WOOD & GRIEVE ENGINEERS

Dubbo Hospital Stages 3 & 4 Redevelopment Delivery

Acoustic

Report

Construction Noise & Vibration Management Plan

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Revision

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1	20/02/2018	For Comments	**ORFG**

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Contents

1. Introduction

Wood & Grieve Engineers have been engaged by Hansen Yuncken (HY) to prepare a Noise Impact Assessment for the Construction Noise and Vibration associated with the construction works to be conducted as part of the Dubbo Health Services Redevelopment Stage 4.

This report has been prepared to meet the DA consent condition B22 from the NSW Government Department of Planning and Environment under Schedule 2, Part B, '*Prior to Commencement of Works*' for development Application SSD 7720 approved 12/12/2017.

Consequently, this report discusses the following:

- Project overview which summarises extent of the redevelopment works and site layout.
- Unattended acoustic noise survey conducted in order to obtain existing ambient noise levels at the boundary of the nearest noise sensitive receivers
- Construction Noise and Vibration acoustic criteria which are based on regulatory requirements and guidelines typically used for acoustic assessments. These include:
    - NSW Noise Policy for Industry (NPI) 2017
    - NSW Interim Construction Noise Guideline (ICNG) 2009
    - Assessing vibration: A technical Guideline.
    - German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures"
    - British Standard BS 6472 – Guide to Evaluate Human Exposure to Vibration in Buildings (1Hz to 80Hz)
- Establishment of noise and vibration criteria for typical each phase of the stage 4 construction, demolition and refurbishment.
- Strategies to mitigate the noise and vibration generated during the construction phase.
- Conclusions

The construction for stage 4 of the project includes 6 phases of construction, demolition and refurbishment works:

- Phase 01
    - Isolation areas
    - Corridor works
- Phase 02
    - 4A Demolition, of George Hatch Building
    - Playmates Doctors Accom
- Phase 03
    - Parking/ Storage on demolished sites
    - 75m 12T Crane erected
    - Stage 4 A Building
- Phase 04
    - Stage 4B Building
    - Stage 4C.2A Refurbishment
    - Paving, parking and ambulatory access
- Phase 0500
    - Stage 4C.1 and 4C.2 Build
- Phase 06
    - Stage 4C.2B Refurbishment Area
    - External work
        - Entry paving
        - Landscaping

Hours of operation have been approved for extension on Saturdays from 8am – 1pm as outlined in the INCG to 8am – 5pm in accordance with the Development Consent Condition Part C 'Hours of Work' C1. a).

2. Project Description

2.1 Site Description

The Dubbo Hospital is located along Myall Street in Dubbo, NSW. McGuinn Drive runs off Myall Street through the complex. Myall Street is situated off of the major road Cobbora Road and east of the train line as shown in Figure 1. Neighbouring receivers include:

- East – Residential Receivers on Leonard Street separated by the hospital car park.
- North – "Opal Dubbo", a specialist aged care facility and rural health school to the north east of the facility.
- West – Commercial premises (Opioid treatment centre), Train line and Residential Receivers.
- South – TAFE educational institution.

Redevelopment of the hospital complex in stage 4 includes demolition of 3 buildings in the southern section to make way for additional car parking spaces and ambulance access, as well as the demolishment of existing buildings to make way for the new development 4A and 4B.

Detailed construction phases of stage 4 are shown in Figure 2, Figure 3 and Figure 4.

Figure 1: Site layout

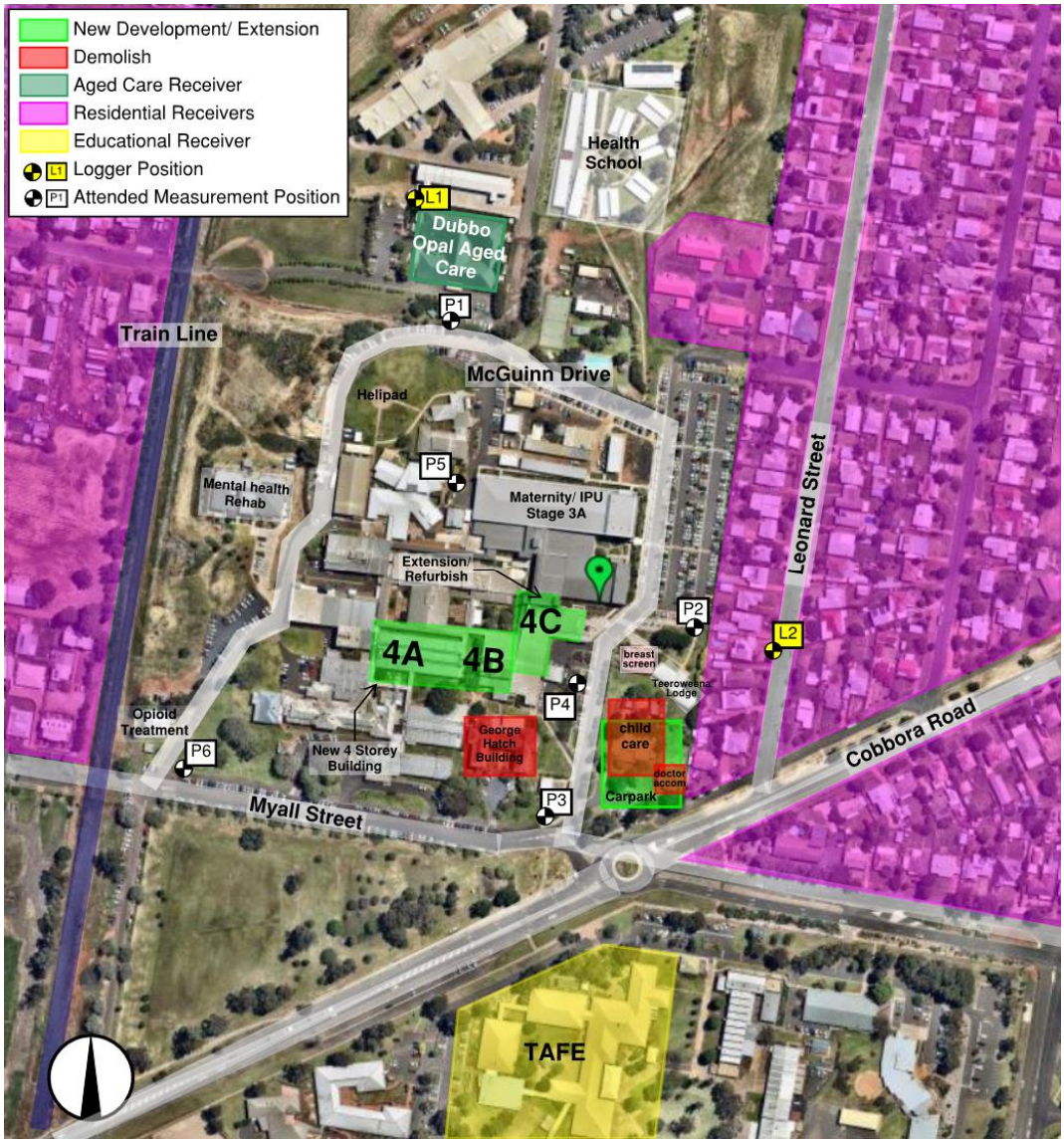


Figure 2: Phase 1

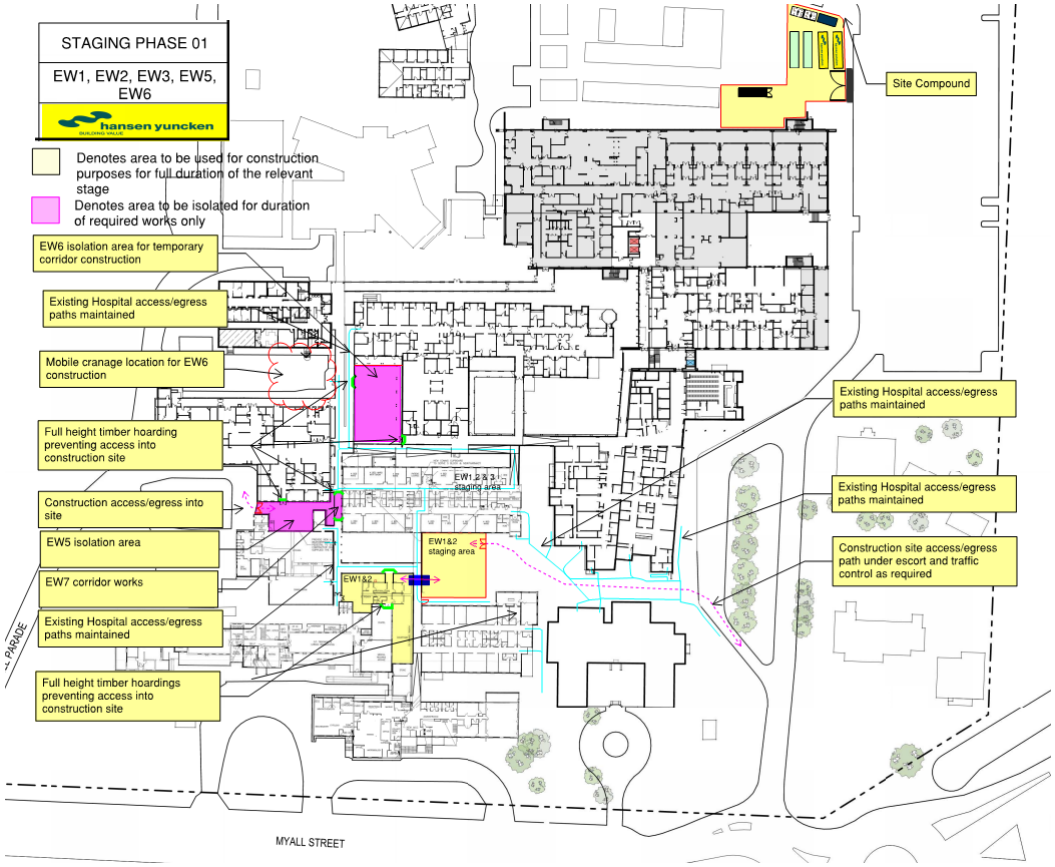


Figure 3: Phase 2

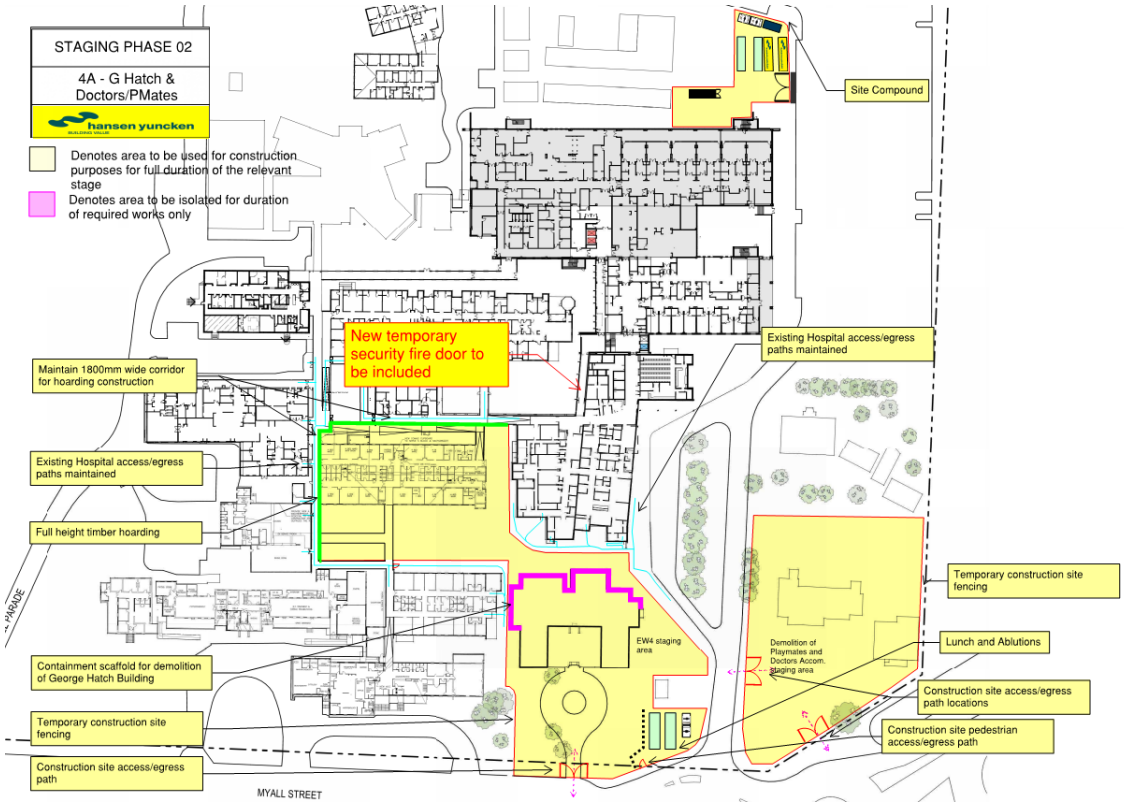


Figure 4: Phase 3

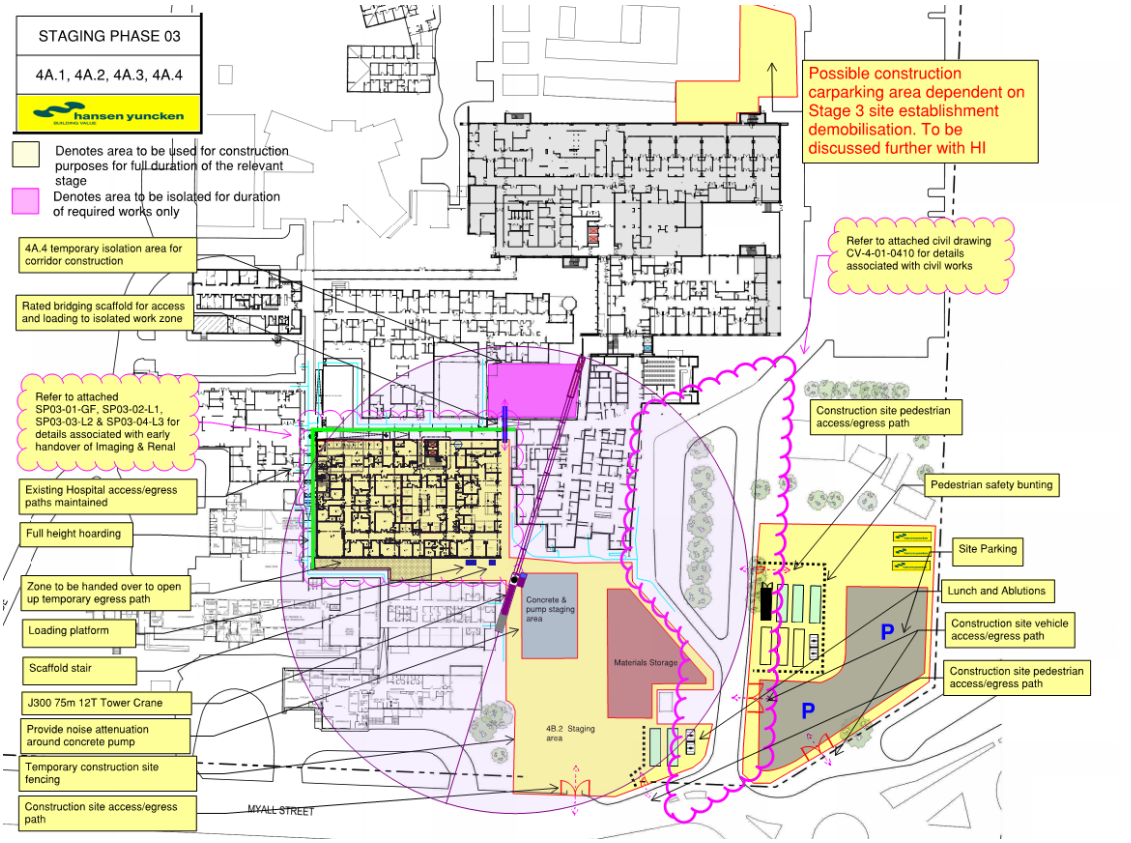


Figure 5: Phase 4

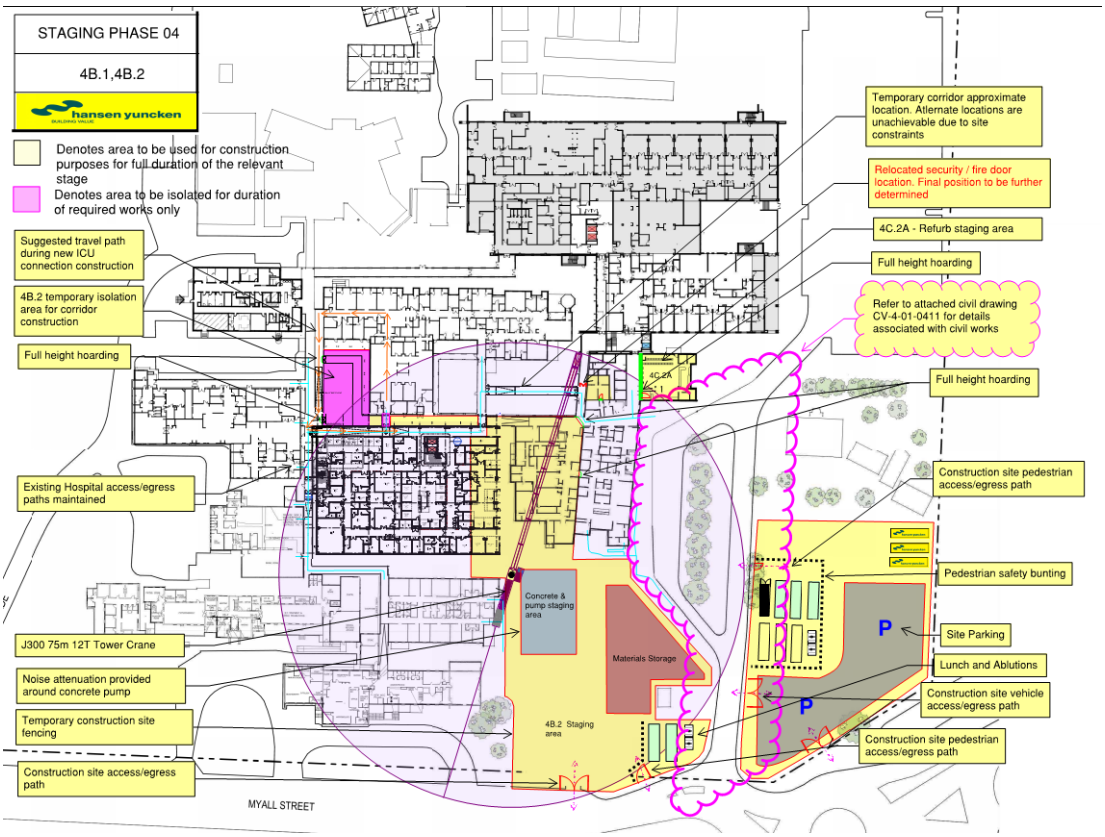


Figure 6: Phase 5

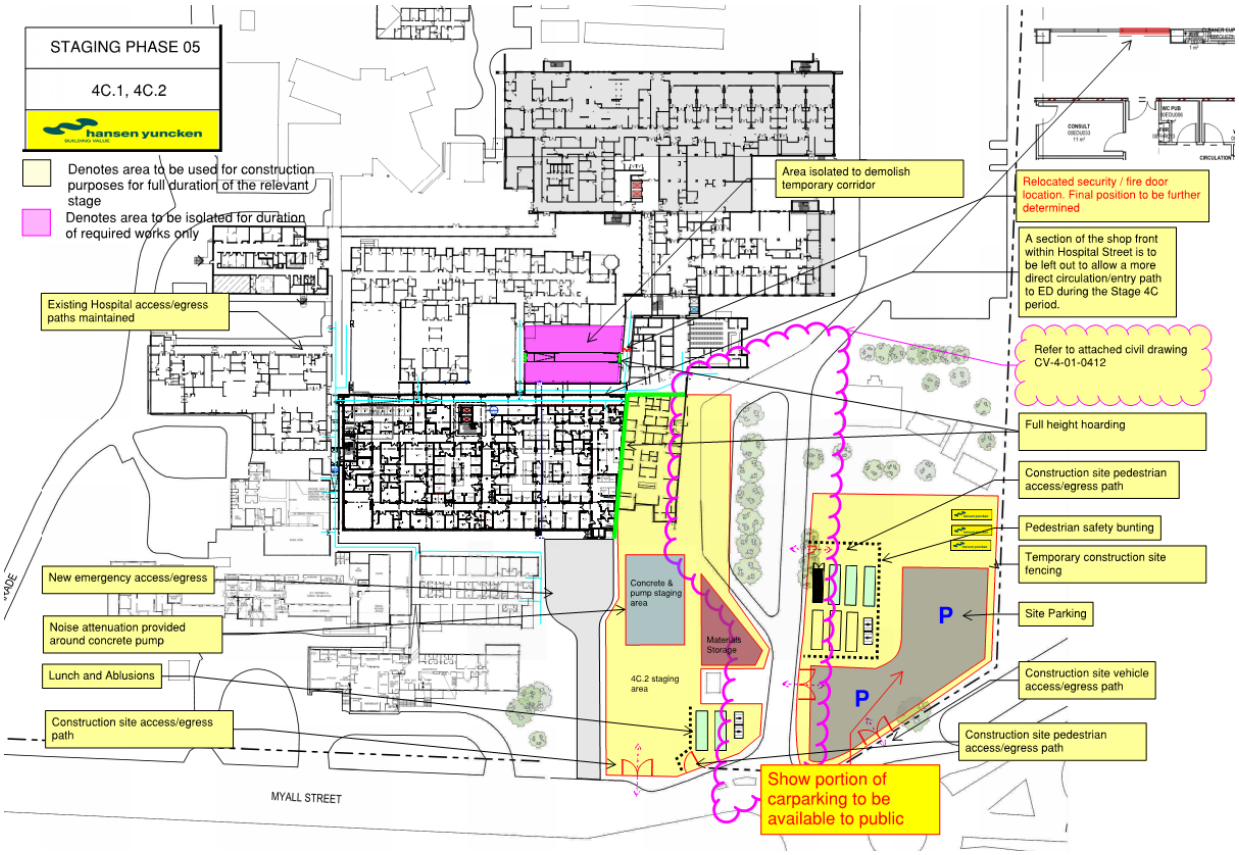
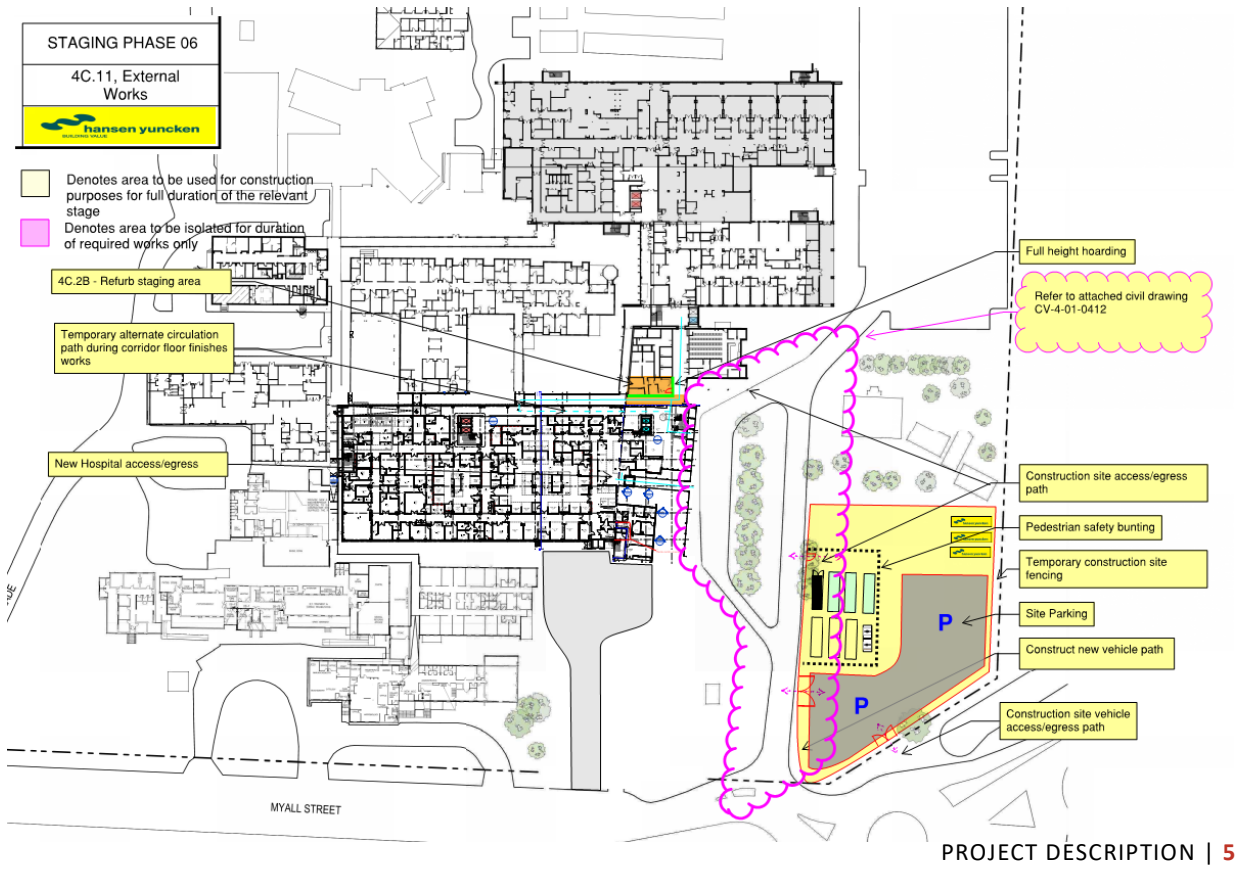


Figure 7: Phase 6



3. Acoustic Criteria

3.1 Construction Noise Criteria

The noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the Office of Environment and Heritage (OEH). This document is referred to as OEH's standard policy for assessing construction noise on new projects.

The key components of the ICNG 2009 incorporated into this assessment include:

1. **Use of LAeq as the noise metric for measuring and assessing construction noise**

   In recent years, NSW noise policies including OEH INP and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) have selected the LAeq to be the primary noise metric when measuring and assessing construction noise. Consistent with ICNG 2009, the use of the LAeq as a key descriptor for measuring and assessing construction noise may follow a 'best practice' approach.

2. **Application of feasible and reasonable noise mitigation measures**

   As stated in the ICNG 2009, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints. Selecting reasonable mitigation measures from those that are feasible requires one to determine whether the overall noise benefit of applying the measure outweighs the overall social, economic and environmental effects, including the cost of the measure.

3. **Quantitative and qualitative assessment**

   The ICNG 2009 provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

   A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

   A qualitative assessment is recommended for small projects with a short-term duration where works are not likely to affect an individual or sensitive land use for more than three weeks in total. It focuses on minimising noise disturbance through the implementation of feasible and reasonable work practice, and community notification.

   Given the significant scale of the construction works proposed for this Project, a quantitative assessment is carried out herein, consistent with the ICNG 2009 requirements.

4. **Management levels**

   Table 1 below (based on the ICNG criteria and the Conditions of Consent construction hours) sets out the noise management levels and how they should be applied. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

   The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 1: OEH ICNG Construction Noise Criteria at Residences

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Construction Hours Mon – Fri (7am – 6pm) Sat (8am – 1pm)	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 residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: 1. 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) 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	• The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

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

Table 2 (reproduced from Table 2 Sec 4.1.1 (Chapter 4) of the ICNG 2009) sets out the noise management levels for various sensitive land use developments. Other businesses that may be sensitive to noise including the opioid treatment facility at 170 Myall St, the recommended 'maximum' internal noise levels should comply with in AS/NZS 2107:2000. These are also presented in Table 2.

Table 2: OEH ICNG Construction Noise Criteria at Other Sensitive Land Uses

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Opioid Treatment – Waiting room	Internal Noise level 50 dB (A)
Opioid Treatment – Consult room	Internal Noise level 45 dB (A)

3.1.1 Project Specific Noise Levels

Given the criteria set out in Section 3, and the Unattended Measurement results, the Project Specific Construction Noise Levels are adopted as per Table 3. DA conditions have allowed for Saturday hours of construction to extend to 5pm.

Table 3: Project Specific Noise Levels

Time of Day	Management Level $L_{Aeq(15min)}$	Affection of noise on receiver
Standard Hours Monday – Friday 7am - 6pm Saturday 8am – 5pm	51 dB (A)	Noise Affected
	≥ 75 dB(A)	Highly Noise Affected
Outside of Standard Hours	46 dB (A)	Noise Affected

3.1.2 DA Conditions – Construction Noise Management

In addition to the recommendations above, the DA consent conditions C9 – C14 relate to construction noise management below must be adhered to at all times:

Condition C9.

The development must be constructed with the aim of achieving the construction noise management levels detailed in the *Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009).* All feasible and reasonable noise mitigation measures* must be implemented and any activities that could exceed the construction noise management levels must be identified and managed in accordance with the CNVMP, as required by condition B22.

**See feasible and reasonable noise mitigation measures in Section XXX*

Condition C10.

If the noise from a construction activity is substantially tonal or impulsive in nature (as described in Chapter 4 of the NSW *Industrial Noise Policy*), 5 dB(A) must be added to the measured construction noise level when comparing the measured noise with the construction noise management levels.

Condition C11

The applicant shall ensure construction vehicles do not arrive at the Subject Site or surrounding residential precincts outside of the construction hours of work outlined under condition C1.*

**Hours of construction shown in Table 3.*

Condition C12.

Schedule rock breaking/ hammering, sheet piling, pile driving and any similar activity only between the following hours unless otherwise approved by the Secretary:

a) 9am – 12pm, Monday to Friday
b) 2pm – 5pm Monday to Friday; and
c) 9am – 12pm, Saturday

Condition C13.

Wherever practical, and where sensitive receivers may be affected, piling activities are completed using augered piling methods. If driven piles are required they must only be installed where outlined in a CNVMP.*

**No approval has been sought for driven piles and therefore has not been outlined in this CNVMP report.*

Condition C14.

Any noise generated during the construction of the development must not be offensive noise within the meaning of the *Protection of the Environment Operation Act, 1997* or exceed approved noise limits for the Subject Site.

3.2 Construction Vibration Criteria

The NSW EPA has issued a document titled *"Assessing vibration: A technical Guideline"* (NSW AV TG) which is dated February 2006. This document has been produced in order to assist on the assessment of vibration levels. The guideline does not however address vibration induced damage to structures or structure-borne noise effects.

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

3.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

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

Maximum allowable magnitudes of vibration levels with respect to human response are shown in Table 4. Please note that the assessment period is defined as follows:

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

Table 4: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80Hz

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

3.2.2 Human Comfort – Intermittent Vibration Criteria

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

Table 5: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

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

In addition to these human comfort criteria, we also recommend to consider the following vibration criteria which address structural damage.

3.2.3 Structural Damage – Vibration Criteria

Generally structural vibration criteria are defined in order to minimize the risk of cosmetic superficial damage (such as surface cracks). These criteria are set below the levels that have the potential to cause damage to the main structure.

Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings".

Table 6 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage does not occur.

Table 6: Guideline value of vibration velocity (vi) for evaluating the effects of short term vibration

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

Table 7 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS 7385-Part 2:1993.

Table 7: Transient vibration guide values for cosmetic damage

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

3.2.4 Criteria for Vibration Sensitive Equipment

Vibration criteria for vibration sensitive equipment has been compiled by the American Society of Heating and Refrigeration Engineers (ASHRAE) and published in the *ASHRAE Handbook - HVAC Applications* Figure 8 below summarises these criteria.

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

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

Also please refer to vibration criteria discussed in Section 6 which are classified under *Critical Areas.*

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

Figure 8: Building vibration criteria for vibration measured on building structure

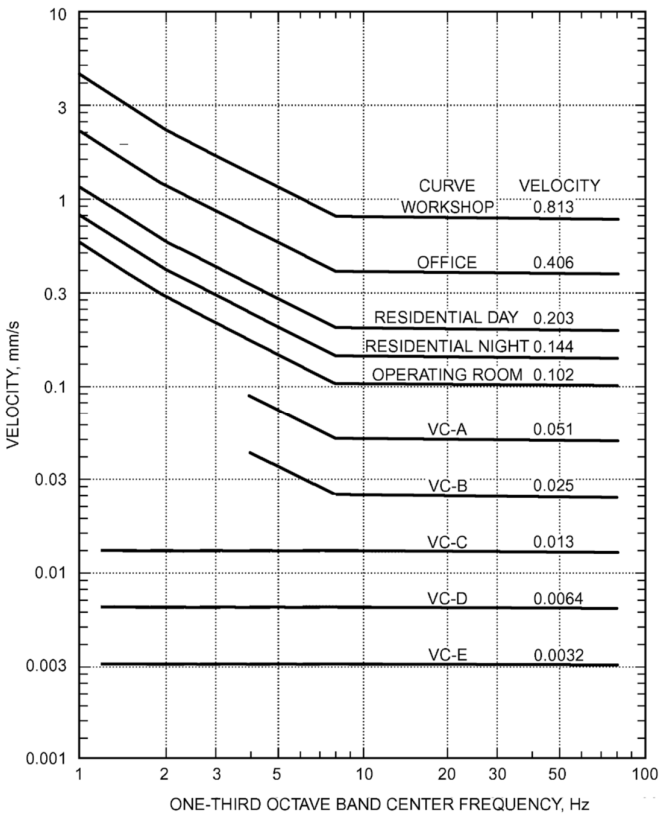


Table 46 Human Comfort and Equipment Vibration Criteria

Human Comfort	Time of Day	8 to 80 Hz Curve,[a] mm/s
Workshops	All	0.813
Office areas	All[b]	0.406
Residential (good environmental standards)	0700-2200[b]	0.203
	2200-0700[b]	0.144
Hospital operating rooms and critical work areas	All	0.102
Equipment Requirements		**Curve[a]**
Adequate for computer equipment, probe test equipment, and microscopes less than 40×		0.203
Bench microscopes up to 100× magnification; laboratory robots		0.102
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.		0.051
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths[c]		0.025
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size[c]		0.013
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems[c]		0.0054
Unisolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems[c]		0.0032

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

3.2.5 Vibration Levels from Construction and Demolition Activities

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.

Safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the *"Construction Noise Strategy "*document (issued by the Transport Infrastructure Development Corporation, dated November 2007). This document presents the safe construction working limits for Cosmetic Damage to adjacent structures and Human Comfort. It is recommended that the indicative safe working distances shown in Table 10 distance should be maintained from vibrating equipment to be used during demolition and construction tasks.

Table 8: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

Further to the above the vibration criteria for vibration sensitive instrumentation (as discussed in Section 3.2.4) are more stringent than the criteria for human comfort. Therefore, the safe working distances could be increased for particular equipment. Therefore, the following is recommended:

- Hospital staff or instrumentation manufacturer to provide criteria for each vibration sensitive instrumentation.
- As part of the CNVMP, a trial test should be conducted where vibration levels are measured near each vibration sensitive equipment when using construction and demolition equipment. These measured vibration levels should be assessed against the equipment criteria, and operational procedures should be investigated. Hence it is advised that the construction and demolition program should be provided in order to identify and coordinate the tasks from which trial measurements should be undertaken.

Finally, the CNVMP should consider the following amelioration measures which are to be taken into account in order to minimise the transmitted vibration around the site:

- Monitor vibration levels using attended/un-attended methods during construction to manage excessive vibration.
- Manage construction program so as to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.

As far as practical, locate heavy machinery away from nearby sensitive receiver

3.2.6 DA Conditions – Vibration Criteria

In addition to the recommendations above, the DA consent conditions C15 – C17 relating to vibration management below must be adhered to at all times:

Condition C15.

Vibration caused by construction at any residence or structure outside the Subject Site must be limited to:*

a) For structural damage vibration, *German Standard DIN 4150 Part 3 Structural Vibration in Buildings. Effects on Structures*; and
b) For human exposure to vibration, the evaluation criteria presented in *British Standard BS 6472 – Guide to Evaluate Human Exposure to Vibration in Buildings* (1 Hz to 80 Hz) for low probability of adverse comment.

**These standards have been included as part of this CNVMP criteria*

Condition C16.

The above limits apply unless otherwise outlines in a CNVMP, approved by the Certifying Authority

Condition C17.

Vibratory compactors must not be used closer than 30 meters from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified above.

4. Construction Noise Assessment

4.1 Methodology and Assumptions

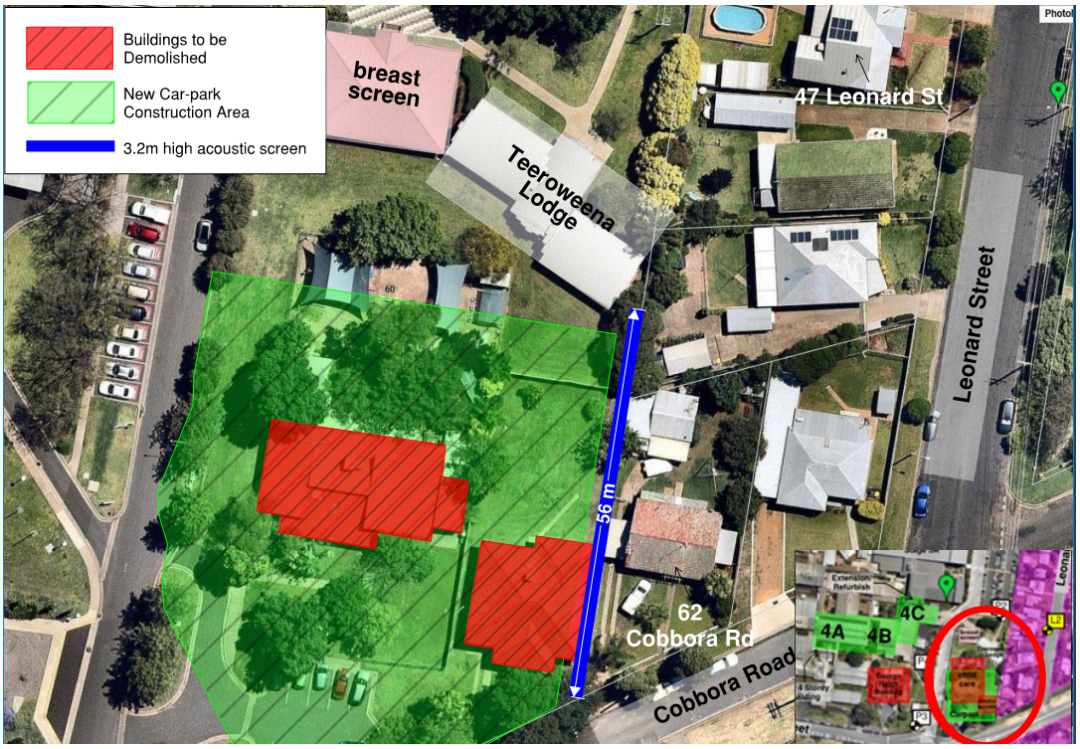
The noise emissions from construction associated with stage 4 of the Dubbo Health Services Redevelopment has been modelled in SoundPLAN 7.4. The modelling has been conducted using an implementation of the ISO 9613-2 Acoustics – Attenuation of the sound during propagation outdoors. The following features were included in the noise model:

- Ground topography
- Ground absorption
- Atmospheric absorption was based on an average temperature of 20°C and an average humidity of 60%
- Atmospheric propagation conditions were modelled with worst wind conditions (source to receiver)

The following assumptions for the premises noise model were made by WGE in order to estimate a suitable noise level corresponding to the type of activities and spaces:

- The equipment noise levels used have been based on AS2436:2010 and the NSW ICNG
- Equipment is used at varying frequency and duration, conservative use for each is shown in tables below
- An acoustic barrier shall be erected with a miniumum height 3.2m along the property boarder line between 60 and 62 Cobbora Road, from Cobbora Rd, back to the Teeroweena Lodge as shown in Figure 9.
    - This is a necessary mitigation measure for both noise and visual privacy for the demolition at 60 Coborra Rd to the neighbouring property at 62 Cobbora Rd.

Figure 9: Acoustic Screen for Construction to Cobbora Rd/ Leonard St Residences



To assess noise and vibration impacts during construction, a number of typical scenarios using various type of equipment have been used. Assumptions of typical equipment associated with the works for phases 1 – 6 have been made in Section 4.2. The equipment noise levels are extracted from AS2436:2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites" and Department of Environmental and Climate Change NSW – Interim Construction Noise Guideline (July 2009).

4.2 Program and Associated Noise Emission Assumptions

The staging presentation for construction works dated 23 January 2018 indicates the program in 6 phases. Based on the details provided for each stage the following noise levels are predicted to be typical of the associated works.

Phase 1 – EW1, EW2, EW3, EW5, EW6

- Full Height Timber Hoarding
- Corridor Works
- Isolation Areas
- Mobile Cranage

Table 9: Equipment Noise Schedule Phase 1

Phase 1 Early Works	Equipment	SWL dB (A)	Operation per hour (mins)
	Crane (tower)	105	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	AC unit (site office)	56	60
	Crane (mobile)	104	40

Phase 2 – 4A, George Hatch & Doctors/ PMates

- Demolition of George Hatch Building
- Construction of temporary Noise Barrier to east of Playmates demolition site
- Demolition of Playmates and Doctors Accommodation
- Full Height Timber Hoarding to Stage 4 Building

Table 10: Equipment Noise Schedule Phase 2

Stage 4 Early Works	Equipment	SWL dB (A)	Operation per hour (mins)
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Crane (tower)	105	32
	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40
	Excavator with rock breaker	118	48
Construction	Excavator	107	40
	Generator (diesel)	99	60
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	AC unit (site office)	56	60

Phase 3 – 4A.1, 4A.2, 4A.3, 4A.4

- Parking site established on Playmates Demolition area

- Stage 4 A building ground, level 1, 2, 3 and 4
- 75m 12Tonne Crane Erected
- Concrete Pump with Noise attenuation

Table 11: Equipment Noise Schedule Phase 3

Stage 4 A	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Excavator	107	40
	Crane (tower)	105	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	40
	Concrete vibrator screed	115	40
	AC unit (site office)	56	60
	Generator (diesel)	99	60
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Generator (diesel)	99	60
	Concrete saw	117	40

Phase 4 – 4B.1, 4B.2,

- Stage 4B building works
- Stage 4C.2A Refurbishment
- 75m 12Tonne Crane
- Concrete Pump with Noise attenuation
- Outdoor works – Paving temporary access roads and demolition of temporary access roads

Table 12: Equipment Noise Schedule Phase 4

Stage 4 B	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Bobcat	105	40
	Truck (6 tonnes)	107	40
	Asphalt paver	108	48
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	48
	Concrete vibrator screed	115	48
	AC unit (site office)	56	60
	Roller (vibratory)	108	40
	Generator (diesel)	99	60
	Crane (tower)	105	40
Refurbishment	Hand held jackhammers, hammer drills (pneumatic)	116	40
	Truck (6 tonnes)	107	40

	AC unit (site office)	56	60
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	40
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Crane (tower)	105	32
	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40
	Truck (dump)	117	48
	Excavator with rock breaker	118	48

Phase 5 – 4C.1, 4C.2,

- Stage 4C building works
- Relocated security/ fire door
- Demolish temporary corridor
- New Emergency Egress
- 75m 12Tonne Crane
- Concrete Pump with Noise attenuation

Table 13: Equipment Noise Schedule Phase 5

Stage 4 C	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Excavator	107	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	40
	Concrete vibrator screed	115	40
	Generator (diesel)	99	60
	AC unit (site office)	56	60
Demolition	Truck (6 tonnes)	107	48
	Generator (diesel)	99	40
	AC unit (site office)	56	60
	Truck (dump)	117	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48

Phase 6 – 4C.11, External Works

- Stage 4C.2B Refurbishment
- Corridor floor finishes works
- Outdoor works – Paving temporary access roads and demolition of temporary access roads

Table 14: Equipment Noise Schedule Phase 6

Stage 4 B	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Bobcat	105	40
	Truck (6 tonnes)	107	40
	Asphalt paver	108	48
	AC unit (site office)	56	60
	Roller (vibratory)	108	40
	Generator (diesel)	99	60
Refurbishment	Truck (6 tonnes)	107	40
	AC unit (site office)	56	60
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	40
Demolition	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40
	Truck (dump)	117	48
	Excavator with rock breaker	118	48

5. Construction Vibration Assessment

Use of noise and vibration monitoring during construction will be essential in order to ascertain the extent of vibration and noise generated in and around the site. In particular, the demolition works of the Playmates and Doctors Accommodation will have the most significant effect onto 62 Cobbora Road and vibration from rock breakers should be closely monitored with rest periods.

Further to the above, generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the *"Construction Noise Strategy "*document (issued by the Transport Infrastructure Development Corporation, dated November 2007). This document presents the safe construction working limits for Cosmetic Damage to adjacent structures and Human Comfort. It is recommended that the indicative safe working distances should be maintained from vibrating equipment which could be used during demolition and construction tasks.

Table 15: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

Please note these safe distances should be confirmed and updated based on the following information:

- Details of the demolition and construction tasks (including scope and precise duration).
- List of equipment to be used in each demolition and construction task – in particular the at the close distance to 63 Cobbora Road.

Further to the above the vibration criteria for vibration sensitive instrumentation (as discussed in Section 3.2.4) are more stringent than the criteria for human comfort. Therefore the safe working distances could be increased for particular equipment (this is currently not considered in Table 15). This would be relevant for machinery using precision lasers and MRI and CT scanners.

Therefore, the following is recommended:

- Hospital staff or instrumentation manufacturer to provide criteria for each vibration sensitive instrumentation.
- As part of the CNVMP, a trial test should be conducted where vibration levels are measured near each vibration sensitive equipment when using construction and demolition equipment. These measured vibration levels should be assessed against the equipment criteria, and operational procedures should be investigated. Hence it is advised that the construction and demolition program should be provided in order to identify and coordinate the tasks from which trial measurements should be undertaken.

Finally, the CNVMP recommends the following amelioration measures are taken into account in order to minimise the transmitted vibration around the site:

- Monitor vibration levels using attended/un-attended methods during construction in order to manage potential excessive vibration.
- Manage construction program so as to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.
- As far as practical, locate heavy machinery away from nearby sensitive receivers (ie MRI and CT scanners)

The worst affected residence to vibration dosages is 62 Cobbora Rd, whose façade is less than 5m from the doctor's accommodation to be demolished during phase 2 as shown in Figure 3. It is recommended when in close proximity to buildings, particularly for the sections of the demolition and carpark construction closest 62 Coborra Road to use

- Small excavators (2m safe working distance)
- Potential to use a medium size (12t) when receiver is at a distance greater than 7m.

Despite all feasible and reasonable mitigation methods, it is anticipated the residents at 62 Coborra Rd will be very affected by the works, particularly for Phase 2 demolition of existing buildings and carpark construction. All vibration management strategies shall be followed and ongoing vibration monitoring with a flashlight/ alert system in place for when vibration dosages are exceeded.

6. Construction Noise and Vibration Management

6.1 Management Plan

6.1.1 Demolition and Structure works

These two construction stages are predicted to produce the highest noise levels of all of the construction phases. Sporadic attended and unattended monitoring should be conducted during these stages of construction which represent the highest risk in terms of noise and vibration exposure for the surrounding community. This monitoring would include 15 minute measurements using a type 1 sound level meter, vibration analyzer and noise and vibration loggers. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

It has also been recommended to have ongoing vibration measurements during demolition stages of 4A and carpark construction of 4B at 62 Cobbora Rd to ensure the property is not a t risk of any structural damage.

6.1.2 Other construction works

The remaining phases of construction are predicted to have a lower overall noise and vibration impact on the surrounding residents. Some of the internal works also will be completed after the façade will be installed minimizing even more the predicted noise levels.

Sporadic attended monitoring could also be conducted during this construction stage. This monitoring would include 15 minute measurements using a type 1 sound level meter and vibration analysis. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

The following flow chart (See Figure 10) can be used to assist with noise mitigation and management measures in order to comply with the standards as aforementioned.

6.2 Generic Noise and Vibration Mitigation Strategies

According to AS 2436 – 2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* the following techniques could be applied to minimize noise and vibrations exposure of the potential most affected receivers.

6.2.1 Noise

If noisy processes cannot be avoided, then the amount of noise reaching the receiver should be minimized. There are two ways of achieving this, either in increasing the distance between the noise source and the receiver or in introducing noise reduction measures such as screens.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. Practices that will reduce noise from the site include:

(a) Increasing the distance between noise sources and sensitive receivers.
(b) Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
(c) Constructing barriers that are part of the project design early in the project to provide mitigation against site noise.
(d) Installing purpose built noise barriers, acoustic sheds and enclosures. This is critical between 60 and 62 Cobbora Rd for the duration of construction and demolition. A minimum height of 3.2m has been nominated. Material od the barrier should be selected based on transmission loss from construction to the façade of the residence to meet the criteria outlined in this report.

Screening

On site where distance between source and receiver is limited, the screening of noise may be of benefit and this should be taken into account at the planning stage.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, then sound insulation measures may be necessary to protect workers occupying them. The existing site offices and buildings have provided shielding to the nursing home receiver to the north as shown in section 4.

A hoarding that includes a site office on an elevated structure offers a superior noise reduction when compared with a standard (simple) hoarding. This performance is further enhanced when the hoarding is a continuous barrier.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. Noisy stationary plant can be put in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficient running.

Where such noise barriers are not practicable, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen the plant from any noise-sensitive areas. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant and equipment that operate on a 24-hour basis may not be a source of noise nuisance by day but can create problems at night. They should therefore be effectively screened either by being sited behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

In many cases it will not be practicable to screen earthmoving operations effectively, but it may be possible to partially shield construction plant or to build-in at the early stages protective features ultimately required to screen traffic noise. Where earth noise barriers are not a practical proposition because of lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any of the materials suggested in Appendix D of AS2436:2010 “Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites”.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the listener, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

If complaints from residents along Leonard Street arise, extension of the 5.6m barrier at 62 Cobbora Rd should be extended along the hospital boundary.

Crane (in case it is a diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from it.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternatives capable of providing a safe system of work that are equal to or better than the traditional ‘beeper’, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

(a) Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal-frequency ‘beep’) are less intrusive when heard in the neighborhood.
(b) Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
(c) Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, providing safety considerations, are not compromised.
(d) Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
(e) Spotters or observers.

The above methods should be combined, where appropriate.

6.2.2 Vibration

Vibration can be more difficult to control than noise, and there are few generalizations that can be made about its control. It should be kept in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement. Impulsive vibration can, in some cases, provide a trigger mechanism that could result in the failure of some building component that had previously been in a stable state.

During the demolition works some vibrations (transmitted through the structure from the demolition sites) are expected, being more of a concern for the surrounding sensitive receivers.

It can also trigger annoyance being elevated into action by occupants of exposed buildings, and should therefore be included in planning of communication with impacted communities. It should be remembered that failures, sometimes catastrophic, can occur as a result of conditions not directly connected with the transmission of vibrations, e.g. the removal of supports from retaining structures to facilitate site access. BS 7385-2 provides information on managing ground borne vibration and its potential effects on buildings.

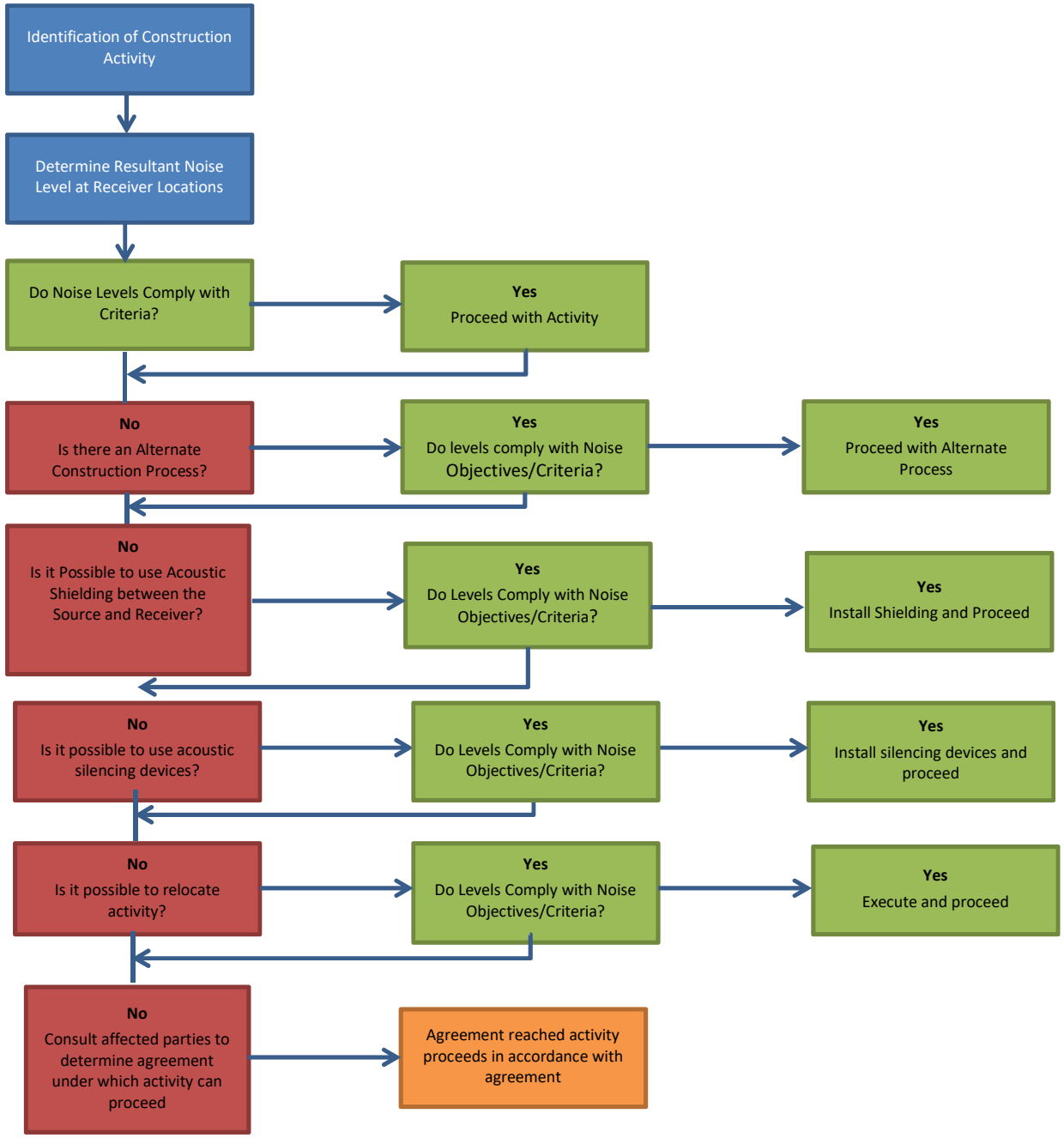
Where site activities may affect existing structures, a thorough engineering appraisal should be made at the planning stage.

General principles of seeking minimal vibration at receiving structures should be followed in the first instance. Predictions of vibration levels likely to occur at sensitive receivers is recommended when these are relatively close, depending on the magnitude of source of the vibration or the distance involved. Relatively simple prediction methods are available in texts, codes of practice or other standards, however it is preferable to measure and assess site transmission and propagation characteristics between source and receiver locations.

Comparison of predicted levels of vibration with preferred or regulatory levels will indicate when either more detailed predictions are required or mitigation of transmitted vibration is advisable or necessary. Guidance in measures available for mitigation of vibration transmitted can be sought in more detailed standards, such as BS 5228-2 or policy documents, such as the NSW DEC Assessing Vibration: A technical guideline.

Identifying the strategy best suited to controlling vibration follows a similar approach to that of noise—of avoidance, control at the source, control along the propagation path, control at the receiver, or a combination of these. It is noted that vibration sources can include stationary plant (pumps and compressors), portable plant (jackhammers and pavement vibrators), mobile plant, pile-drivers, tunneling machines and activities, and blasting, amongst others. Unusual ground conditions, such as a high water-table, can also cause a difference to expected or predicted results, especially with piling.

Figure 10: Noise Mitigation Management Flow Chart



6.3 Complaint Handling Procedures and Community Liaison

It is recommended that the builder directly contact adjacent noise sensitive receivers and provide them with the following information:

a) The contact details for a nominated representative in order to make noise / vibration complaints.
b) Explain the timeframe for the construction works and the proposed activities, i.e the proposed start / stop dates of work and a description of the noise producing equipment that will be used.
c) Notify the noise sensitive receivers and City of Sydney in a timely manner should there be any need for an extension to the proposed arrangements.
d) Provide them with a copy of this report as approved by the City of Sydney.
e) City of Sydney should be notified of the nature and details of complaints received (time, complainant etc) and what remedial action has taken place, if any.
f) Where noise is demonstrated as being compliant with criteria, this should not limit the proponent in undertaking further additional reasonable and feasible steps to reduce noise emissions.

To assist in the management of noise and vibration complaints various procedures are to be followed. These include:

- Clearly visible signage identifying any key personnel along with their contact details to be erected along the perimeter of the building site including;
  - A 24-hour contact name, phone number and email address provided for the resident to address any complaint. The signage will declare; “For any enquiry, complaint or emergency relating to this site at any time please contact…”
- Give complaints a fair hearing.
- Have a documented complaints process, including an escalation procedure so that if a complaint is not satisfied there is a clear path to follow.
- Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night time only if requested by the complainant to avoid further disturbance.
- Implement all feasible and reasonable measures to address the source of the complaint.
- A register is to be kept by the contractor to keep a record of complaints and detail any information associated with them. The contents of the register will include:
  - The name and the address of the complaint
  - Time and date of the complaint
  - The nature of the complaint (Noise/Vibration)
  - Subsequent details
  - Remedial action undertaken

The contents of the register will be maintained and updated with any new complaint without delay. The report will be reported to both City of Sydney and client representative. The investigation of the complaint and any remedial actions will be performed by the builder and/or client representative.

In the event of noisy works scheduled, the builder will notify residents 5 business days in advance.

6.4 Noise & Vibration Monitoring Strategy

6.4.1 General Methodology

Noise and vibration levels should be monitored from time to time to ensure that noise generated as a result of remediation and construction activities does not disturb local businesses and residents.

Monitoring may be in the form of regular checks by the builder or indirectly by an acoustic consultant engaged by the builder and in response to any noise or vibration complaints. Where noise and vibration criteria are being exceeded or in response to valid complaints, noise and / or vibration monitoring should be undertaken. This would be performed inside the premises of the affected property and on site adjacent to the affected receivers.

Monitoring is to be undertaken by an experienced noise and vibration monitoring professional or an acoustic consultant. The results of any noise or vibration monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise and vibration monitoring can take two forms:

1. Short term monitoring
2. Long-term monitoring

Short-term monitoring

Short-term monitoring consists of attended monitoring when critical stages of the construction are occurring. This normally provides real-time assistance and guidance to the subcontractor on site letting them know when the noise and vibration criteria are exceeded allowing the selection of alternative method on construction or equipment selection in order to minimise noise and vibration impacts.

Long-term monitoring

Similarly, long-term monitoring uses noise and vibration loggers providing real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded.

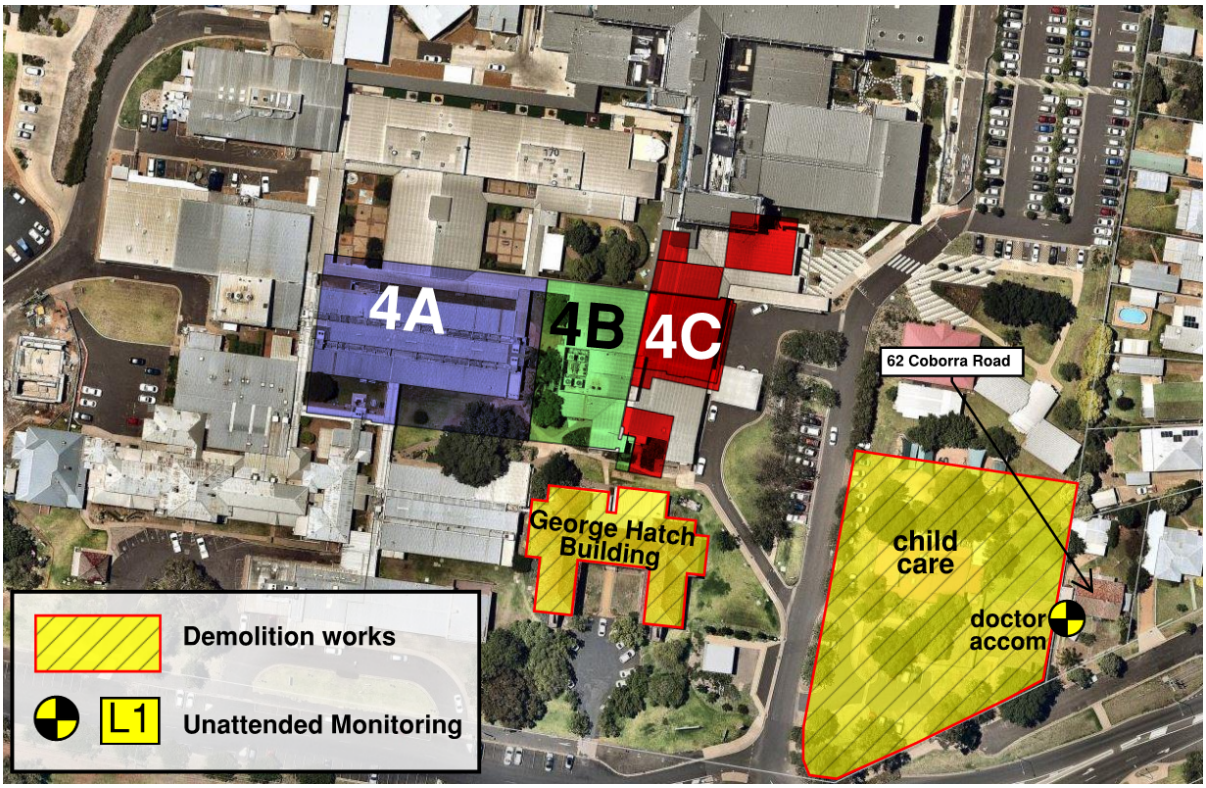
Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the DA conditions.

Both methodologies are complementary and normally used simultaneously providing a significant of amount of data via the long-term monitoring but also providing information on the sources of noise and vibration generating exceedances via the short-term or attended monitoring.

6.4.2 Proposed Location

The proposed location for the noise and vibration monitoring to be conducted by Wood & Grieve Engineers is displayed in Figure 11.

Figure 11: Unattended noise and vibration monitoring location



6.4.3 Monitoring Program

Wood & Grieve Engineers propose the following monitoring program:

1. Unattended noise and vibration measurements at location L1 shown in Figure 11 to assess the background noise and vibration levels characteristic to the site. The measurements will be two weeks in duration and must be performed prior to the commencement of construction in order to capture the noise and vibration background level in the area.

2. Noise and vibration monitoring at location L1 for a period of one month in duration during the demolition phase of the proposed redevelopment.

3. Noise and vibration monitoring at location L1 for four months, each having a duration of one month with a one month respite period between each monitoring campaign (seven months in total). Specifically, the noise and vibration schedule is as follows:

    - One month of continuous noise and vibration monitoring during the Site Establishment phase.
    - One month of continuous noise and vibration monitoring during the Hotel Construction phase.
    - Two continuous noise and vibration measurements, each one month in duration during the Hotel Construction phase.

4. Random attended noise and vibration monitoring at location L1 during the periods of long-term noise and vibration monitoring

APPENDIX A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.

LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.