University of Sydney
Health Precinct Stage 1
SEARs Noise and Vibration Assessment

Report Date: Friday, 11 August 2017
Reference: M17183RP2, Revision A

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Document Information

Project	University of Sydney Health Building – Health Precinct Stage 1	
Client	Umow Lai	
Report title	SEARs Noise and Vibration Assessment	
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Revision Table

Report revision	Date	Comments
0	22 June 2017	Draft Issue
A	11 August 2017	For Issue

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm as defined in the INP.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Evening	Between 6 pm and 10 pm as defined in the INP.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 to 20,000 Hz.
INP	New South Wales *Industrial Noise Policy*, 2000.
Intrusive Noise	Noise emission that when assessed at a noise-sensitive receiver (principally a residential premises boundary) is greater than 5 dB(A) above the background noise level.
L_{10}	Noise level exceeded for 10% of the measurement time. The L_{10} level is commonly referred to as the average maximum noise level.
L_{90}	Noise level exceeded for 90% of the measurement time. The L90 level is commonly referred to as the background noise level.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{max}	Maximum measured sound pressure level in the time period.
mm/s	Millimetres per second—units of vibration velocity.
Night-time	Between 10 pm on one day and 7 am on the following day as defined in the INP.
Rating Background Level (RBL)	Overall single-figure A-weighted background level representing an assessment period (Day/Evening/Night). For the short-term method, the RBL is simply the measured $L_{90,15min}$ noise level. For the long-term method, it is the median value of all measured background levels during the relevant assessment period.

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Executive summary

The University of Sydney are proposing to develop a Health Precinct on the Camperdown campus. Stage 1 of the Health Precinct involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

The Department of Planning & Environment (DPE) has issued Stage 1 of the Health Precinct with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS, to consider construction and operational noise and vibration from the development. This report has been prepared to address SEAR 7.

Construction phase

A preliminary construction noise and vibration assessment has been conducted against noise and vibration criteria determined from:

- existing noise monitoring data for the site
- the *Interim Construction Noise Guideline* (ICNG)
- *Assessing Vibration – a technical guideline* (the Vibration Guideline).

Based on the preliminary assessment, it is anticipated that some noise and vibration impacts may occur during construction at the Royal Prince Alfred Hospital and Wesley College on the University of Sydney Campus. Limited noise impacts may also occur at the University of Sydney Oval to the north of the site.

The construction noise and vibration impacts are considered to be manageable through:

- the development and implementation of a Construction Noise and Vibration Management Plan
- carrying out works during standard daytime working hours wherever possible
- appropriate stakeholder consultation and complaint handling procedures for noise and vibration
- the implementation of all feasible and reasonable work practices to minimise noise and vibration from the site in accordance with the ICNG and Vibration Guideline.

Operational phase

Operational noise emission criteria for the development have been established in accordance with the NSW *Industrial Noise Policy* (INP). The noise emission criteria for the nearest noise-sensitive land uses are shown in Table 1.

Table 1 INP noise emission criteria for residential land uses and Colleges

Location	INP noise emission criteria, dB(A) $L_{eq,15min}$		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Residences and Colleges	51	46	41
Royal Prince Alfred Hospital	35 – 40 internal 50 – 55 external	35 – 40 internal 50 – 55 external	35 – 40 internal 50 – 55 external

Noise emissions from the development will predominantly be a result of rooftop mechanical plant including a rooftop plant room, water-cooled chiller and cooling towers, and emergency generator. Detailed information on the rooftop plant selection is not available at this stage but noise mitigation techniques will be investigated and determined during detailed design, and will include consideration of:

- Selection of lower noise plant and equipment, particularly the chiller and cooling towers.
- Screening of external plant using solid barriers or acoustic louvres.
- Appropriate construction of a rooftop plant room to reduce noise emissions to neighbouring land uses.
- Installation of the emergency generator in an acoustically-rated enclosure.

The measures will be selected and designed to ensure that compliance is achieved with the INP noise emission criteria.

1 Introduction

The University of Sydney are proposing to develop a Health Precinct on the Camperdown campus, to support the business needs of the health disciplines and to co-locate the faculties of Nursing and Midwifery and Health Sciences with components of Medicine, Pharmacy, and Dentistry.

Stage 1 of the Health Precinct involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

The Department of Planning & Environment (DPE) has issued Stage 1 of the Health Precinct with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS:

> Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding sensitive receivers.
>
> *Relevant Policies and Guidelines:*
>
> - *NSW Industrial Noise Policy (EPA)*
> - *Interim Construction Noise Guideline (DECC)*
> - *Assessing Vibration: A Technical Guideline 2006*

This report has been prepared to address SEAR 7 and:

- Defines noise and vibration assessment criteria for the construction and operation of the Stage 1 building.
- Identifies likely construction phase noise and vibration impacts and recommends management procedures to be implemented during construction.
- Provides a preliminary assessment of operational noise from the development.

2 Project description

2.1 Location

Stage 1 of the Health Precinct will be constructed on the Camperdown campus, located on Lambie Dew Drive and immediately east of the Royal Prince Alfred Hospital. Figure 1 shows the proposed site location.

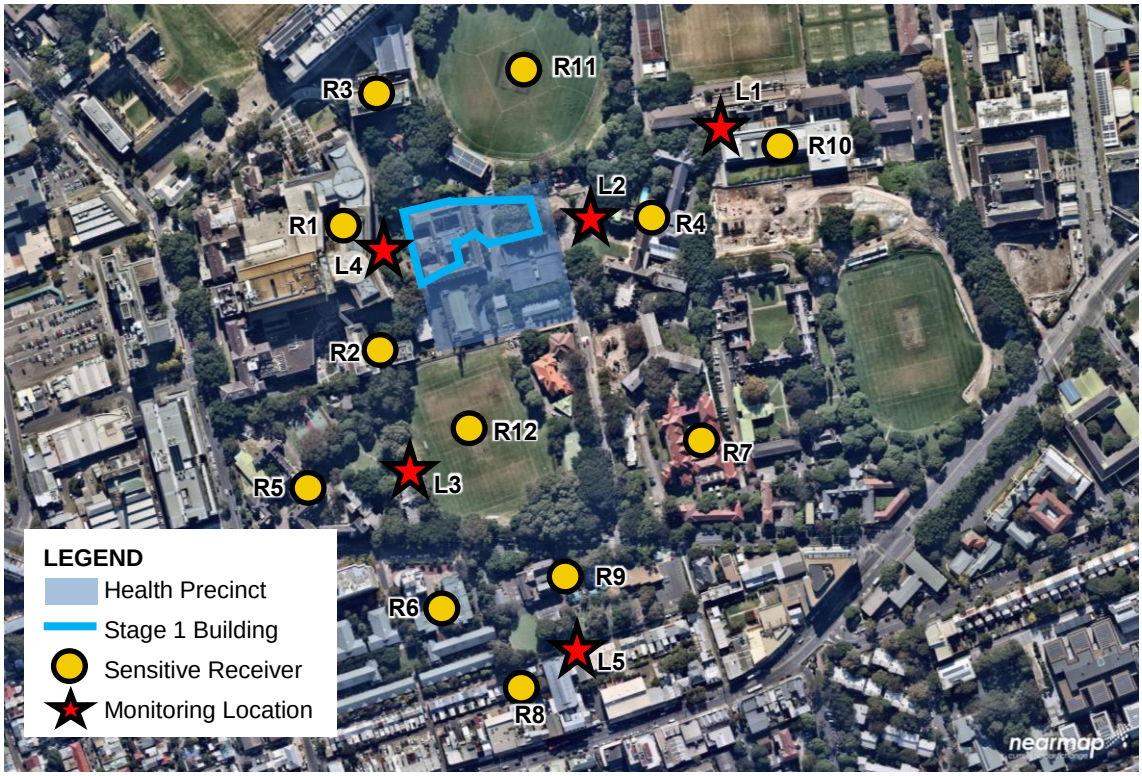

Figure 1 Stage 1 site location

A number of noise and vibration-sensitive land uses are located in the immediate vicinity of the Stage 1 site as shown on Figure 1, with the most significant being the Hospital to the west and Wesley College to the east. The nearest non-University residences are located a significant distance away from the site.

The sensitive land uses are summarised in Table 2 alongside a description of the land use.

Table 2 Noise and vibration sensitive land uses

Reference (see Figure 1) and name	Description
Health buildings	
R1 – Royal Prince Alfred Hospital	Main hospital building. Approximately 30 m west of site.
R2 – Gloucester House	Royal Prince Alfred Hospital building housing Sydney Cancer Centre. Approximately 50 m southwest of site.
R3 – Centenary Institute	Medical research institute. Approximately 80 m north of site.
Residential buildings and colleges	
R4 – Wesley College	Colleges and/or residential villages located on or around University of Sydney Camperdown campus. Wesley College is the closest, approximately 60 m east of the site.
R5 – St Andrew's College	
R6 – Sydney University Village	
R7 – Women's College	
R8 – Campbell Street	Nearest non-University residential uses to the south of the site. Over 300 m south of site.
Educational buildings	
R9 – Newtown North Public School	Public school, also includes Carillon Avenue Childcare Centre. Approximately 230 m south of site.
R10 – Sydney Nanoscience Hub	Educational and research building housing highly vibration-sensitive equipment. Approximately 150 m east of site.
Recreational land uses	
R11 – University Oval No. 1	Active recreation land uses. University Oval No. 1 is approximately 50 m north of the site.
R12 – St Andrew's College Oval	

2.2 Stage 1 development

Stage 1 of the Health Precinct will involve the construction of an eight-level building (Level 0 up to Level 7) on the footprint shown in Figure 1. Landscaping will also occur around the Health Precinct area.

Construction

Construction of the Stage 1 development is scheduled to commence in December 2017 and be completed by mid-2019. The construction staging has been broadly summarised in Table 3.

Table 3 Anticipated construction schedule

Stage	Description
Site establishment	Bulk excavation and services diversions. December 2017 – January 2018
Substructure	Piling works, followed by creation of Level 0 substructure. January – May 2018
Superstructure and facade	Creation of building superstructure up to Level 7 roof and installation of building facade progressively. May – December 2018
Internal works and fitout	Internal works and fitout of all levels. Will commence progressively as Level superstructures completed. July 2018 – June 2019
External landscaping	Landscaping works around the Stage 1 building and Health Precinct. December 2018 – June 2019

It is planned that works would be undertaken during the standard working hours of:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 1 pm
- No work on Sundays or public holidays.

The demolition of the existing buildings at the site is to be undertaken as part of a separate project, which has been subject to a separate Review of Environmental Factors and approval.

Operation

The Stage 1 building will house teaching, research, office and support spaces that are not expected to have a noise and vibration impact outside of the building footprint. A small carpark, with space for no more than 25 vehicles, and a loading dock will be located on Level 0 and accessed via a road to the east of the building on the University of Sydney campus.

The predominant operational noise consideration for the development will be the rooftop plant, which will include a water-cooled chiller and cooling towers. An emergency standby generator will also be installed on the roof level.

3 Existing environment

The existing environment in the area immediately around the site is typical of an urban University campus, with a relatively low level of steady background noise from distant traffic and mechanical plant, with short-term noise from pedestrians and occasional vehicles on and around the campus.

3.1 Unattended noise monitoring

The nearest residential-type noise-sensitive land use is Wesley College to the east of the site. Unattended noise monitoring was previously undertaken by AECOM at Wesley College in 2012 prior to the development of the Sydney Nanoscience Hub. The noise levels were measured at two locations, with the measurement results for the quietest location (L1 on Figure 1) presented in Table 4.

Table 4 Unattended monitoring results from 2012

Location	Rating Background Level, dB(A) L_{90}[1]			Ambient noise level, dB(A) L_{eq}		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Wesley College L1	46	46	46	55	56	51

(1) The Rating Background Level is a measure of the typical minimum steady background noise level for each time of day.

The adoption of the above results for this assessment is considered conservative as noise levels typically increase over time and it does not include any mechanical plant noise from the Sydney Nanoscience Hub. It is noted that current construction works underway near the Sydney Nanoscience Hub mean that any additional unattended noise logging conducted at present near Wesley College may have been influenced by construction noise.

3.2 Attended noise monitoring

To supplement the unattended monitoring results, attended monitoring was conducted at locations around the site on Friday, 16 June 2017 between 10:00 am and 11:30 am. The monitoring was conducted during University exam period and therefore there were fewer pedestrians on campus at the time of the measurements than would be during teaching times.

The measured noise levels over 15-minute periods at each location are shown in Table 5, with the measurement locations shown on Figure 1. The measurements indicate that there is a moderate level of existing noise in the environment during the daytime period, including relatively steady noise levels of 61 dB(A) L_{eq} at the Royal Prince Alfred Hospital eastern facade.

Table 5 Attended monitoring results on Friday, 16 June 2017

Location	Measured noise level, dB(A)				Description
	L_{max}	L_{10}	L_{eq}	L_{90}	
Wesley College L2	79	62	60	51	Measurement at 10:00 am. Influenced by construction noise, aircraft flyover and distant traffic noise.
St Andrew's College L3	70	59	56	52	Measurement at 10:30 am. Influenced by aircraft noise, mechanical plant at Hospital and distant construction noise.
Royal Prince Alfred Hospital L4	82	63	61	57	Measurement at 10:50 am. Influenced by activity around Hospital loading dock, mechanical plant and distant traffic.
97 Campbell Street L5	79	66	53	57	Measurement at 11:20 am. Influenced by road traffic noise and aircraft flyover.

4 Assessment criteria

4.1 Construction noise

Construction noise in New South Wales is assessed using the Department of Environment & Climate Change (now Environment Protection Authority) *Interim Construction Noise Guideline* (ICNG). The ICNG is also defined as the relevant guideline for construction noise by the SEARs issued by DPE.

The ICNG aims to manage noise from construction works regulated by the EPA. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment.

The ICNG prescribes $L_{eq,15min}$ Noise Management Levels (NML) for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

Residential land uses

The NMLs prescribed for residential land uses by the ICNG are presented in Table 6. The levels apply at the most exposed property boundary of the noise sensitive receiver at a height of 1.5 metres above ground level.

The NMLs have also been adopted for the University colleges on and around the Camperdown campus including:

- Wesley College
- St Andrew's College
- Sydney University Village
- Women's College.

Other sensitive land uses

The ICNG also prescribes NMLs for other sensitive land uses, including educational buildings and hospitals. The NMLs for relevant land uses are summarised in Table 7 and apply only when those land uses are in use.

For those receivers where an internal NML applies, it is common to assume an outdoor-to-indoor noise reduction of 25 dB(A). This is based on a standard commercial building facade with windows kept closed, such as that at the Royal Prince Alfred Hospital. Therefore, for this assessment, an external NML of 70 dB(A) $L_{eq,15min}$ will be used for the health and educational sensitive land uses surrounding the development site.

Table 6 Noise management levels for residential land uses

Time of day	NML, $L_{eq,15min}$	Application notes
Recommended Standard Working Hours	Noise affected: RBL + 10 dB(A)	May be some community reaction to noise. • Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. • All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected: 75 dB(A)	May be strong community reaction to noise. • Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. • Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Outside recommended Standard Working Hours	Noise affected: RBL + 5 dB(A)	• 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 affected noise level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the affected noise level, the proponent should negotiate with the affected community.

Table 7 ICNG noise management levels for other sensitive land uses

Land use	NML $L_{eq,15min}$ (applies when property in use)
Classrooms at schools and other educational institutions	Internal noise level of 45 dB(A)
Hospital wards and operating theatres	Internal noise level of 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion).	External noise level of 65 dB(A)

Noise Management Levels

Table 8 summarises the NMLs applicable to sensitive land uses around the Health Precinct Stage 1 site during the construction phase. The NMLs are based on the background levels measured at Wesley College in 2012, which is considered a conservative approach. Although works are only proposed during Standard Working Hours, NMLs are also presented for other time periods for information.

Table 8 Noise Management Levels applicable to Health Precinct Stage 1

Land use	NML for time period, dB(A)	
	Standard Working Hours	Outside of Standard Working Hours
Colleges and residential land uses	56 (NML) 75 (Highly noise affected)	51
Royal Prince Alfred Hospital and associated buildings	70	70
Educational buildings	70	70
Sporting ovals	65	65

4.2 Construction vibration

Ground vibration generated by construction can have a range of effects on buildings and building occupants. The main effects are generally classified as:

- human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- effects on building structures – vibration which may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on buildings. Building occupants will normally feel vibration readily at levels well below those which may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[1]
- Human comfort: *Assessing Vibration – A Technical Guideline* (the Vibration Guideline)

[1] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

Cosmetic and structural damage

DIN 4150-3 summarises structural and cosmetic damage assessment criteria for different types of buildings, which are presented in Table 3, which are widely used for the assessment of construction vibration effects on buildings in Australia. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

Table 3 DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

With respect to the project site, the only neighbouring State heritage sites on the NSW Office & Environment Heritage Register are:

- Royal Prince Alfred Hospital Admissions Block and Victoria & Albert Pavilions which are both located on the western side of the Hospital away from the works.
- The University Women's College which is over 100 m from the site.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended would not necessarily result in damage. Rather, it recommends these values as maximum levels of short-term construction vibration at which experience has shown damage reducing the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if:

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

Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Vibration Guideline), consistent with the SEARs issued by DPE.

The vibration assessment criteria defined in the Vibration Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction activities as part of the proposed works would be expected to be continuous or intermittent in nature.

Table 9 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted RMS vibration velocity levels. The Vibration Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 9 RMS velocity management levels for continuous and impulsive vibration

Land use	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Maximum
Critical areas[1]	0.1	0.2	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4	6.0	12.0
Residences and hospital wards – night time[3]	0.14	0.28	2.0	4.0
Offices, schools	0.4	0.8	13.0	26.0
Workshops	0.8	1.6	13.0	26.0

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 10.

Table 10 VDV management levels for intermittent vibration

Land use	VDV – intermittent vibration, m/s$^{1.75}$	
	Preferred	Maximum
Critical areas[1]	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4
Residences and hospital wards – night time[3]	0.13	0.26
Offices, schools	0.4	0.8
Workshops	0.8	1.6

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

Sensitive equipment

Certain land uses around the site have vibration-sensitive equipment that could be affected by vibration levels well below the level at which discomfort may arise for occupants of buildings. This would include the Sydney Nanoscience Hub and may also include sensitive equipment at the Royal Prince Alfred Hospital.

Specific vibration criteria for sensitive equipment will depend on equipment specifications. However, a number of 'generic' vibration criteria have been developed over the years for sensitive electron microscope equipment. The VC criteria developed by Colin Gordon and Associates is internationally accepted and is one of the most commonly used vibration criteria for sensitive equipment. The VC criteria are reproduced in Table 11, with the highest value for operating theatres corresponding to the lowest 'Preferred' level from the Guideline for continuous vibration shown in Table 9.

Consultation will need to be undertaken with the Hospital, in particular, to determine the location and sensitivity of equipment near to the site. It is noted that the vibration criteria for sensitive equipment can be difficult to achieve during construction works and, therefore, it may be necessary to coordinate vibration-intensive works with neighbouring land uses such that they are not occurring at times when use of the equipment is required.

Table 11 Generic VC criteria for sensitive equipment (from Colin Gordon and Associates)

Criterion curve	Amplitude, mm/s[1]	Detail size, μm[2]	Description of use
Operating theatre	0.1	25	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100x and for other equipment of low sensitivity.
VC-A	0.05	8	Adequate in most instances for optical microscopes to 400x, microbalances, optical balances, proximity and projection aligners etc.
VC-B	0.025	3	Appropriate for inspection and lithography equipment (including steppers) to 3 μm line widths.
VC-C	0.0125	1 – 3	Appropriate standard for optical microscopes to 1000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 μm detail size, TFT-LCD stepper/scanner processes.
VC-D	0.00625	0.1 – 0.3	Suitable in most instances for demanding equipment, including many electron microscopes (SEMs and TEMs) and E-Beam systems.
VC-E	0.00312	< 0.1	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems. E-Beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	0.00156	n/a	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.
VC-G	0.00078	n/a	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.

(1) As measured in one-third octave bands over the frequency range 8 to 80 Hz (for operating theatres, VC-A and VC-B) or 1 to 80 Hz (for VC-C through VC-G).

(2) The detail size refers to line width in the case of microelectronics fabrication, the particle (cell) size in the case of medical and pharmaceutical research, etc. It is not relevant to imaging associated with probe technologies, AFMs, and nanotechnology.

4.3 Operational noise criteria

Noise emissions from the Stage 1 Building when operational should comply with the requirements of the NSW *Industrial Noise Policy* (INP). The INP applies to noise emissions from rooftop plant and the like at the development.

The INP sets two separate noise criteria to meet desirable environmental outcomes:

- Intrusiveness – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the RBL measured for different time periods in the environment.
- Amenity – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significant exceed the amenity criteria.

Internal noise criteria are also set by the INP for non-residential land uses such as hospital wards, educational facilities and active recreation areas.

Normal operation

Table 12 presents the INP noise emission criteria for residential land uses, including the Colleges on the University campus, for the Day, Evening and Night periods.

Table 12 INP noise emission criteria for residential land uses and Colleges

Location	**INP noise emission criteria, dB(A) $L_{eq,15min}$ (dB re 20 µPa)**		
Residential land uses and Colleges	**Day 7 am–6 pm**	**Evening 6 pm–10 pm**	**Night 10 pm–7 am**
Rating Background Level (RBL)	*46*	*46*	*46*
Intrusive criterion (RBL + 5 dB)	51	51	51
Amenity criterion for all sources (Suburban[1])	55 – 60	45 – 50	40 – 45
Amenity criterion for new sources[2]	58	46	41
Project specific criterion for residences and Colleges[3]	**51**	**46**	**41**

(1) A suburban classification has been adopted for the site, described as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry.

(2) The Amenity criterion for new sources have been determined on the conservative basis that the ambient noise levels measured at Wesley College in 2012 were controlled by existing industrial noise.

(3) The project-specific criteria are the minimum of the Intrusive criterion and the Amenity criterion for new sources for each time period.

Table 13 presents the applicable INP criteria for other (non-residential) sensitive land uses.

Table 13 INP noise emission criteria for other sensitive land uses

Land use	Time of day	Noise emission criteria, dB(A)	
		Acceptable	Recommended maximum
Hospital wards, such as Royal Prince Alfred Hospital	Noisiest one-hour period	Internal 35 External 50	Internal 40 External 55
Classrooms	Noisiest one-hour period when in use	Internal 35	Internal 40
Active recreation area	When in use	External 55	External 60
Commercial premises	When in use	External 65	External 70

Emergency operation

A rooftop emergency generator will be installed as part of the Stage 1 development. This will only operate in emergencies and during occasional short-duration daytime maintenance periods.

The NSW INP does not specify requirements for emergency equipment but does suggest that short-term exceedances of the approved noise levels may be required depending on the nature of the site. Based on the INP and our previous experience, it is recommended that the applicable noise criteria for the emergency generator be relaxed (increased) by 5 dB(A).

5 Construction assessment

5.1 Construction noise

Construction noise sources

Table 14 summarises the assumed sound power levels (L_W) for the major construction noise sources which we expect would be on site during each phase. The sound power levels have been based on data obtained from previous measurements conducted by Resonate and those within the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*. An overall sound power level for each phase has also been assumed based on the loudest typical source(s) operating for each works phase.

Table 14 Construction noise source sound power levels

Stage	Typical plant items	Assumed sound power level, dB(A)
Site establishment	Large excavator	111
	Vibratory roller	107
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Typical overall sound power level	**112**
Substructure	Bored piling rig	111
	Crane	106
	Large excavator	111
	Pneumatic jackhammer	109
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Typical overall sound power level	**114**
Superstructure and facade	Concrete truck	109
	Concrete pump	107
	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	**111**

Stage	Typical plant items	Assumed sound power level, dB(A)
Internal works and fitout	General hand tools	98
	Compressor	94
	Portable generator	95
	Typical overall sound power level	**84**[1]
External landscaping	Large excavator	111
	Grader	112
	Large truck	108
	Typical overall sound power level	**113**

(1) Includes a 15 dB(A) indoor-to-outdoor reduction in noise levels for internal works.

Typical construction noise levels

Typical worst-case predicted noise levels are shown in Table 15 for each sensitive-receiver location and each phase of works. Predicted noise levels that exceed the relevant Standard Work Hours NML are highlighted in **bold** type.

Based on the predictions, it can be seen that construction noise from the site is predicted to exceed the relevant NMLs at:

- The Royal Prince Alfred Hospital and associated Gloucester House for major external works. The predicted exceedance is a maximum of 5 – 6 dB(A).
- Wesley College during major external works.
- University Oval No. 1 during major external works.

At other locations, no significant noise impacts are expected during the construction phase, particularly if work is only undertaken during standard working hours. Recommendations for construction noise management are provided in Section 0.

It is important to note that these predictions are typical worst-case predictions as they assume that:

- The construction works are occurring at the nearest point to each receiver and that the receiver is located at the most exposed position (e.g. the nearest windows of Wesley College and the Hospital).
- The noisiest construction sources are operating continuously for the entire 15-minute period. This will not occur at all times as equipment will regularly be stood down or idled while other activities are undertaken.

Table 15 Typical worst-case external construction noise levels for each phase

Receiver	Typical worst-case external construction noise level for phase, dB(A) L_{eq}				
	Site establishment	Substructure	Superstructure and facade	Internal works and fitout	External landscaping
R1 – Royal Prince Alfred Hospital	**74**	**76**	**73**	46	**75**
R2 – Gloucester House	70	**72**	69	42	**71**
R3 – Centenary Institute	63	65	62	35	64
R4 – Wesley College	**65**	**67**	**64**	37	**66**
R5 – St Andrew's College	52	54	51	24	53
R6 – Sydney University Village	49	51	48	21	50
R7 – Women's College	48	50	47	20	49
R8 – Campbell Street	44	46	43	16	45
R9 – Newtown North Public School	49	51	48	21	50
R10 – Sydney Nanoscience Hub	50	52	49	22	51
R11 – University Oval No. 1	**70**	**72**	**69**	42	**71**
R12 – St Andrew's College Oval	57	59	56	29	58

5.2 Construction vibration

Table 16 summarises recommended safe working distances for key vibration-generating activities that would be expected during the construction phase, based on prior measurements conducted by Resonate Acoustics. We understand that preliminary geotechnical studies have indicated that bored piling will be able to be undertaken and that no rock-breaking will need to occur at the site.

Table 16 Recommended safe working distances for key vibration generating activities

Plant	Rating	Typical safe working distance for occupant comfort, m		Typical safe working distance for building damage, m	
		Preferred vibration target	Maximum vibration target	Heritage structure	Commercial building
Vibratory roller	< 7t	≥ 35	≥ 20	≥ 10	≥ 2
	7t – 12t	≥ 50	≥ 30	≥ 15	≥ 5
	≥ 13t	≥ 75	≥ 40	≥ 20	≥ 10
Excavator	Large excavator digging	≥ 25	≥ 15	≥ 5	≥ 1
Bored piling	≤ 800mm	≥ 20	≥ 10	≥ 2	≥ 1
Jackhammer	Handheld	–(1)	–(1)	≥ 3	≥ 1

Based on the safe working distances above, vibration impacts on buildings are not expected and impacts on occupant comfort are likely to be limited to any vibratory compaction works occurring near to the Royal Prince Alfred Hospital. Recommendations are provided in Section 0 for the management of construction vibration from the works.

The safe working distances in Table 16 do not address highly vibration-sensitive equipment, such as that at the Sydney Nanoscience Hub and that may be housed at the Hospital. Given the significant distance to the Sydney Nanoscience Hub and the relatively low vibration intensity of the proposed works, impacts on equipment at this location are not expected. Consultation should be undertaken with the Hospital, as per the recommendations in Section 0, to determine whether specific vibration sensitive equipment needs to be taken into account during the works.

5.3 Recommendations

To manage the potential impact of noise and vibration during construction, reasonable and feasible management measures and work practices should be implemented as detailed below.

Construction Noise and Vibration Management Plan

Prior to the commencement of major construction works for the Stage 1 building being considered as part of this EIS, the contractor should develop a Construction Noise and Vibration Management Plan (CNVMP). The CNVMP should:

- identify relevant construction noise and vibration criteria as detailed in this report
- identify neighbouring sensitive land uses for noise and vibration
- summarise key noise- and vibration-generating construction activities and the associated predicted levels at neighbouring land uses
- identify reasonable and feasible work practices to be implemented during the works
- summarise stakeholder consultation and complaints handling procedures for noise and vibration.

Stakeholder consultation

Nearby stakeholders should be consulted prior to the works and kept regularly informed of potential noise and vibration impacts from the works. Specifically, this would involve:

- Consultation with the Royal Prince Alfred Hospital to determine the location of noise and vibration sensitive uses on the eastern building facade, and to discuss noise and vibration mitigation options with them such as appropriate programming of noisy works.
- Consultation with residential Colleges at the University of Sydney, in particular Wesley College, to inform them of the works.

A noise and vibration complaints handling procedure and register should be developed and implemented during construction.

Work programming

Work should be programmed such that works, and particularly noisy works, occur during standard working hours wherever feasible, namely:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 1 pm
- No work on Sundays or public holidays.

If high noise works are to occur outside of these times, then the CNVMP should define an approval process for undertaken out of hours works and for identifying reasonable and feasible mitigation measures to be implemented.

Truck movements and site access

Truck movements during long term construction projects have the potential to cause annoyance for sensitive receivers, even where trucks may be travelling on sealed roads. The design and selection of site access routes shall consider the potential disturbance to residents. In particular:

- site access and delivery points shall be located as far away from residences as possible
- truck movements shall use arterial roads and be diverted away from residential streets where feasible
- deliveries to/from site shall not occur during the night time period where possible.

Site management

Site management procedures should include the following:

- processes that generate lower noise levels should be selected where feasible
- noisy plant should be located as far away from residences as is practical to allow efficient and safe completion of the task
- the potential shielding provided by site topography and intervening buildings should be taken into account in locating equipment
- site compounds should be located as far away as possible from residences
- equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use
- works should be planned to minimise the reduce the noise from reversing signals
- warning horns should not be used as signalling devices
- two way radios should be set to the minimum effective volume
- noise associated with packing up plant and equipment at the end of works should be minimised.

Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment where possible
- equipment should be well maintained
- equipment should have quality mufflers and silencers installed where relevant
- equipment not in use on site should be shut down
- tasks should be completed using the minimum feasible power and equipment.

6 Operational assessment

Due to the early stage of the project, details on the precise nature of mechanical plant at the site are not available. However, it is understood that the development will include:

- rooftop plant room
- water-cooled chiller and cooling towers on the roof
- rooftop emergency generator.

As the equipment will be located on the rooftop, there will be little or no direct line-of-sight between the rooftop plant and the neighbouring noise-sensitive land uses. Any shielding effect will be lower to the upper levels of the Royal Prince Alfred Hospital, but these windows are kept closed and do not appear to be operable.

Noise mitigation techniques that will need to be considered for rooftop plant include as the design progresses include:

- Selection of lower noise plant and equipment, particularly the chiller and cooling towers.
- Screening of external plant using solid barriers or acoustic louvres.
- Appropriate construction of a rooftop plant room to reduce noise emissions to neighbouring land uses.
- Installation of the emergency generator in an acoustically-rated enclosure.

Other operational noise from the site will typically be limited to noise from cars accessing the car park and occasional loading dock deliveries. Access to the car park and loading dock is located on the eastern side of the western wing of the building, such that it is over 100 m from Wesley College and the Hospital is well shielded from these sources. Noise levels from car movements into and out of the building, and loading dock access from a typical delivery truck is predicted to be below 50 dB(A) L_{eq} at the Hospital facade and well below the INP daytime criterion of 51 dB(A) L_{eq} at Wesley College.

The noise levels from mechanical plant, and other noise sources, will be assessed as the design progresses to ensure that compliance with the INP noise emission criteria can be achieved.

7 Conclusion

This report presents a construction and operational noise and vibration assessment for the proposed Stage 1 of the University of Sydney Health Precinct. Stage 1 involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

Construction noise and vibration criteria have been determined in accordance with relevant guidance such as the ICNG and Vibration Guideline. It is likely that construction works may have some noise and vibration impact on the Royal Prince Alfred Hospital and some construction noise impact on Wesley College at the University of Sydney. It is anticipated that these impacts will be able to be managed through works being carried out during standard working hours and with the implementation of reasonable and feasible work practices.

Operational noise emission criteria have been set in accordance with the NSW INP and apply predominantly to mechanical plant noise emissions from the site. As the design progresses, noise mitigation measures will need to be incorporated into the design of the building to ensure that noise from rooftop plant in particular can comply with the INP noise emission criteria at neighbouring noise-sensitive land uses.