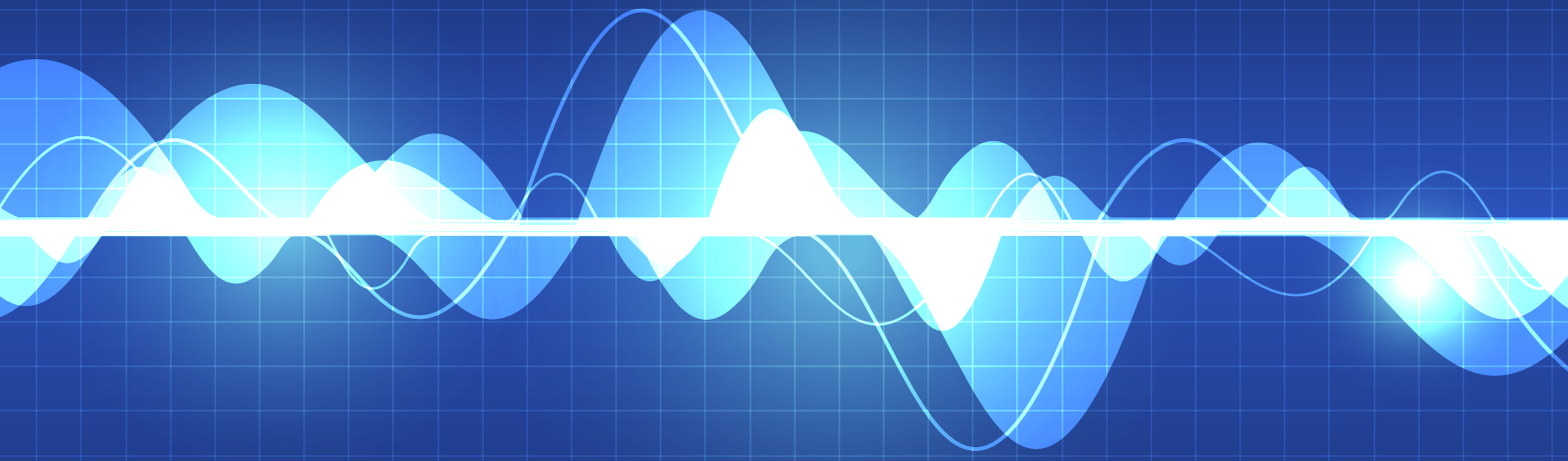
Nepean Hospital - Stage 2

Noise and vibration impact assessment

Prepared for Health Infrastructure
December 2021



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Nepean Hospital - Stage 2

Noise and vibration impact assessment

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Executive Summary

This noise and vibration impact assessment (NVIA) has been commissioned by NSW Health Infrastructure to address potential noise impacts associated with Stage 2 of the Nepean Hospital redevelopment ('the Project') located at Derby Street, Kingswood NSW. The NVIA has been prepared in support of the state significant development application (SSDA) for the Project.

The proposal will include:

- the Stage 2 tower, being predominantly a 7-storey building, with roof plant;
- demolition of parts of the existing North Block and other satellite buildings directly within the Stage 2 Tower footprint (excluding other buildings already approved under the Stage 1 SSD consent);
- demolition of the total asset management (TAM) facility;
- reconfiguration of the loading dock area and back of house functions;
- landscaping and other associated at-grade works within the Stage 2 tower's immediate vicinity; and
- Barber Avenue upgrade and access road to the Stage 2 Tower's forecourt, port cochere, and front of house area.

The scope of this NVIA is to undertake a review of potential noise and vibration impacts associated with the construction and operation of the Project in accordance with Environmental Protection Authority (EPA) guidelines. This includes noise and vibration impacts associated with:

- demolition and construction works on the site;
- on-site vehicle movements which will predominantly be associated with new and redeveloped loading docks on the Nepean Hospital campus;
- mechanical plant operation; and
- road traffic noise intrusion into the Project.

The assessment of noise and vibration from the construction and use of the site has been undertaken to address Item 10 of the Secretary's Environmental Assessment Requirements (SEARs). Noise from the construction and operation of the Project has been assessed against the following guidelines and policies referenced in Item 10:

- Noise Policy for Industry (NSW Environment Protection Authority (EPA), 2017);
- Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009);
- Assessing Vibration: A Technical Guideline (Department of Environment and Conservation, 2006); and
- Development Near Rail Corridors and Busy Roads - Interim Guideline (Department of Planning, 2008) (referred to as the 'interim guideline').

An assessment of construction noise and vibration has been undertaken. Noise predictions indicate exceedances of the project noise management levels at residential dwellings external to the site during demolition and excavation works.

Exceedances of the project noise management levels may be experienced at the Nepean Private Hospital and Tresillian to the north of the project envelope given proximity to the construction site. This is not atypical for a project of this size which is being constructed in proximity to sensitive land uses.

Vibration generated by heavy construction works are expected to generally comply with cosmetic damage limits excepting select pieces of machinery for receivers external to the campus. A detailed construction noise and vibration management plan (CNVMP) should be prepared as part of the main works contract to ensure that noise and vibration impacts from proposed construction methodologies are minimised as practicable.

A review of operational noise impacts indicates the following:

- noise from on-site vehicle movements will comply with the noise emission requirements of the NPfI;

- a preliminary review of noise impacts associated with mechanical plant operation has been undertaken. It is expected that mechanical plant noise can be suitably treated using relatively standard acoustic treatments such as lined ductwork, acoustic attenuators and the like such that the acoustic requirements of the NPfI are achieved. Noise from mechanical plant is reviewed as part of the detailed design and construction phases and as such is generally conditioned within the project consent. It is expected that a similar condition would be included in this case; and

- road traffic noise from Parker Street and the Great Western Highway has been assessed against the requirements of the Department of Planning (DoP) *Development Near Rail Corridors and Busy Roads - Interim Guideline* ('interim guideline'). Traffic noise intrusion into the hospital can be suitability mitigated using relatively standard building constructions typical to a hospital development.

It is concluded that noise and vibration generated by the construction and operation of the Project may be suitably managed to achieve the requirements of the ICNG, NPfI and RNP. Noise intrusion requirements applicable to the Project can be reasonably met in accordance with the DoP interim guideline.

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Figures

1 Introduction

1.1 Background

Indigeco has been engaged by NSW Health Infrastructure to assess potential noise and vibration impacts associated with the proposed Stage 2 of the Nepean Hospital redevelopment ('the Project') within the Nepean Hospital campus. Indigeco has utilised our specialist services partner EMM Consulting Pty Ltd (EMM) to assist in the preparation of this report.

Stage 2 of the redevelopment includes the construction of an eight-level tower (ground to level seven) which will be annexed to Stage 1 of the Nepean Hospital development. Demolition of existing structures in Stage 2 footprint are included in the Stage 2 works, in addition to alterations to North Block for an upgraded loading dock and back of house area.

The assessment has been prepared to accompany the state significant development application (SSDA) for the Project and addresses the requirements of Item 10 of the Secretary's Environmental Assessment Requirements (SEARs) for application number SSD-16928008. This includes noise and vibration impacts associated with:

- demolition and construction works on the site;
- on-site vehicle movements which will predominantly be associated with upgrades to the existing North Block loading dock and a new loading dock as part of the Stage 2 tower;
- additional road traffic generated by the Project;
- mechanical plant operation; and
- road traffic noise intrusion into the Project.

Reference has been made to the Acoustic Logic Consultancy (ALC) 2018, *Nepean Hospital and Integrated Ambulatory Services Redevelopment – SSDA Acoustic Assessment* prepared for Stage 1 of the Nepean Hospital redevelopment on behalf of Health Infrastructure. Baseline noise levels and operational noise emission objectives established in ALC's report have been utilised in EMM's assessment.

1.2 SEARs requirements

The report has been prepared to address the requirements of the SEARs issued for the project. Item 10 relates to the assessment of noise impacts from the site and is detailed in Table 1.1.

Table 1.1 SEARs requirements

Item	Requirement	Where addressed in report
10. Noise and vibration	• Provide a noise and vibration impact assessment that:	
	– includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction.	Section 5
	– 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 4.1
	– includes a quantitative assessment of the main sources of operational noise.	Section 6
	– outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers.	Section 8
	– considers sources of external noise intrusion in proximity to the site (including, road rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards.	Section 7
	– demonstrates that the assessment has been prepared in accordance with polices and guidelines relevant to the context of the site and the nature of the proposed development.	Section 9
	Relevant Policies and Guidelines:	
	• NSW Noise Policy for Industry 2017 (NSW Environment Protection Authority (EPA)	Section 4.3
	• Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)	Section 4.1
	• Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)	Section 4.2
	• Development Near Rail Corridors and Busy Roads - Interim Guideline (Department of Planning, 2008)	Section 4.4
	• Australian Standard 2363 Acoustics – Measurement of noise from helicopter operations (AS 2363).	

These guidelines will form the basis of the assessment for construction noise and vibration impacts from the development.

It is noted that there is no mandatory requirement for addressing noise from emergency helicopter movements. As such, noise measurements have not been undertaken of helicopter movements which would necessitate the use of AS 2363.

2 Site background and proposal

2.1 Site location

The Nepean Hospital campus is located on the Great Western Highway, Kingswood NSW. The hospital campus includes public and private development and is bound by the Great Western Highway to the north, Somerset Street to the east, Derby Street to the south and Parker Street to the west (refer to Figure 2.1).

The Nepean Hospital is currently under redevelopment, with Stage 1 of the project nearing completion. Stage 2 of the project will adjoin the western façade of Stage 1.

Stage 2 is located approximately 160 m west of Somerset Street, with north block to the south, existing multi-storey carpark to the west and Nepean Private Hospital and Tresillian to the north. The Stage 1 structure separates Stage 2 from Somerset Street (refer to Figure 2.2).

The surrounding uses of the hospital site include medical, commercial and residential land uses. Noise impacts associated with the proposed works are to be addressed to these receivers.

2.2 Development description

The Stage 2 redevelopment project scope includes:

- the Stage 2 tower, being predominantly a 7-storey building, with roof plant;
- demolition of parts of the existing North Block and other satellite buildings directly within the Stage 2 Tower footprint (excluding other buildings already approved under the Stage 1 SSD consent);
- demolition of the Total Asset Management (TAM) facility;
- reconfiguration of the loading dock area and back of house functions;
- landscaping and other associated at-grade works within the Stage 2 Tower's immediate vicinity; and
- Barber Avenue upgrade and access road to the Stage 2 Tower's forecourt, port cochere, and front of house area.

Departments to be provided in the Stage 2 Tower include:

- front of house, including retail;
- education and training Centre;
- transit lounge;
- medical imaging;
- interventional radiology;
- intensive care unit and close observation unit;
- in-centre dialysis and renal inpatient unit;

- paediatric in-patient unit;
- plant areas;
- clinical support areas; and
- kitchen.

The expected construction works associated with the proposal includes:

- demolition of:
    - parts of the existing North Block and other satellite buildings directly within the Stage 2 Tower footprint; and
    - the TAM facility.
- detailed excavation of the site;
- formwork and structural works;
- construction and fitout works; and
- minor roadworks modifications and landscaping.

This study provides a preliminary assessment of construction noise and vibration generated by typical construction works on the site which may have potential acoustic impacts on surrounding noise sensitive land uses.

It is anticipated that a detailed construction management plan will be generated by the main works contractor once detailed methodologies are formulated for the construction of the development.

Source: EMM (2021); Health Infrastructure (2021); DFSI (2017); GA (2011)

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KEY

- Nepean Hospital Precinct
- Project envelope
- Train station
- Rail line
- Major road
- Minor road
- Watercourse/drainage line

Nepean Hospital redevelopment

- Stage 1
- Stage 2

Site locality

Nepean Hospital Redevelopment - Stage 2
Noise and Vibration Impact Assessment
Figure 2.1

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2.3 Noise sensitive assessment locations

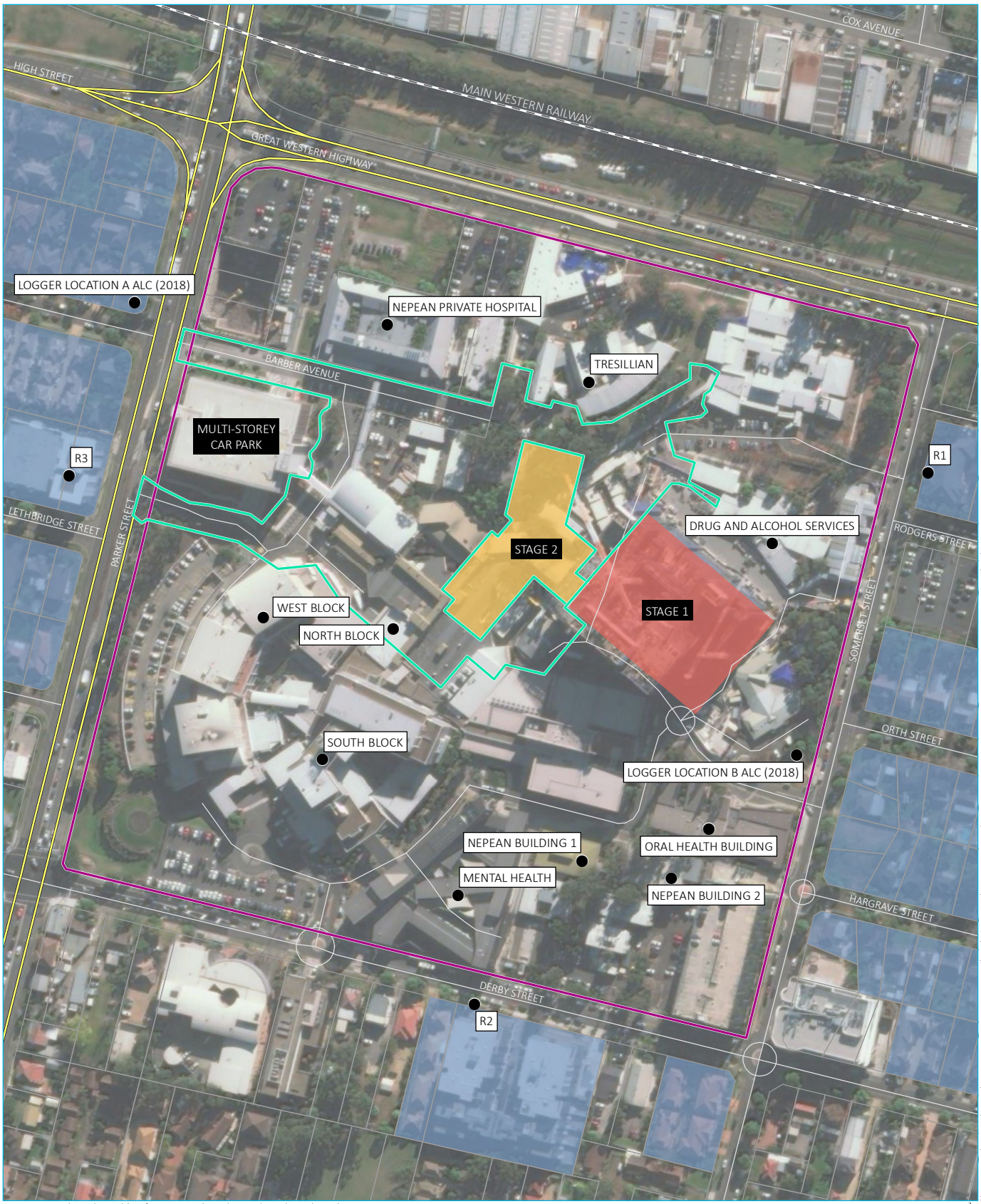
Noise sensitive assessment locations addressed as part of this assessment are identified in Figure 2.2 and include:

- residential uses along Somerset Street to the east. The three-level residential apartment block at 43-45 Rodgers Street, Kingswood has been identified as the worst-case receiver in this direction, given the height of receivers and screening provide by Nepean Hospital campus structures (ie Stage 1 of the redevelopment);
- the 'Omega Apartments' eight level mixed use residential building located at 48-56 Derby Street, Kingswood to the south. Other uses along Derby Street will be generally screened by existing structures on the Nepean Hospital campus;
- residential uses along Parker Street to the west. The five level Onyx Apartments building located at 5 Lethbridge Street has been selected as the assessment location for these uses given the multi-storey nature of the apartment block and visibility over the sight for higher levels;
- to the north, Tresillian and Nepean Private Hospital.

Assessment locations are summarised in Table 2.1.

Table 2.1 Assessment locations

Assessment location	Address	Representation
R1	43-45 Rodgers Street, Kingswood	Noise sensitive (residential) receivers external to the site along Somerset Street to the east
R2	Omega Apartments 48-56 Derby Street, Kingswood	Noise sensitive (residential) receivers external to the site along Derby Street to the south
R3	Onyx Apartments 5 Lethbridge Street, Penrith	Noise sensitive (residential) receivers external to the site along Parker Street to the north
Tresillian	1B Barber Avenue, Kingswood	Noise sensitive hospital use external to the Nepean Hospital campus
Nepean Private Hospital	1-9 Barber Avenue, Kingswood	Noise sensitive hospital use external to the Nepean Hospital campus



Source: EMM (2021); Health Infrastructure (2021); DFSI (2017); GA (2011)

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KEY

- Noise assessment location
- Nepean Hospital Precinct
- Project envelope

Nepean Hospital redevelopment

- Stage 1
- Stage 2
- Rail line
- Major road
- Minor road
- Cadastral boundary
- Residential uses

Assessment locations

Nepean Hospital Redevelopment - Stage 2
Noise and Vibration Impact Assessment
Figure 2.2

EMM
creating opportunities

3 Existing site conditions

3.1 Background

Existing ambient conditions at assessment locations surrounding the site are generally categorised by the following:

- dwellings along Parker Street to the west are impacted by high road traffic noise levels. Some level of mechanical plant noise from the hospital campus is also expected at this location, however likely to be comparatively low in context with the road traffic noise environment; and
- dwellings along Somerset Street and Derby Street are impacted by more moderate and intermittent road traffic noise levels. Some level of mechanical plant noise from the hospital campus is also expected at these locations.

Consideration of existing mechanical plant noise was included in the ALC (2018) report for the Stage 1 redevelopment in determining suitable noise emission objectives.

3.2 Noise monitoring

Ambient noise conditions have been adopted from the ALC (2018) report prepared for the Stage 1 redevelopment. The noise monitoring conducted as part of this assessment was undertaken prior to construction works on site and as such the noise data collected is not affected by construction related activities. The results from this noise monitoring are presented in Table 3.1.

Table 3.1 Previously recorded ambient noise levels – ALC (2018)

Location	Equivalent continuous sound pressure level, dB $L_{Aeq\ period}$			Rating background noise level, dB		
	Day	Evening	Night	Day	Evening	Night
Logger A 15 Barber Street	65	65	60	48	47	38
Logger B Somerset Street	59	57	54	47	41	37

The rating background noise levels provided in the ALC (2018) report will be used as a basis for addressing potential noise impact in this assessment.

4 Assessment criteria

4.1 Construction noise

The Interim Construction Noise Guideline (ICNG) (DECC 2009) has been jointly developed by NSW Government agencies including the EPA and Department of Planning, Industry and Environment (DPIE). The objectives of the guideline relevant to the planning process are to promote a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices.

The guideline recommends standard construction hours where noise from construction activities is audible at residential premises (ie assessment locations):

- Monday to Friday 7.00 am to 6.00 pm;
- Saturday 8.00 am to 1.00 pm; and
- no construction work is to take place on Sundays or public holidays.

Construction work is largely proposed during the ICNG recommended construction hours, however some out of hours work between 1.00 pm and 5.00 pm on Saturdays is also proposed. The ICNG acknowledges that works outside standard hours may be necessary, and justification is required to be provided to the relevant authorities for the proposed works outside of non-standard hours.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach, which is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

This assessment has adopted a quantitative approach. The assessment includes identification of assessment locations, description of likely works involved including predicted noise levels and proposed management measures that include a complaint's handling procedure which is to be further developed as part of a construction environmental noise and vibration management plan.

4.1.1 Noise management levels

Table 2 of the ICNG provides guidance on establishing noise management levels (NML) for residential assessment locations during standard hours and has been reproduced in Table 4.1.

Table 4.1 ICNG residential NMLs

Time of day	NML $L_{Aeq,15min}$	How to apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	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 reasonable and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Source: ICNG (DECC 2009).

Table 4.2 summarises noise management levels for non-residential land uses as defined in the ICNG.

Table 4.2 ICNG noise management levels at non-residential land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)

Source: ICNG (DECC, 2009).

4.1.2 Noise to Nepean Hospital buildings

The ICNG provides guidance on addressing impacts to non-residential noise sensitive assessment locations. Noise sensitive locations are those on properties other than the site itself. As such, noise to uses on the Nepean Hospital campus will be addressed internally as part of the development construction noise and vibration management plan. Nepean Private Hospital and Tresillian are external to the Nepean Hospital campus and have been addressed accordingly. Table 3 of the ICNG includes assessment noise levels for hospital wards and operating theatres. These objectives are dictated in terms of the internal noise level and are reproduced in Table 4.3.

Table 4.3 NMLs for non-residential hospital receivers

Type of occupancy / activity	Recommended noise level, dB $L_{Aeq\ 15min}$	
	Internal (AS2107)	External[1]
Hospital wards and operating theatres (ICNG)	45	65
Consulting rooms	45	65
Dental clinics	45	65
Office areas	45	65
Waiting rooms, reception areas	50	70

Note: 1. The external noise target for uses within the Nepean Hospital grounds has been based on the internal noise level plus 20dB to account for a closed façade which will typically be the case for clinical areas.

4.1.3 Project construction residential NMLs

The construction NMLs for residential assessment locations have been based on the RBLs provided in Table 3.1. The NMLs for standard construction hours adopted for this assessment were derived in accordance with the ICNG for all assessment locations and are presented in Table 4.4. The highly noise affected management level (HNL) has also been provided.

Table 4.4 Construction NMLs for standard hours

Period	Assessment location	RBL, dB(A)[1]	NML, $L_{Aeq,15min}$, dB	HNL[2]
Day (standard ICNG hours)	Somerset Street and Derby Street residences	47	57	75
	Parker Street residences	48	58	75
Day (outside standard ICNG hours)	Somerset Street and Derby Street residences	47	52	N/A
	Parker Street residences	48	53	N/A

Notes: 1. Based on the day period RBL established in Table 3.1.
2. HNL – highly noise affected level

The construction NMLs for non-residential assessment locations are based on the recommended internal noise levels provided in Table 4.3 in accordance with the ICNG.

4.2 Construction vibration

Vibration criteria for the project has been adopted from the following guidelines and standards:

- human comfort limits provided in the NSW *Assessing Vibration: a technical guideline* (DEC, 2006);
- Australian Standard AS 2187.2 - 2006 “Explosives - Storage and Use - Use of Explosives”; and
- BS 7385 Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2” as they are “applicable to Australian conditions”.

4.2.1 Human comfort – Assessing vibration: a technical guideline (DEC)

The human comfort assessment criteria provided in the *Assessing Vibration: a technical guideline* (DEC, 2006) is based on the limits contained in BS 6472 – 2008 'Evaluation of human exposure to vibration in buildings (1-80Hz)'.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.5.

Table 4.5 Examples of types of vibration (from Table 2.1 of the guideline)

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Intermittent vibration is representative of activities such as impact hammering, vibratory rolling or general excavation work (such as an excavator tracking) and, as such, is most relevant to this assessment.

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula (refer *section 2.4.1* of the guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for intermittent vibration are reproduced in Table 4.6.

Table 4.6 Acceptable vibration dose values (VDV) for intermittent vibration (m/s $^{1.75}$)

Location	Daytime		Night-time	
	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$
Critical Areas	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
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.

2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The Guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.2.2 Cosmetic damage vibration criteria

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 'Explosives - storage and use - Use of explosives' recommends the frequency dependent guideline values and assessment methods given in *BS 7385 Part 2-1993 'Evaluation and measurement for vibration in buildings'* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.7 and graphically in Figure 4.1.

Table 4.7 Transient vibration guide values – minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse, mm/s	
		4 Hz - 15 Hz	15 Hz and Above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	N/A
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

AS2187 states that the guide values in Table 4.7 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration gives rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 5.4 may need to be reduced by up to 50%.

Sheet piling activities (for example) are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may, therefore, be appropriate to reduce the transient values by 50% for this activity.

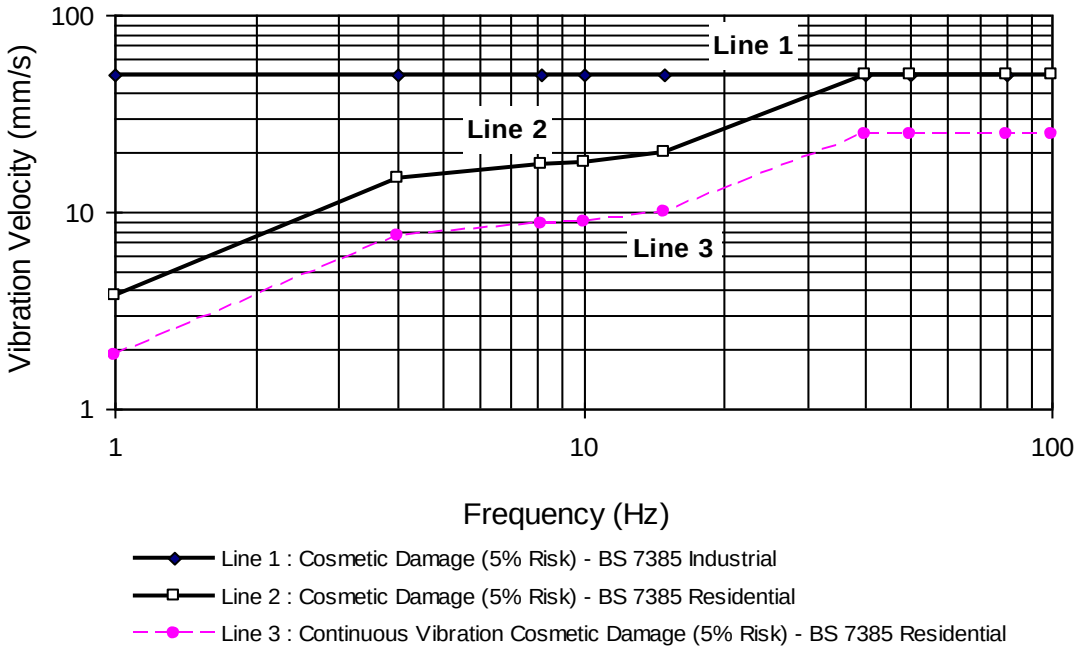


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high

displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 4.7, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.7 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.7.

It is noteworthy that, additional to the guide values nominated in Table 4.7, the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

Also that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

4.3 Operational noise emissions

Noise emissions from the operation of the development are to comply with the noise conditions of the development consent, if approval is granted. It is anticipated that this will be based on the requirements of the NPfI.

The NPfI provides guidance on establishing site specific noise emission objectives to govern noise from an industrial or commercial site to maintain suitable levels of acoustic amenity for surrounding receivers. To ensure these objectives are met, the EPA provides project specific noise trigger levels, namely intrusiveness and amenity.

The objectives of noise trigger levels are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location.

The project noise trigger levels (PNTL) have been established using noise monitoring at the site by ALC and provided in the ALC (2018) report.

4.3.1 Intrusiveness noise levels

The intrusiveness criteria apply to sensitive residential receivers and requires that $L_{Aeq,15min}$ noise levels from the site during the relevant operational periods do not exceed the rating background level (RBL) by more than 5 dB.

The rating background noise levels used for assessment purposes have been adopted from the ALC (2018) report prepared for Stage 1.

4.3.2 Project amenity noise levels

The assessment of amenity is based on noise levels specific to the land use. The noise levels relate only to noise generated by a commercial or industrial site and exclude road or rail traffic noise. Where the measured existing

noise approaches recommended amenity noise levels, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that amenity noise levels are exceeded.

Consistent with the ALC (2018) report, the neighbouring area is classed as 'suburban'. To allow for other possible industrial noise (existing or future), the acceptable amenity noise targets need not be adjusted down 5dB according to the NPfI.

4.3.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusiveness or amenity noise level. To standardise the time periods for the intrusiveness and amenity noise levels, the NPfI considers that the $L_{Aeq,15min}$ is equivalent to the $L_{Aeq,period}$ + 3 dB, unless robust evidence is provided for an alternative approach for the particular project being considered.

A summary of the PNTL for assessment of operational noise from the project is presented in Table 4.8, based on RBL data provided in the ALC (2018) report prepared for Stage 1.

Table 4.8 Project noise trigger levels – residential receivers

Assessment location	Assessment period[1]	Intrusiveness noise level, $L_{Aeq,15min}$, dB[2]	Amenity noise level, $L_{Aeq,15min}$, dB[2]	PNTL[3], $L_{Aeq,15min}$, dB
Somerset Street assessment locations	Day	52	53	52
	Evening	46	43	43
	Night	42	37	37
Parker Street assessment locations	Day	53	56	53
	Evening	52	56	52
	Night	43	42	42

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Morning shoulder: 6 am to 7 am Monday to Saturday, 6 am to 8 am Sundays and public holidays; Night: remaining periods.

2. The intrusiveness noise target and amenity noise target are adopted from the ALC (2018) report.

3. PNTL is the lower of the calculated intrusiveness or amenity noise levels.

The amenity noise levels for neighbouring land uses other than residential are provided in Table 4.9. These will be adopted for Nepean Hospital and Tresillian. Noise sensitive locations are typically those on properties other than the site itself (ie Nepean Hospital) and as such would not be addressed as part of the SSDA.

Table 4.9 Project noise trigger levels – land uses other than residential

Receiver type	Amenity noise level, $L_{Aeq,15min}$ dB
Hospital ward	
internal	33 – noisiest 1-hour period
external	48 – noisiest 1-hour period
Commercial premises	63 – when in use

Notes: 1. Project amenity $L_{Aeq,15min}$ noise level is the recommended amenity noise level $L_{Aeq,period}$ +3 dB as per the NPfI.

4.4 Road traffic noise intrusion criteria

The SEARs require that noise intrusion from external noise sources be addressed in accordance with the Department of Planning (DoP) 2008, *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

The guideline assists in the planning, design and assessment of development in or adjacent to rail corridors and busy roads and supports the NSW State Environment Planning Policy (Infrastructure) ('Infrastructure SEPP'). The guidelines are mandatory for select sensitive land use developments proposed adjacent to busy roads with an Annual Average Daily Traffic (AADT) of greater than 20,000 vehicles.

Traffic volumes for roads exceeding 20,000 vehicles per day are provided on the Transport for NSW (TfNSW) website. Parker Street to the west and the Great Western Highway to the north both exceed 20,000 vehicles per day as provided on Map 5 of the TfNSW *Traffic volume maps for Infrastructure SEPP*.

Noise level objectives applicable to the hospital is provided in Table 3.1 of the interim guideline which have been reproduced in Table 4.10.

Table 4.10 Road traffic noise intrusion criteria (Table 3.1 of *Development Near Rail Corridors and Busy Roads - Interim Guideline)*

Non-residential buildings	Interior use	Internal noise level, dB $L_{Aeq\ 1hour}$[1]
Hospitals	Wards	35
	Other noise sensitive areas	45

Note: 1. Table 3.1 of the guideline clarifies that the noise criteria above are to be determined as a maximum level. EMM adopt this to be an $L_{eq,1hr}$ or peak hour noise road traffic noise level.

Road traffic noise intrusion from Parker Street and the Great Western Highway is to be assessed to confirm that the internal noise levels in Table 4.10 can be met.

5 Construction noise and vibration impact assessment

A preliminary assessment of noise and vibration impacts from the proposed construction has been undertaken. At this stage, a detailed construction methodology has not been developed. As such, noise predictions are based on the likely worst-case plant that may be deployed on site.

5.1 Construction stages

5.1.1 Demolition, excavation and site preparation phase

The site is occupied by existing Nepean Hospital campus structures which are to be demolished to make way for the Stage 2 tower. For the most part, these structures are relatively insubstantial and will be demolished using excavators and hydraulic hammers to break-up rubble.

The ground floor of the development will cut into the existing ground elevation with excavation depths in the order of 6 m. The excavation activities will likely be undertaken using a suite of excavator mounted appliances including:

- rock saw;
- milling attachment;
- rock hammer; and
- bucket.

The worst-case appliance for noise and vibration will be the rock hammer due to its noise level and intermittent noise characteristics. Excavated fill is expected to be removed from the site using dump trucks and truck and dog type arrangements.

Site preparation works will typically entail the detailed excavation and relocation of fill around the site using excavators and dozers.

5.1.2 Formwork and concrete pours

The construction of Tower 2 will include significant structural works for the large floor plate. This will include the construction of formwork and concrete pours using the following equipment:

- hand tools for the assembly of formwork;
- concrete trucks;
- concrete pump; and
- helicopter floats.

5.1.3 General construction phase works

The general construction phase of the project will typically include:

- installation of the building façade including cladding and glazing installation;
- internal partitioning;
- mechanical, hydraulic and electrical services;
- clinical finishes; and
- minor earthworks, trimming and roadworks.

5.2 Construction noise modelling

Equipment sound power levels have been taken from:

- the Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*;
- AS 2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites"; and
- Roads and Maritime Services (RMS) 2016 *Construction and maintenance noise estimator*.

Otherwise data was sourced from an EMM database of similar equipment which is based on measurements at other construction sites as indicated.

A detailed analysis of equipment should be undertaken as part of the main works contractor's construction noise and vibration management plan once detailed information of plant equipment is established.

Typical worst-case plant utilised for the assessment is presented in Table 5.1.

Table 5.1 Construction phase and equipment sound power levels

Construction phase	Construction appliance	Sound power level, dB $L_{Aeq\ 15min}$
Demolition and excavation	Breaker on excavator (brick foundations)[1]	118
	Excavator dumping rubble[1]	113
	Dump trucks	103
	Rock hammer[1]	120
	Rock saw[1]	117
	Excavator (clearing site)[1]	106
	Cumulative noise level	**124**
Structural works	Concrete pump[1]	106
	Power float (three in use)	100 each 105 cumulative
	Hand tools (electric)[2]	102
	Cumulative noise level	**109**

Table 5.1 Construction phase and equipment sound power levels

Construction phase	Construction appliance	Sound power level, dB $L_{Aeq\ 15min}$
Construction phase	Forklift[2]	106
	Hand tools (electric)[2]	102
	Angle grinder (grinding steel)[1]	108
	Handheld jackhammer	107
	Welder[2]	105
	Cumulative noise level	**113**
New roadworks	Asphalt truck and sprayer[3]	107
	Pneumatic hammer[3]	113
	Smooth drum roller[3]	107
	Soft cut saw[3]	105
	Bobcat[3]	104
	Cumulative noise level	**116**

Notes: 1. Noise level adopted from DEFRA noise database.
2. Adopted from AS2436
3. RMS *Construction and maintenance noise estimator*

5.3 Predicted noise levels

The proponent will manage construction noise levels where exceedances of NMLs have been identified. The construction noise management methods will be detailed in a construction noise and vibration management plan as recommended in Section 8.1.

The ICNG recommends the following where NMLs are predicted to be exceeded:

- application of feasible and reasonable work practices to minimise noise; and
- inform potentially impacted residents or other noise sensitive receivers (ie hospital operators) of the nature of the works to be carried out, expected noise levels and duration and relevant contact details.

Noise predictions have been presented for the most affected assessment locations for a given locality (eg Somerset Street residences to the east of the site). Predicted noise levels are presented for cumulative noise from worst case construction equipment. The loudest typical works during general construction are provided in Table 5.1.

5.3.1 Predicted noise levels during demolition and excavation stages

Site works associated with the demolition and excavation stages will be largely screened to surrounding residential assessment locations external to the campus (ie Somerset Street, Derby Street and Parker Street) by existing structures on the site including:

- north block for Derby Street and pathology wing;
- north block pathology wing, west block and the multi-level carpark for Parker Street; and
- east block for Somerset Street.

Predicted noise levels consider screening effects provided by these structures. Noise predictions from the demolition phase are provided in Table 5.2.

Table 5.2 Predicted construction noise levels during demolition

Area	Land use	Assessment location	Predicted cumulative construction noise level, dB $L_{Aeq\ 15min}$	'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]		'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
				Standard hours	Out of hours works (day)	
Somerset Street	Residential	43-45 Rogers Street	58	57	52	75
Derby Street	Residential	Omega Apartments	53	57	52	75
Parker Street	Residential	Onyx Apartments	48	58	53	75
Nepean Private Hospital	Healthcare	Nearest façade to works	75	65	65	n/a
Tresillian	Healthcare	Nearest façade to works	75	65	65	n/a

Notes: 1. Noise affected level based on RBL + 10dB in accordance with the ICNG.
2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels for works during the demolition and excavation phase will be generally compliant with 'noise affected' NMLs during standard hours at all worst affected residential assessment locations excepting a minor 1dB exceedance for Somerset Street receivers. During non-standard hours (ie 1.00 pm to 5.00 pm Saturdays), an exceedance of up to 6 dB is predicted at Somerset Street receivers. The 'highly noise affected' level is not predicted to be exceeded during the demolition and excavation phase.

Noise predications indicate exceedances of the NML for non-residential assessment locations at Nepean Private Hospital and Tresillian.

Possible mitigation measures are discussed in Section 5.5. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan. Where possible, particularly noisy activities, such as use of rock breakers and rock hammers, should be scheduled within standard construction hours to reduce the risk of potential impacts during out of hours works.

5.3.2 Predicted noise levels during formwork and concrete works

Noise associated with formwork and concrete works will typically have minimal impact on surrounding noise sensitive residential uses given screening provided by existing site structures. Modelling has incorporated noise sources at higher levels (ie level six) to substantiate concrete works at unscreened locations which will occur for upper levels later in the project.

Noise predictions from the formwork and concrete works phase are provided in Table 5.3.

Table 5.3 Predicted construction noise levels during formwork and concrete works

Area	Land use	Assessment location	Predicted cumulative construction noise level, dB $L_{Aeq\ 15min}$	'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]		'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
				Standard hours	Out of hours works (day)	
Somerset Street	Residential	43-45 Rogers Street	47	57	52	75
Derby Street	Residential	Omega Apartments	46	57	52	75
Parker Street	Residential	Onyx Apartments	47	58	53	75
Nepean Private Hospital	Healthcare	Nearest façade to works	63	65	65	n/a
Tresillian	Healthcare	Nearest façade to works	67	65	65	n/a

Notes: 1. Noise affected level based on RBL + 10dB in accordance with the ICNG.

2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels during the formwork and concrete works phase will meet the 'noise affected' NMLs at all worst affected residential assessment locations. The 'highly noise affected' level is not predicted to be exceeded during this phase.

Noise predications indicate only marginal exceedances of the NML for non-residential assessment locations. Possible mitigation measures are discussed in Section 5.5. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.3.3 Predicted noise levels during general construction works

General construction works will encompass all internal works, façade and services installation. Noise from these works typically have less impact and is further reduced with the incorporation of the building façade.

Consistent with the formwork and concrete predictions, modelling has been undertaken for lower levels and upper levels (with the worst case presented) which considers screening effects to noise sensitive residential receivers external to the site. Noise predictions from general construction works are provided in Table 5.4

Table 5.4 Predicted construction noise levels during general construction works

Area	Land use	Assessment location	Predicted cumulative construction noise level, dB $L_{Aeq\ 15min}$	'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]		'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
				Standard hours	Out of hours works (day)	
Somerset Street	Residential	43-45 Rogers Street	52	57	52	75
Derby Street	Residential	Omega Apartments	49	57	52	75
Parker Street	Residential	Onyx Apartments	50	58	53	75
Nepean Private Hospital	Healthcare	Nearest façade to works	67	65	65	n/a
Tresillian	Healthcare	Nearest façade to works	67	65	65	n/a

Notes: 1. Noise affected level based on RBL + 10dB in accordance with the ICNG.

2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels during general construction works phase will meet the 'noise affected' NMLs at all worst affected residential assessment locations. The 'highly noise affected' level is not predicted to be exceeded during this phase.

Noise predications indicate only marginal exceedances of the NML for non-residential assessment locations. Possible mitigation measures are discussed in Section 5.5. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.4 Construction vibration

Safe working distances for typical items of vibration intensive plant are listed in Table 5.5. The safe working distances are quoted for both "Cosmetic Damage" (refer British Standard BS 7385) and "Human Comfort" (refer British Standard BS 6472-1).

Table 5.5 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg - 12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg - 18 to 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand-held	1 m (nominal)	Avoid contact with structure
Vibratory Rollers	<50kN (Typically 1-2 tonnes)	5 m	15 to 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>18 tonnes)	25 m	100 m

Source: From Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects), November 2007 – based on residential building.

Safe work distances relate to continuous vibration. For most construction activity, vibration emissions are intermittent in nature. The safe working distances are therefore conservative.

The safe working distances presented in Table 5.5 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

The safe working distances have been used to assess the potential for construction vibration impacts based on proposed construction activities. With regard to cosmetic damage, equipment noted in Table 5.5 will generally satisfy the minimum offset distances for receivers external to the site including Nepean Private and Tresillian. Consideration should be given to adjoining structures on the campus as part of the main works contractor's CNVMP. Assessment of these receivers is however outside the scope of this assessment.

Human response vibration limits should be considered with the preparation of the detailed construction noise and vibration management plan. Consideration should be given to existing patient wards and consultation rooms within Nepean Private, Tresillian and the larger campus particularly where vibration sensitive equipment such as microscopes and the like are utilised.

5.5 Construction noise and vibration mitigation

Mitigation measures which may be employed to further minimise noise impacts from the construction of the project are discussed in this section. These can include physical measures, such as acoustic screens or shrouds, or noise management measures such as scheduling, alternative plant, community consultation and the like.

5.5.1 Stakeholder and community consultation

Community consultation and complaints handling procedures and stakeholder disruption notice procedures should be developed such that noise affected receivers may be kept apprised of:

- construction timeline;
- expected noisy works particularly concrete pours which may extend into the evening; and
- readily available avenues to address noise complaints.

5.5.2 Site hoarding

Acoustically rated site hoarding may be employed between the site and surrounding receiver locations. The use of imperforate materials such as plywood (a typically standard hoarding material) can provide realistic noise reductions in the order of 10-15dB assuming that the barrier inhibits line of sight to receptor locations.

5.5.3 Temporary noise barriers

Temporary noise barriers may be incorporated around particularly noisy static equipment to minimise noise being transmitted to surrounding noise sensitive locations.

5.5.4 Scheduling of works

Noisy works may be scheduled to times which are more mutually agreeable to surrounding noise receptors. This can also include scheduling works such that multiple pieces of noisy plant equipment are not being utilised in close proximity to a particular noise receptor.

5.5.5 Plant and equipment

Additional measures for plant and equipment include:

- where possible, choose quieter and less vibration intensive plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- operate plant and equipment in the quietest and most efficient manner; and
- regularly inspect and maintain plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

5.5.6 Work practices

Work practice methods include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby hospital stakeholders or residents;
- locating vehicles to minimise noise;
- where possible, avoid the use of equipment that generates impulsive noise (i.e. hammering);
- minimise the movement of materials and plant and unnecessary metal-on-metal contact; and
- minimise truck movements.

6 Assessment of operational noise impacts

6.1 Assessment methodology

Noise generated by the development will be generally associated with the following noise sources:

- loading dock operations; and
- mechanical plant operation.

It is noted that there will be only minor additions to carparking as part of the proposal which will have negligible acoustic impact on surrounding assessment locations.

6.2 Loading dock operations

The development will include an upgrade to the existing loading dock in the back of house area of North Block. This will include the decantation and demolition of pathology to make way for the upgraded and expanded loading dock and back of house area. The loading dock has capacity for three heavy rigid vehicles and a semi-trailer bay.

An additional loading dock will be provided as part of the Stage 2 tower works with access via Barber Avenue which will include two medium rigid loading dock bays.

Loading dock operations have been assessed based on the maximum capacity of trucks entering the loading dock within a 15-minute period. It is anticipated that the loading dock will only be utilised during normal business hours. Predicted noise levels from heavy vehicles within the loading dock are based on the assumptions provided in Table 6.1.

Table 6.1 North block loading dock traffic noise sources and expected volumes

Loading dock	Traffic source	Source SWL, L_{Aeq} dB(A)	Vehicle movements
North Block	Semi-trailer	105 at 10km/h	1 in
	Heavy rigid	100 at 10km/h	3 in
Stage 2 tower	Medium rigid	95 at 10km/h	2 in

The predicted noise levels from loading dock operations are provided in Table 6.2. The nearest most potentially affected receiver to the North Block loading dock is the residential dwellings within Onyx Apartments on Parker Street. The nearest receiver to the Stage 2 tower loading dock is Tresillian to the north. Predicted noise levels have been provided for these locations.

Table 6.2 Loading dock movements

Receiver location	Predicted noise level, dB $L_{Aeq, 15min}$	Noise criteria (day), dB $L_{Aeq, 15min}$
Onyx Apartments – Parker Street	44	53
Tresillian	34	48

6.3 Mechanical plant

A detailed review of mechanical plant cannot be undertaken at the SSDA stage given that the mechanical design is only in its infancy. A detailed review is generally conducted during the detailed design and construction phases of the project.

However, an in-principle assessment of operational noise impacts has been undertaken to discuss potential mitigation measures which may be employed to reduced mechanical noise emissions from the site.

Mechanical plant as part of Stage 2 will be generally located in the following locations:

- level four plant room, incorporating air handling units and emergency generator; and
- Stage 2 tower roof, incorporating cooling towers, kitchen exhaust fans, exhaust fans, smoke exhaust and stair pressurisation.

Each of these locations will be discussed with regard to likely levels of impact on surrounding noise sensitive uses and within the hospital itself.

6.3.1 Level four plant room

The level four plant room will likely accommodate general mechanical plant including air handling units (AHU), relief/return air fans (RAF), supply air fans (SAF) and water cooled chillers. Acoustic treatment to these plant items may include:

- internally lined duct on AHU outside air intakes;
- internally lined duct or silencers on RAF discharge and SAF intakes; and
- wrapping of fan casing with a loaded vinyl material if required.

The water-cooled chillers will be located within an enclosed chiller plant room on level four which is partitioned from the rest of the plant room. Noise breakout from the chiller plant room can be managed by acoustically rating the bounding partitions.

An emergency generator will also be located on this floor, which is anticipated to be used in the event of a power outage; yet may run for an extended period. Emergency generators emit significant noise and will require additional acoustic treatment to the plant room intake, discharge and shell to mitigate noise emissions both to external sensitive land uses and within the Stage 2 building. Acoustic treatments are discussed as follows:

- the generator may require a separate room within the plant room to avoid spill of noise through weather louvres on the plant room façade; and
- air intakes and discharge from the generator plant room will likely require acoustic attenuators or acoustic louvres to the building façade.

Noise transfer to spaces within Tower 2 would be addressed as part of the detailed design and is in any case outside the scope of this assessment.

6.3.2 Stage 2 tower roof plant

The development roof will accommodate cooling towers, kitchen exhaust fans, exhaust fans, smoke exhaust and stair pressurisation. External plant equipment on the roof may have the potential for noise impact to surrounding noise sensitive receivers.

The following commentary is provided in-principle with regard to available acoustic treatment:

- acoustic treatment to kitchen exhaust fans may include Melinex lined discharge attenuators or duct work;
- exhaust fans may be treated using a combination of internally lined intake and discharge duct work; and
- smoke exhaust and stair pressurisation would only be used in the event of an emergency or for monthly tests. As such, acoustic treatment to mitigate noise to surrounding sensitive land use is not generally required given the infrequent nature of operation.

Cooling towers may require a combination of the following acoustic treatments to achieve compliance with noise emission criteria:

- acoustic intake louvres and/or solid cladding to inhibit visual line of sight to air intakes of the cooling towers; and
- discharge silencers on the cooling tower fan.

The aforementioned acoustic treatments are typical of this application and would be considered in further detail with the development of the mechanical scheme.

A detailed review of mechanical plant should be undertaken as part of the detailed design and construction phases to ensure that cumulative noise emissions comply with the PNTLs provided in Table 4.8 and Table 4.9.

7 External noise intrusion

7.1 Road traffic noise modelling

Road traffic noise predictions have been undertaken using a SoundPlan™ noise model incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithm, developed by the UK Department of Transport. Road traffic noise measurements have not been conducted in this instance due to significant impacts on typical road traffic noise levels due to the COVID-19 pandemic.

The CoRTN algorithm considers traffic flow volume, average speed, percentage of heavy vehicles, and road gradient to establish noise source strength, and includes attenuation via spherical spreading (or cylindrical in the case of a line source such as a road), soft ground, atmospheric absorption and screening from buildings or barriers.

Road traffic volumes have been collected from Transport for NSW (TfNSW) counting stations at the following locations:

- counting station 86008 located along the Great Western Highway, 30m east of Bridge Street, Werrington; and
- counting station 68025 located along the Great Western Highway, 240m east of Liverpool-Parramatta Transitway, South Wentworthville.

Traffic volumes for 2019 are representative of volumes prior to the COVID-19 pandemic and have been utilised to model traffic noise in this assessment. The 2019 road traffic volumes are provided in Table 7.1.

Table 7.1 Modelled road traffic volumes and assumptions

Road	Direction	2019 traffic volumes		Speed limit (km/h)
		AADT	%HV	
Great Western Highway	Eastbound	17,299 (1,283 peak hour)	4.3	60
	Westbound	15,571 (1,242 peak hour)	5.4	60
Parker Street	Southbound	21,624 (1,451 peak hour)	1.7	70
	Northbound	18,567 (1,436 peak hour)	5.9	70

Table 3.1 of the guideline (DoP 2008) clarifies that the noise criteria are to be determined as a maximum level, which has been determined to be an $L_{eq,1hr}$ or peak hour.

7.2 Predicted noise levels

Predicted noise levels from Parker Street to the west and the Great Western Highway to the north are provided in Table 7.2. Predicted noise levels are presented for the worst-case façade (and floor) on the Stage 2 tower. It is noted that the upper floors will overlook any screening provided by the natural or built environment to surrounding roadways.

Table 7.2 Predicted road traffic noise levels

Facade	Worst cast floor	Predicted external road traffic noise level, $L_{Aeq\ 1hour}$	Internal traffic noise objective, dB $L_{Aeq\ 1hour}$[1]	Required façade reduction, dB
West (facing Parker Street)	Level six	61	35	26
North (facing Great Western Highway)	Level four	62	35	27

Note: 1.Traffic noise objective based on wards being the most stringent criteria provided in the interim guideline.

7.3 In-principle acoustic treatments

The façade design will be undertaken as part of the detailed design and construction stages of the development to ensure that the internal noise requirements of the interim guideline are satisfied. This would be conducted in consultation with structural and ecological sustainable development (ESD) requirements.

The following acoustic treatments could be adopted to satisfy the 27dB reduction required for the northern façade, which will also satisfy all other facades for road traffic noise intrusion.

Other sensitive spaces are to comply with 45dB $L_{Aeq,\ 1hour}$ which is 10dB less stringent than that for wards. A nominal 20dB reduction can be achieved with standard building constructions with windows closed. As such, internal noise levels within all other spaces will comply with the interim guideline.

7.3.1 Glazing

The following in-principle glazing constructions provided in Table 7.3 could be adopted to satisfy the requirements in Table 7.2.

Table 7.3 In-principle glazing requirements

Room type	Glazing area	Room floor area	Recommended glazing construction	Minimum Rw requirement
In-patient unit (IPU) – single bed ward	$3m^2$	$18\ m^2$	Single glazed - 6.38mm laminated; or IGU[1] - 6mm float / 12mm airgap / 6mm float	31
In-patient unit (IPU) – double bed ward	$5m^2$	$26\ m^2$	Single glazed - 6.38mm laminated; or IGU[1] - 6mm float / 12mm airgap / 6mm float	31

Note: 1. Insulated glazed unit (IGU)

The insulated glazed unit (IGU) glazing constructions nominated in Table 7.3 are typical for hospital developments and would be typically nominated across all facades.

7.3.2 Façade construction

Façade constructions will typically consist of some type of:

- sheet metal or fibre cement cladding;
- large cavity studwork (eg 150mm or greater) filled with bulk thermal insulation; and
- plasterboard or fibre cement sheet internal lining.

This construction would be acoustically acceptable in achieving the internal noise requirements of the DoP interim guideline. Detailed design of the façade construction would be undertaken in consultation with structural, architectural and ESD requirements.

7.4 Discussion

Predicted road traffic noise levels have been presented based on noise modelling using road traffic volumes prior to the COVID-19 pandemic. Noise predictions indicate façade noise levels which can be reasonably mitigated using standard building constructions typical to that adopted on hospital projects.

The design of the façade will be undertaken as part of the detailed design and construction stages of the project.

8 Recommend mitigation measures

The following mitigation measures are recommended based on the assessment of:

- construction noise and vibration;
- operational noise generated by the development; and
- noise intrusion from external noise sources.

8.1 Construction noise and vibration

Construction noise is predicted to satisfy noise management levels at residential assessment locations, except during demolition and excavation works. Marginal excursions of criteria are predicted for non-residential assessment locations and hence nominal measures should be considered where feasible and reasonable. A detailed construction noise and vibration management plan should be prepared as part of the main works contract to ensure that all feasible and reasonable treatments and management conditions are considered to minimise noise and vibration from the site.

8.2 Operational noise

No additional mitigation measures are required to address noise generated by the use of the new loading dock beneath the Stage 2 tower and the refurbished loading dock on the western side of North Block.

A detailed review of mechanical plant should be undertaken as part of the detailed design and construction phases to ensure that cumulative noise emissions comply with the PNTLs provided in Table 4.8 and Table 4.9.

8.3 Noise intrusion from external noise sources

Road traffic noise intrusion into the development has been assessed. In-principle acoustic treatments have been determined in Section 7.3 to sufficiently mitigate road traffic noise intrusion. Constructions included in this assessment based on the most exposed façade on the worst case floor will suitably mitigate road traffic noise to meet the requirements of the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

The detailed design of the façade is to be undertaken as part of the detailed design and construction stages of the project to ensure that the requirements of the interim guideline are met.

9 Conclusion

Indigeco with specialist assistance by EMM has prepared an assessment of potential noise and vibration impacts associated with the construction and operation of the proposed Stage 2 Nepean Hospital redevelopment project. This assessment has addressed the requirements outlined in Item 10 of the SEARs issued for the Project in support of the SSDA.

Construction noise predictions indicate exceedance of the project NML at residential assessment locations in the vicinity of the site during demolition and excavation works, particularly during out of hours works (from 1pm to 5pm on Saturdays). It is noted that the 'highly affected' NML is not expected to be exceeded.

Vibration generated by heavy construction works are expected to comply with cosmetic damage limits for surrounding assessment locations, although select pieces of machinery may need to be carefully reviewed for implementation on the site.

A detailed construction noise and vibration management plan will be prepared as part of the main works contract to ensure that all feasible and reasonable treatments and management conditions are considered to minimise noise and vibration from the site. This review would be undertaken once demolition, excavation and construction methodologies and equipment can be detailed appropriately.

Operational noise associated with on-site vehicle movements has been addressed. Predictions indicate that noise from peak hour movements during the daytime period will comply with the NPfI.

External noise intrusion into the development has been addressed. The assessment concludes that road traffic noise levels can be mitigated using relatively standard constructions for a hospital development to meet the requirements of the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline*. A detailed assessment of the façade is to be conducted as part of the detailed design and construction stages.

References

NSW Environment Protection Authority (EPA) 2017, *NSW Noise Policy for Industry* (NPfI)

NSW Department of Environment Climate Change and Water (DECCW) 2011, *Road Noise Policy* (RNP)

NSW Environmental Protection Authority (EPA) 2009, *The Interim Construction Noise Guideline* (ICNG)

NSW State Environmental Planning Policy (Infrastructure) 2007 ('infrastructure SEPP')

NSW Department of Planning (DoP) 2008, *Development near Rail Corridors and Busy Roads – Interim Guideline*

Glossary

Project and technical terms

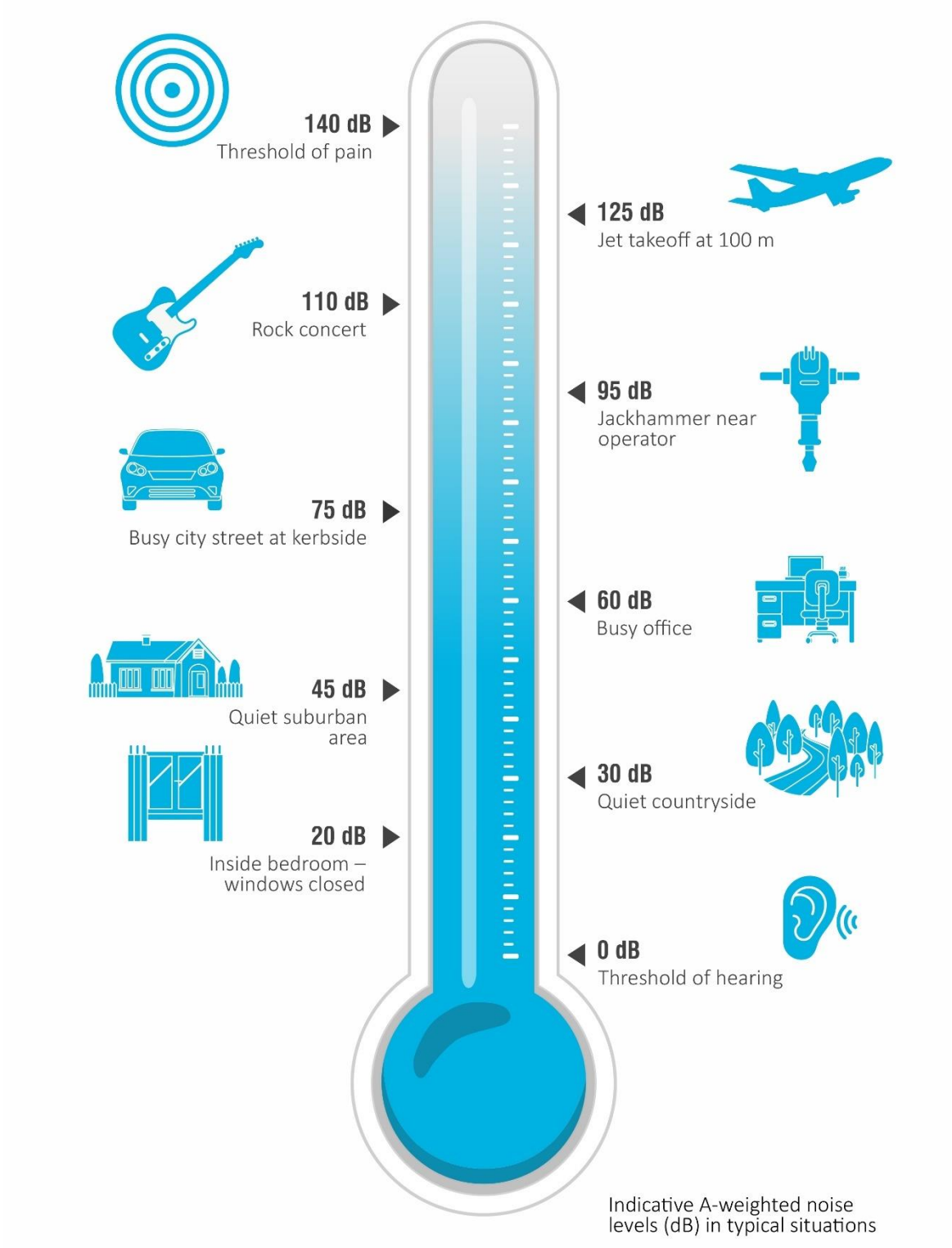
Term	Meaning
ABL	The assessment background level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Amenity noise criteria	The amenity noise criteria relate to existing industrial noise. Where industrial noise approaches base amenity noise criteria, then noise levels from new industries need to demonstrate that they will not be an additional contributor to existing industrial noise. See Section 4.3.2 for more detail.
Day period	Monday-Saturday: 7 am to 6 pm, on Sundays and public holidays: 8 am to 6 pm.
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dBC	Noise is measured in units called decibels (dB). There are several scales for describing noise, with the 'C-weighted' scale typically used to assess low frequency noise.
Evening period	Monday-Sunday: 6 pm to 10 pm
Intrusiveness noise criteria	The intrusive noise criteria refers to noise that intrudes above the background level by more than 5 dB. The intrusiveness criterion is described in detail in Section 4.3.1
L1	The noise level exceeded for 1% of the time.
L10	The noise level which is exceeded 10% of the time. It is roughly equivalent to the average of maximum noise level.
L90	The noise level that is exceeded 90% of the time. Commonly referred to as the background noise level.
Leq	The energy average noise from a source. This is the equivalent continuous sound pressure level over a given period. The Leq(15min) descriptor refers to a Leq noise level measured over a 15-minute period.
Linear peak	The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.
Lmax	The maximum sound pressure level received during a measuring interval.
Night period	Monday-Saturday: 10 pm to 7 am, on Sundays and public holidays: 10 pm to 8 am.
NPfI	Noise Policy for Industry
NVIA	NVIA Noise and vibration impact assessment.
PNTL	The project-noise trigger level (PNTL) is criteria for a particular industrial noise source or industry. The PNTL is the lower of either the intrusive noise criteria or amenity noise criteria.
RBL	The rating background level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the average background levels.
Sound power level (Lw)	A measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.

Common noise levels

The table below gives an indication as to what an average person perceives about changes in noise levels. Examples of common noise levels encountered on a daily basis are provided in the figure below.

Perceived change in noise

Change in sound level (dB)	Perceived change in noise
up to 2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud.



Common sources of noise with levels

Abbreviations

Abbreviation	Term
ARL	Acoustic Research Laboratories
AGL	above ground level
ANZEC	Australian and New Zealand Environment Council
ABL	Assessment background level
BoM	Bureau of Meteorology
CSSI	critical State significant infrastructure
CEMP	Construction Environmental Management Plan
DECC	Department of Environment and Climate Change
DEC	Department of Environment and Conservation
DEFRA	Department of Environment, Food and Rural Affairs (United Kingdom)
D&B	drill and blast
DP&E	Department of Planning and Environment
EPA	Environmental Protection Authority
EIS	environmental impact statement
EMM	EMM Consulting Pty Limited
FGJV	Future Generation Joint Venture
FHWA	US EPA Federal Highways
GWh	gigawatt hours
HV	heavy vehicle
ICNG	Interim Construction Noise Guideline
LGAs	local government areas
LV	light vehicle
MAT	Main Access Tunnel
MW	megawatts
NATA	National Association of Testing Authorities
NPfI	Noise Policy for Industry
NML	noise management level
NVIA	Noise and vibration impact assessment
OOH	out of hours
PHES	Pumped Hydro-Electric Storage
PPV	peak particle velocity
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
PNTL	project noise trigger level
RBL	rating background level
RNP	Road Noise Policy
RMS	root mean square
SHL	Snowy Hydro Limited
SEARs	Secretary's environmental assessment requirements
SSI	State significant infrastructure
VDV	vibration dose value