommended minimum working distances for vibration intensive plant

Plant Item	**Rating / Description**	**Minimum working distance (m)**			
		Cosmetic damage			**Disturbance to building occupants**
		BS 7385 Table 25 Line 1 (Screening criterion of 25 mm/s as per Section 6.3.3.2)	BS 7385 Table 25 Line 2 (Screening criterion of 7.5 mm/s as per Section 6.3.3.2)	DIN 4150 Table Line 3 (Screening criterion of 3 mm/s as per Section 6.3.3.3)	Human response (OH&E Vibration Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	2 m	5 m	11 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	2 m	6 m	13 m	20 m
	< 200 kN (Typically 4-6 tonnes)	5 m	12 m	26 m	40 m
	< 300 kN (Typically 7-13 tonnes)	6 m	15 m	31 m	100 m
	> 300 kN (Typically 13-18 tonnes)	8 m	20 m	40 m	100 m
	> 300 kN (> 18 tonnes)	10 m	25 m	50 m	100 m

Plant Item	Rating / Description	Minimum working distance (m)			
		Cosmetic damage			Disturbance to building occupants
		BS 7385 Table 25 Line 1 (Screening criterion of 25 mm/s as per Section 6.3.3.2)	BS 7385 Table 25 Line 2 (Screening criterion of 7.5 mm/s as per Section 6.3.3.2)	DIN 4150 Table Line 3 (Screening criterion of 3 mm/s as per Section 6.3.3.3)	Human response (OH&E Vibration Guideline)
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	1 m	2 m	5 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	3 m	7 m	15 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	9 m	22 m	44 m	73 m
Pile Driver - Vibratory	Sheet piles	9 m	22 m	44 m	73 m
Piling Rig - Bored	≤ 800 mm	1 m (nominal)	2 m (nominal)	5 m	10 m (nominal)
Piling Rig – Hammer	12t down force	6 m	15 m	30 m	50 m
Jackhammer	Hand-held	1 m (nominal)	1 m (nominal)	3 m	5 m
Mechanised bored tunnelling works (Tunnel Boring Machine, Horizontal Directional Drilling, Micro-tunnelling)	-	1 m to 5 m	2 m to 12 m	4 m to 24 m	6 m to 35 m

7 Summary of mitigation measures

Based on the findings and recommendations of this report, the following measures are suggested to mitigate the identified impacts of the development:

Table 32: Recommended noise mitigation and management measures

No.	Item	Detail
Operational Noise		
1	External Plant	Noise emissions from any external mechanical plant shall be treated such that noise emission complies with NPfI PANL criteria at all surrounding receivers. This may require the use of acoustic louvres, enclosures, barriers or attenuators.
Impacts upon development		
2	Road Traffic and Light Rail Noise	Internal noise criteria can be readily achieved with a sealed façade. The acoustic requirements and specification of the façade will be determined during the Detailed Design phase.
Construction noise and vibration		
3	Noise and vibration management plan	A Construction Noise and Vibration Management Plan shall be prepared prior to the issuing of a Construction Certificate. This will specify the actual equipment to be used and will include updated estimates of the likely levels of noise and the scheduling of activities.
4	Staffing	Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration; Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise; Ensuring good work practices are adopted to avoid issues such as noise from dropped items, noise from communication radios is kept as low as is practicable; Avoid the use of radios or stereos outdoors; and Avoid shouting and minimise talking loudly and slamming vehicle doors.
5	Plant and Equipment	Where possible stationary equipment should be located behind structures such as demountable buildings or stockpiles to maximise shielding to receivers; Consider using electric / hydraulic equipment where possible. Using the smallest equipment as is practical. All plant and equipment used on site must be: • maintained in a proper and efficient condition; and • operated in a proper and efficient manner. Turn off all vehicles, plant and equipment when not in use. Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.

No.	Item	Detail
6	Work site training	'Toolbox talks' will be held at regular intervals with the contractor workers, including discussion of noise and vibration mitigation, monitoring and assessment. These topics will also be covered under induction processes. Operate two way radios at the minimum effective volume, and avoid shouting or whistling at the site. Identification of all reasonable and feasible noise mitigation methods will be conducted by the Responsible Person on a daily basis during noisy works. The Responsible Person will have the authority to modify work practices in response to complaints, where this is considered appropriate.
7	Scheduling	Program high noise activities to occur during the daytime hours wherever possible and scheduled with due consideration of the nearest sensitive receivers; and For approved out-of-hours work, schedule noisy activities early in the night to minimise the impact on adjacent residents. Limit the number of consecutive nights receivers are impacted.
8	Community liaison	Ensure that the Responsible Person keeps the local community advised on expected activities and coordinates scheduling and locations of noisy works around any critical user events where practicable. This shall include face to face meetings with nearby receivers if requested and a letter box drop, and shall include close liaison with neighbours during construction; and Maintain appropriate records of complaints to include timing, reported issues, actions taken and measures to be included for on-going works. The complaints log will need to be filed with the Responsible Person.
9	Reversing alarms	The use of audible movement alarms of a type that would minimise noise impacts on surrounding noise sensitive receivers must be implemented. Where practicable, broadband, non-tonal reversing alarms should be utilised on site equipment. Ensure that the difference in volume between the reversing warning devices and the base machine noise level (at maximum governed speed under no load at any given test location) is minimised (in accordance with International Standard ISO9533:1989), and ensure that warning devices are no more than 5 dB above the Australian Standard level.
10	Material handling	Avoid dropping equipment/materials from a height or into trucks. Where practicable, use sound dampening material to cover the surfaces on to which any materials must be dropped.
11	Equipment location	Site noisy equipment away from noise-sensitive areas. Orient plant known to emit noise strongly in one direction so that the noise is directed away from noise-sensitive areas; Locate site access roads and site compounds as far away as possible from noise sensitive receptors; and Plan truck movements to avoid residential streets where possible.
12	Construction vibration	Adherence to minimum working distances presented in Table 31.

No.	Item	Detail
13	Out of hours work	The following measures are taken from Table 9 of the Construction Noise and Vibration Strategy for Out of Hours Work for Period 1 (Highly Intrusive) [15]: • **Verification**: Conduct measurement of the background noise levels and construction noise to confirm that construction noise and vibration from the precinct are consistent with the predictions in the noise assessment and that mitigation and management of construction noise and vibration is appropriate for receivers affected by the works • **Periodic Notification:** Periodic notifications (commonly distributed on a monthly basis) provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g.traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them • **Specific Notifcation:** Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing • **Project Specific Respite Offer:** The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise prepurchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis • **Respite Period 1[1]:** Out of hours construction noise in out of hours period 1 shall be limited to no more than three consecutive evenings and no more than two consecutive nights in the same NCA per week except where there is a Duration Respite. • **Duration Reduction:** Where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite. Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite.

Note:

1 – The CNVG defines Out of Hours Work (OOHW) Period 1 from

- Mon to Friday (6pm to 10pm)
- Sat (7am to 8am & 1pm to 10pm)
- Sun & Public Holiday (8am to 6pm)

8 Conclusion

An assessment of noise and vibration impacts associated with the construction and operation of the UNSW HTH building has been conducted in accordance with Secretary's Environmental Assessment Requirements and relevant noise policies and guidance documents.

The assessment has covered the following issues and concluded:

8.1 Operational noise

Operation noise criteria have been established for noise emissions, which include mechanical services and traffic generated by operation of the site.

Impacts due to the operational road traffic have been assessed against the RNP. From the assessment, the generated road traffic from the operation of the UNSW HTH building will generate a less than 2 dB increase in noise level therefore represents an insignificant effect on the ambient noise environment.

Regarding the proposed operations, further assessment will need to be undertaken during design development to determine whether the proposed development is capable of satisfying the standard NSW EPA noise policy requirements with regard to building services noise control.

8.2 Impact upon development

The UNSW HTH building is located between the existing Prince of Wales Hospital and the UNSW Kensington Campus, and directly adjacent to the CBD and South East Light Rail service which runs along High Street.

Potential noise and vibration impacts from the Light Rail and road traffic from Botany Street and Magill Street to the development have been considered in this report.

While detailed information on the architectural design is not yet available, the measured noise levels in the area are moderate and internal criteria can be readily achieved with a sealed façade. The acoustic requirements and specification of the façade will be determined during the Detailed Design phase.

Measured vibration results during the light rail operations show that they are well below the limits set out in Section 5.2.1 and are therefore are not anticipated to negatively impact the building.

8.3 Construction noise and vibration

Noise generated from the various stages of demolition and construction have been predicted at surrounding noise sensitive receivers.

Regarding construction noise and vibration, the proposed development may result in some exceedances of the relevant noise management levels and, accordingly, mitigation and management procedures will need to be considered for the works.

High level recommendations are given for the control of construction noise for the periods where exceedances are predicted of relevant Noise Management Levels and the Highly Noise Affected Levels. The construction contractor is required to prepare a detailed Construction Noise and Vibration Management Plan when the construction methodology, staging, equipment are confirmed.

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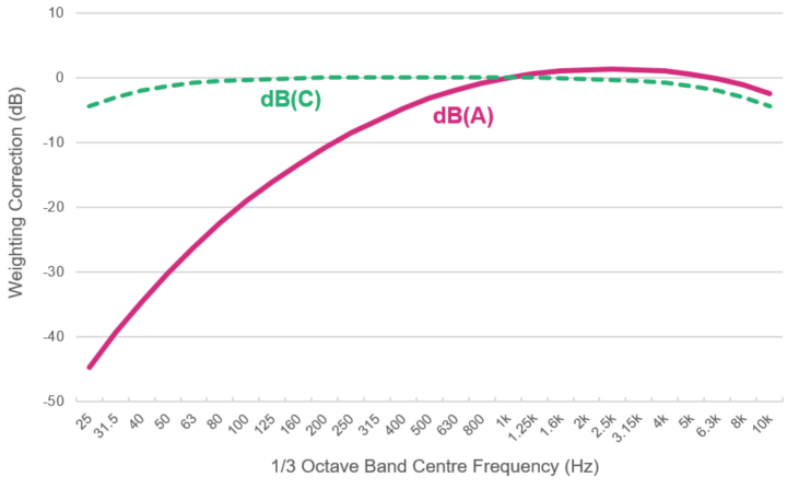
Appendix A

Acoustic Terminology

Term	Definition
Ambient noise level	The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a building is being investigated, the ambient noise level is the noise level from all other sources without the fan operating, such as traffic, birds, people talking and other noise from other buildings.
Background noise level	The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects. **Assessment Background Level (ABL)** A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time. **Rating Background Level (RBL / min$L_{A90,1hour}$)** A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.
Decibel (dB)	The logarithmic scale used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressures, which would be unwieldy if presented on a linear scale. Use of a logarithmic scale allows all sound levels to be expressed based on how loud they are relative to a reference sound (typically 20 µPa, which is the approximate human threshold of hearing). For sound in other media (e.g. underwater noise) a different reference level (1 µPa) is used instead. An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB. The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.
dB weighting curves	The frequency of a sound affects its perceived loudness and human hearing is less sensitive at low and very high frequencies. When seeking to represent the summation of sound pressure levels across the frequency range of human hearing into a single number, weighting is typically applied. Most commonly, A-weighting, denoted as dB(A), is used for environmental noise assessment. This is often supplemented by the linear or C-weighting curves, where there is the potential for excess low-frequency sound at higher sound pressure levels.

Term	Definition



dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting ('A-weighting') to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

dB_{peak}

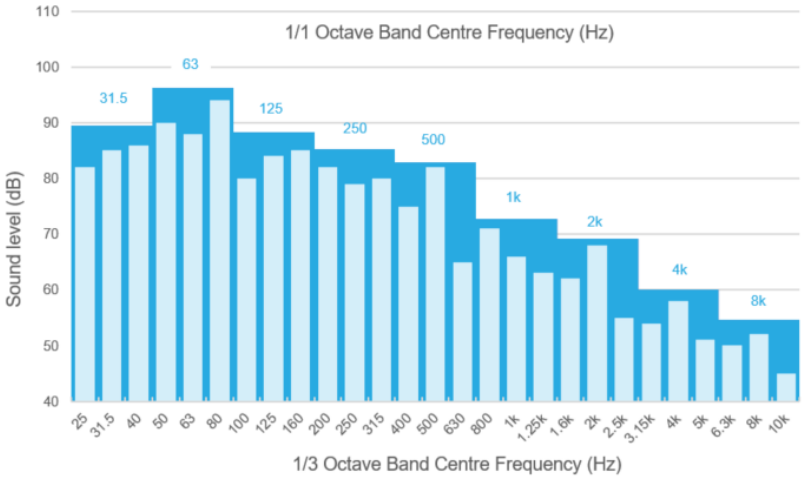
The peak value is the maximum amplitude identified during a measurement period.

dB_{rms}

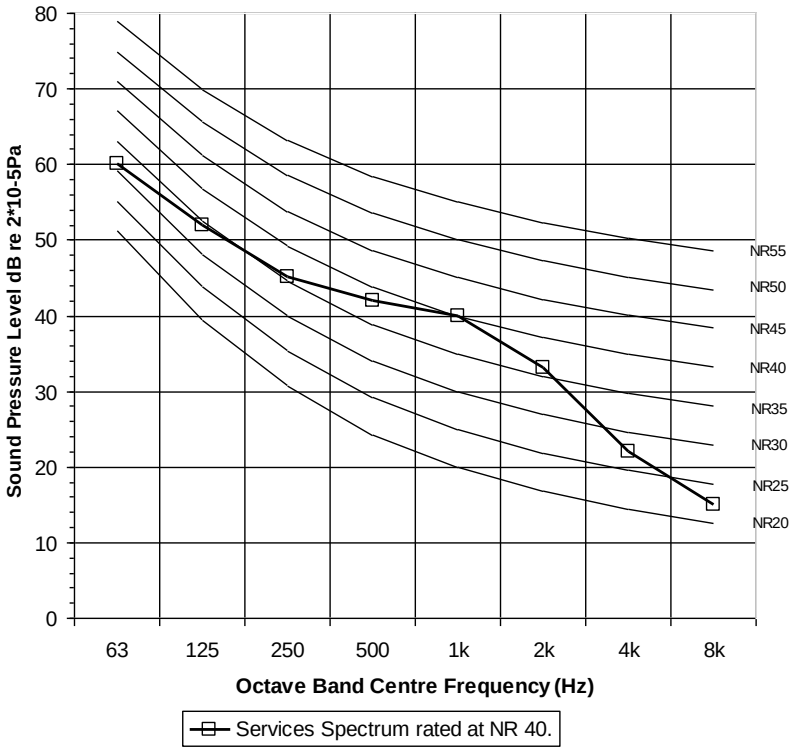
The root mean squared (rms) value takes into account both time history variation and energy content. The rms value is typically equal to 0.707 ($1/\sqrt{2}$) times the peak value

Definition (D_{50})

Definition is a technical index used to objectively evaluate speech clarity. Expressed as a fraction or as a percentage, it is ratio of the total sound energy received in the first 50 ms following (and including) the direct sound energy to the total sound energy – i.e. the proportion of early energy relative to the

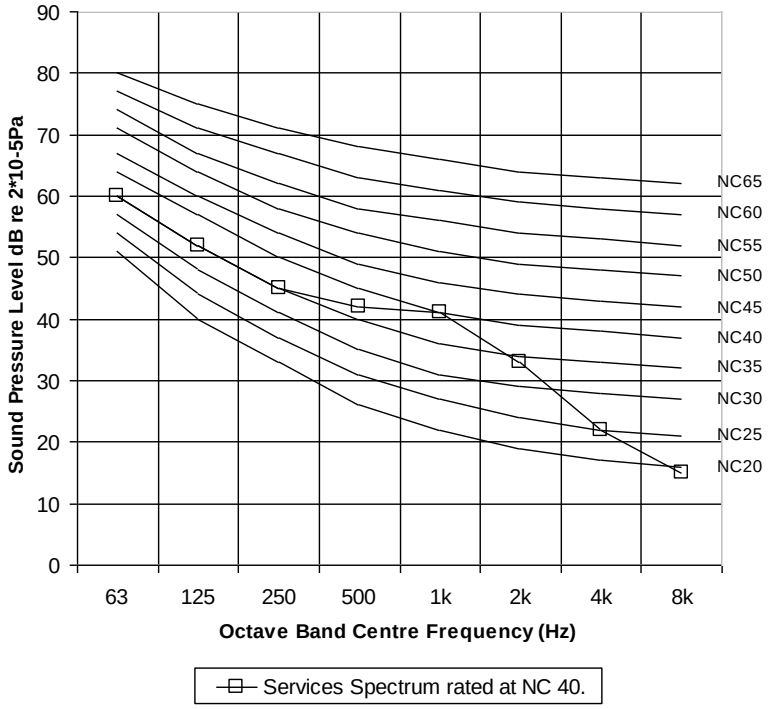
Term	Definition
	total energy. The higher the value of D_{50}, the greater the expected subjective clarity.
Frequency	Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as 'pitch'. Sounds towards the lower end of the human hearing frequency range are perceived as "bass" or 'low-pitched' and sounds with a higher frequency are perceived as 'treble' or 'high pitched'. The unit of frequency is the hertz (Hz), which is identical to cycles per second. A thousand Hz is generally denoted as kHz. Human hearing ranges approximately from 20 Hz to 20 kHz. While single weighted sound pressure levels simplify the assessment and evaluation of sound levels, frequency analysis is often undertaken. 'Octave bands', either 1/1 or 1/3 octave bands are most commonly utilised and are referred to by the nominal centre frequency of the band (e.g. 31.5 Hz), while being the summation of all frequencies between a defined lower and upper frequency. 
Impact Sound Pressure Level	The technical parameter used to determine impact sound isolation of floors is the impact sound pressure level, L_i. In the laboratory, the weighted normalised impact sound pressure level, $L_{n,w}$, is used to represent the impact sound isolation as a single figure. On site, the weighted normalised apparent impact sound pressure level, $L'_{n,w,}$ and the weighted standardised apparent impact sound pressure level, $L'_{n,Tw}$, are used to represent the impact sound isolation of a floor as a single figure. These single weighted values are determined by comparing the spectral impact sound pressure levels (as defined in ISO 140-6 and ISO 140-7) with reference values outlined in AS/NZS ISO 717.2.
$L_{1(period)}$	The sound level exceeded for 1% of the measurement period. The L_1 is often used to describe the maximum sound levels measured. As an example, 65 $dBL_{A1,1min}$ indicates that the A-weighted sound level would not exceed 65 dB for more than 0.6 seconds in the 1-minute measurement period.
$L_{10(period)}$	The sound level exceeded for 10% of the measurement period, or alternatively, the sound levels would be lower for 90% of the time. The L_{10} is often defined as the 'average maximum' sound levels, as in AS1055-19XX with the advent of statistical sound level meters.
$L_{90(period)}$	The sound level exceeded for 90% of the measurement period.

Term	Definition
	The L_{90} is often defined as the 'average minimum' or 'background' noise level for a period of measurement. For example, 45 $dBL_{A90,15min}$ indicates that the sound level is higher than 45 dB(A) for 90% of the 15-minute measurement period.
$L_{eq(period)}$	The equivalent ('eq') continuous sound level, used to describe the level of a time-varying sound or vibration measurement. The L_{eq} is often defined as the 'average' level, and mathematically, is the energy-average level over a measurement period – i.e. the level of a constant sound that contains the same sound energy as the measured sound.
L_{max}	The L_{max} is the 'absolute maximum' level of a sound or vibration recorded over the measurement period. As the L_{max} is often caused by an instantaneous event, it can vary significantly between measurements.
Noise Rating (NR) Curves	A set of internationally-agreed octave band sound pressure level curves, based on the concept of equal loudness. The curves are commonly used to define building services noise limits. The 'NR' value is obtained by plotting the octave band spectrum on the set of standard curves. The highest value curve which is reached by the spectrum is the NR value. Shown below is a mechanical plant noise spectrum at NR 40.



Noise Criteria (NC) Curves	Originally developed in the USA, the curves are commonly used to define building services noise limits. The NC value is obtained by plotting the octave band spectrum of a noise measurement on the set of standard curves. The highest value curve reached by the spectrum is the NC value. Shown below is a mechanical plant noise spectrum equivalent to NC 40.

Term	Definition



Peak Particle Velocity (PPV)

The highest velocity of a particle (such as part of a building structure) as it vibrates. PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of the environment and distance from a source.

The sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

A measure of the sound level loss through a material for a particular frequency band. Sound reduction index is sometimes also referred to as **transmission loss.** It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency band.

The **weighted sound reduction index**, R_w, is a single figure description of sound reduction index across multiple frequency bands and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Note however that R_w is only calculated over a frequency range from 100 Hz to 3.15 kHz and hence sound outside of this range is excluded from calculation of R_w – particularly low frequency (bass) sound below 100 Hz.

Sound insulation ratings derived from site measurements are referred to as **apparent sound reduction index** (R'_w) ratings.

Spectrum Adaptation Terms (C and C_{tr})

The terms C and C_{tr} are spectrum adaptation terms (in dB) that are added to the R_w or D_w value of a partition to determine the overall sound insulation rating of a partition for various conditions.

Term	Definition
	C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech. C_{tr} is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise. The values of C and C_{tr} are dependent on the construction of the partition. Because C and C_{tr} are usually negative quantities, they typically increase the R_w requirement of a partition. For example, for a construction with an R_w of 56 dB and C_{tr} -6 dB, the R_w+C_{tr} is only 50 dB. The overall performance of the partition is quoted as the sum of the R_w value and the spectrum adaptation terms, e.g. D_w+C 55 dB; R_w+C_{tr} 60 dB.
Structureborne noise	The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.
Vibration	Waves in a solid material are called ‘vibration’, as opposed to similar waves in air, which are called ‘sound’ or ‘noise’. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage. A vibrating structure (e.g. a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space. Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s^2) or else using a decibel scale.

Appendix B

Construction Equipment and Sound Power Levels

The activities that require equipment and machinery for the Project are typical for a general construction site. Table 33 provides an indicative but not exhaustive list of the potential equipment and machinery to be used in construction.

Sound power levels have been sourced from Appendix A of the Australia Standard AS 2436-2010 (R2016) 'Guide to noise and vibration control on construction, demolition and maintenance sites' [16] and the Department for Environment Food and Rural Affairs' 'Update of noise database for prediction of noise on construction and open sites' [17].

Table 33: Indicative key equipment and machinery and sound levels

Equipment	**Plant item sound power level, dBL$_{Aeq(15min)}$**
Forklift	106
Concrete Pump	106
Truck	107
Backhoe	108
Compactor	115
Crane (Mobile)	113
Concrete Pump Truck	113
Generator (Diesel)	113
Bulldozer	114
Moxeys	117
Large excavators fitted with teeth	106
Hand tools	117
Hoist	105
Power tool	110
Hand held electric drill	110
Hand held electric grinder	108
Excavator	106
Excavator with hammer	122
Scraper	113
Water cart	107
Roller	109
Hot mix	108